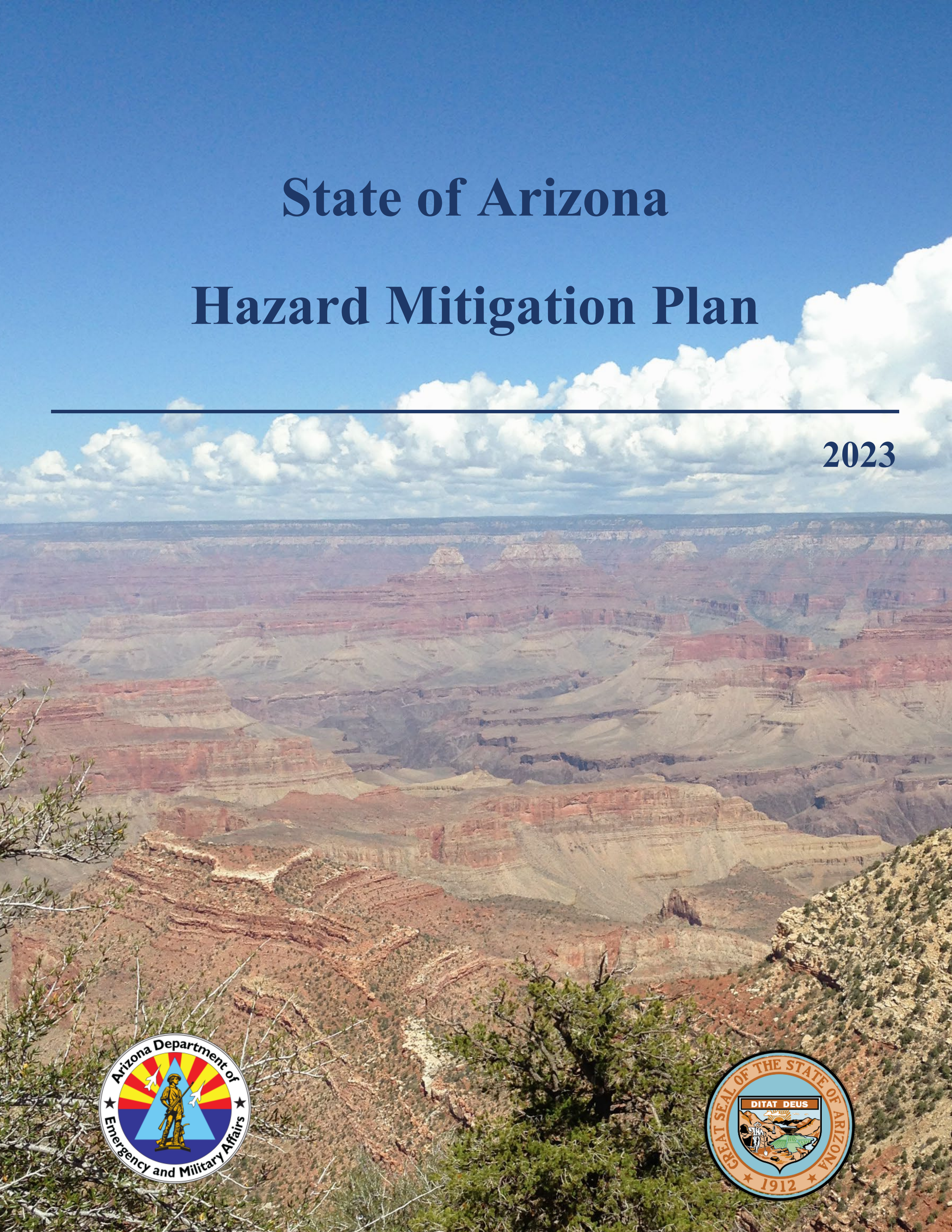
State of Arizona

Hazard Mitigation Plan

2023



Arizona Department of Emergency and Military Affairs

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The 2023 State of Arizona Hazard Mitigation Plan results from collaboration between state agencies and partners, led by the Arizona Department of Emergency and Military Affairs, Emergency Management (DEMA/EM) Planning Branch. For more information on this plan, contact:

DEMA/EM Planning Branch

planning@azdema.gov

602-464-6518

The 2023 State of Arizona Hazard Mitigation Plan is located at:

https://dema.az.gov/emergency-management-landing-page/preparedness/planning-branch

Executive Summary

Natural and human-caused disasters have led to increasing levels of death, injury, property damage, and interruption of business and government services. The time, money, and effort to respond to and recover from these disasters divert public resources and attention from other important programs and problems. Arizona recognizes the consequences of disasters and the critical need to reduce the impacts of natural and human-caused hazards.

It is understood that with careful selection, mitigation measures in the form of education, structural projects, and programs can become long-term, cost-effective means for reducing the impact of natural and human-caused hazards. The State of Arizona Hazard Mitigation Planning Team (the Planning Team) has collaborated to prepare the 2023 State of Arizona Hazard Mitigation Plan (the Plan). With the support of the State of Arizona and the Federal Emergency Management Agency (FEMA), this Plan has resulted in a resource to guide the state toward greater disaster resistance in full harmony with the needs of the region.

Arizona's hazards have the potential to cause widespread loss of life and damage to property, infrastructure, the economy, and the environment. Hazard mitigation is designed to reduce or eliminate risk, by reducing the probability and severity of hazardous events. Mitigation is any sustained action taken to reduce or eliminate long-term risk to life and property, and successful implementation can reduce the enormous cost burden disasters place on individuals in the community and all levels of government. Mitigation can protect critical community facilities, reduce liability, and minimize community disruption. Preparedness, response, and recovery measures support the concept of mitigation and may directly support identified mitigation measures.

This Plan has been prepared in compliance with Section 322 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act or the Act), 42 USC. 5165, enacted under Sec. 104 the Disaster Mitigation Act of 2000, (DMA 2000) Public Law 106-390 of October 30, 2000. This Plan identifies hazard mitigation measures intended to eliminate or reduce the effects of future disasters throughout the state.

U.S. Department of Homeland Security
FEMA Region 9
1111 Broadway, Suite 1200
Oakland, CA 94607

FEMA

November 1, 2023

Gabriel Lavine
Director
Arizona Department of Emergency and Military Affairs
5636 E. McDowell Road
Phoenix, AZ 85008

Reference: Approval of the Arizona State Hazard Mitigation Plan

Director Lavine:

The Federal Emergency Management Agency (FEMA) Region 9 approves the Arizona State Hazard Mitigation Plan effective October 18, 2023 through October 17, 2028. This plan is approved in accordance with applicable mitigation planning regulations and policy requirements.[1]

In addition, this plan meets the requirements to address wildfire risks and mitigation measures and the requirements to address all dam risks.

An approved state hazard mitigation plan is a condition of receiving certain FEMA non-emergency assistance and mitigation grants from the following programs:

- Public Assistance Categories C-G (PA C-G)
- Fire Management Assistance Grants (FMAG)
- Hazard Mitigation Grant Program (HMGP)
- Hazard Mitigation Grant Program Post-Fire (HMGP-PF)
- Building Resilient Infrastructure and Communities (BRIC)
- Flood Mitigation Assistance (FMA)
- Rehabilitation of High Hazard Potential Dams Program (HHPD)
- Safeguarding Tomorrow Revolving Loan Fund (STORM RLF)
- Pre-Disaster Mitigation (PDM)

[1] Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act), as amended; the National Flood Insurance Act of 1968, as amended; Title 44 Code of Federal Regulations (CFR) Part 201; and the "Water Infrastructure Improvements for the Nation Act," or the "WIIN Act," on December 16, 2016, which amends the National Dam Safety Program Act (Pub. L. 92-367).

Approval of a state hazard mitigation plan does not guarantee funding under any FEMA program. Please refer to the individual FEMA non-emergency assistance and mitigation grant program policy and/or annual Notice of Funding Opportunities for specific application and eligibility requirements for the FEMA programs listed above.

State hazard mitigation plans must be updated and resubmitted to FEMA Region 9 for approval every five years. If the plan is not updated and approved by October 17, 2028, the plan is considered lapsed, and FEMA will not obligate funds until the mitigation plan is approved.

If at any time over the plan approval period FEMA determines that the state is not complying with all applicable federal statutes and regulations in effect during the periods for which it receives funding or is unable to fulfill mitigation commitments, FEMA may take action to correct the noncompliance (44 CFR §201.3[b][5] and §201.4[c][7]).

FEMA will provide a reminder at least 12 months before the plan expiration date of the consequences of not having an approved state hazard mitigation plan, which is required to apply for and receive funding for FEMA non-emergency assistance and mitigation grant programs. To continue to apply for and receive funding from the programs listed on page 1, the state must submit a draft of the next plan update before the end of the approval period and allow sufficient time for the review and approval process. This includes any revisions, if needed, and formal adoption by the state following the determination by FEMA that the plan has achieved a status of "approvable pending adoption."

We look forward to working with you to discuss the status of the state hazard mitigation program each year over the approval period of this plan. If you have any questions please contact Kathryn Lipiecki, Mitigation Division Director, by phone at (215) 313-4176, or by email at kathryn.lipiecki@fema.dhs.gov.

Sincerely,

Robert Fenton
Regional Administrator
FEMA Region 9

Enclosure (1)
State of Arizona Plan Review Tool, dated October 18, 2023

cc: Ericka Huston, Assistant Director, AZ DEMA
Andrew Traylor, State Hazard Mitigation Officer, AZ DEMA
Alexandria Maese, Planning Branch Manager, AZ DEMA
Kathryn Lipiecki, Mitigation Division Director, FEMA Region 9
Alison Kearns, Planning and Implementation Branch Chief, FEMA Region 9

DEMA/EM maintains the State of Arizona Hazard Mitigation Plan as a living document intended to be continuously reviewed and revised, with input from all stakeholders, to guarantee the most current plan possible.

PLAN RECORD OF CHANGES			
Date	**Summary of Activity**	**Plan Section**	**Entry Made By**

DEMA/EM is committed to ongoing training and exercise related to the State of Arizona Hazard Mitigation Plan to see how we enhance awareness and improve plan implementation; please refer to the State Integrated Preparedness Plan (IPP) for details. The IPP can be found at the DEMA/EM website.

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SECTION 1: INTRODUCTION

INTRODUCTION

Hazards, exacerbated by climate change, have the potential of creating disasters that endanger the well-being of the entire community. The State of Arizona houses a culturally diverse population of approximately 7.2 million people, and hazards, if unabated, put every resident at risk. Hazard mitigation is a tactic that reduces or eliminates the impact hazards have on the community by reducing risk and vulnerability. In the context of this Plan, mitigation is a long-term solution to hazards and disasters that can prevent the disruption of a community's daily activities, reduce property damage, and save lives. The 2023 Plan identifies 15 hazards that pose a threat to the communities throughout the state. The Plan presents a strategy that has the potential to reduce or eliminate the risks and vulnerabilities associated with the identified hazards. The Plan, with the utilization of a community wide approach that fosters horizontal and vertical integration, can assist the State of Arizona in strengthening resilience and the ability to recover when disasters occur.

WHAT IS HAZARD MITIGATION?

The first step to understanding the State of Arizona Hazard Mitigation Plan is to understand what hazard mitigation is. Hazard mitigation is defined as any action taken to reduce or eliminate the long-term risk to human life and property from human-caused or natural hazards. A hazard is any event or condition that can potentially cause fatalities, injuries, property damage, infrastructure damage, agricultural loss, environmental damage, business interruption, or other structural and financial loss. As communities grow, hazard mitigation will play an even more important role in the government's primary objective of protecting its citizens' health, safety, and welfare.

Hazard mitigation aims to make human development and the natural environment safer and more resilient. Hazard mitigation generally involves altering the built environment to significantly reduce risks and vulnerability to hazards so that life and property losses can be avoided or reduced. Mitigation can also include removing the built environment from disaster-prone areas and maintaining natural mitigating features like wetlands or floodplains. Hazard mitigation makes responding to and recovering from disasters easier and less expensive by breaking the damage and repair cycle.

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 statewide building code and floodplain management regulations;
- Dam safety programs, 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; and
- Public awareness/education campaigns.

Benefits of hazard mitigation include:

- Saving lives and protecting public health;
- Preventing or minimizing property damage;
- Minimizing social dislocation and stress;
- Reducing economic losses;
- Protecting and preserving infrastructure; and
- Fewer expenditures on response and recovery efforts.

The National Institute of Building Sciences issued the *Natural Hazard Mitigation Saves: 2019 Interim Report*. The report project team looked at the results of 23 years of federally funded mitigation grants provided by the Federal Emergency Management Agency (FEMA), US Economic Development Administration, and US Dept of Housing and Urban Development (HUD) and found mitigation funding **can save the nation $6 in future disaster costs, for every $1 spent** on hazard mitigation.

In addition, the project team looked at scenarios that focus on designing new buildings to exceed provisions of the 2015 model building codes. The report also demonstrates that investing in hazard mitigation measures to exceed select requirements of the *2015 International Codes*, the model building codes developed by the International Code Council can save the nation $4 for every $1 spent.

PLAN PURPOSE

The 2023 Plan identifies risks and presents mitigation measures to prevent hazards from becoming disasters. Natural and human-caused disasters create many problems that can affect entire populations for long periods. Mitigation measures have the potential to save lives, prevent injury, reduce property damage, prevent community and economic disruption, protect the environment, and reduce the costs associated with disaster assistance. The Plan is a public record and serves as a source of information for all levels of government, the private and non-profit sectors, and individuals in the community.

AUTHORITY

Meeting the requirements of Section 322 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act or the Act), 42 USC. 5165, enacted under Sec. 104 the Disaster Mitigation Act of 2000, (DMA 2000) Public Law 106-390 of October 30, 2000, keeps the State of Arizona eligible to apply for disaster assistance, including hazard mitigation grants, available through the Robert T. Stafford Disaster Relief and Emergency Assistance Act, P.L. 93-288, as amended.

The Plan was prepared by the Arizona Department of Emergency Management and Military Affairs, Division of Emergency Management (DEMA/EM). Arizona Revised Statutes (ARS) 26-305 establishes DEMA/EM via the following:

A. There is established in the Department of Emergency and Military Affairs the Division of Emergency Management, which is administered by the department under the authority of the Adjutant General, subject to powers vested in the Governor as provided by law.

The section goes on to designate DEMA/EM as the State of Arizona entity responsible for emergency preparedness, including mitigation, via the following:

B. The division shall prepare for and coordinate emergency management activities that may be required to reduce the impact of disaster on persons or property.

C. Through the powers vested in the Governor, the division shall coordinate the cooperative effort of all governmental agencies, including the Federal Government, this state, and its political subdivisions, to alleviate suffering and loss resulting from disaster.

ASSURANCES

This Plan will comply with all applicable federal statutes and regulations in effect with respect to the periods for which it receives grant funding, in compliance with 44 CFR 13.11 (c), and will be amended whenever necessary to reflect changes in state or federal laws and statutes as required in 44 CFR 13.11 (d).

SECTION 2: STATE OVERVIEW

GEOGRAPHY

Ecological Regions

Arizona's ecological regions (ecoregions) vary across the state due to vast differences in elevation. Arizona has an elevation of 12,633 ft at its highest point and 70 ft at its lowest. Ecoregions can be defined as areas of water or land with similar environmental conditions and biological communities. The Plan utilizes the Level I Ecoregion Classification System from the US Environmental Protection Agency (EPA, 2023). The Level I Classification System was selected in order to provide a broad overview of the main ecological regions in the State of Arizona. The North American Deserts, Southern Semi-Arid Highlands, and Temperate Sierras are the three broad ecoregions within Arizona (see Figure 1).

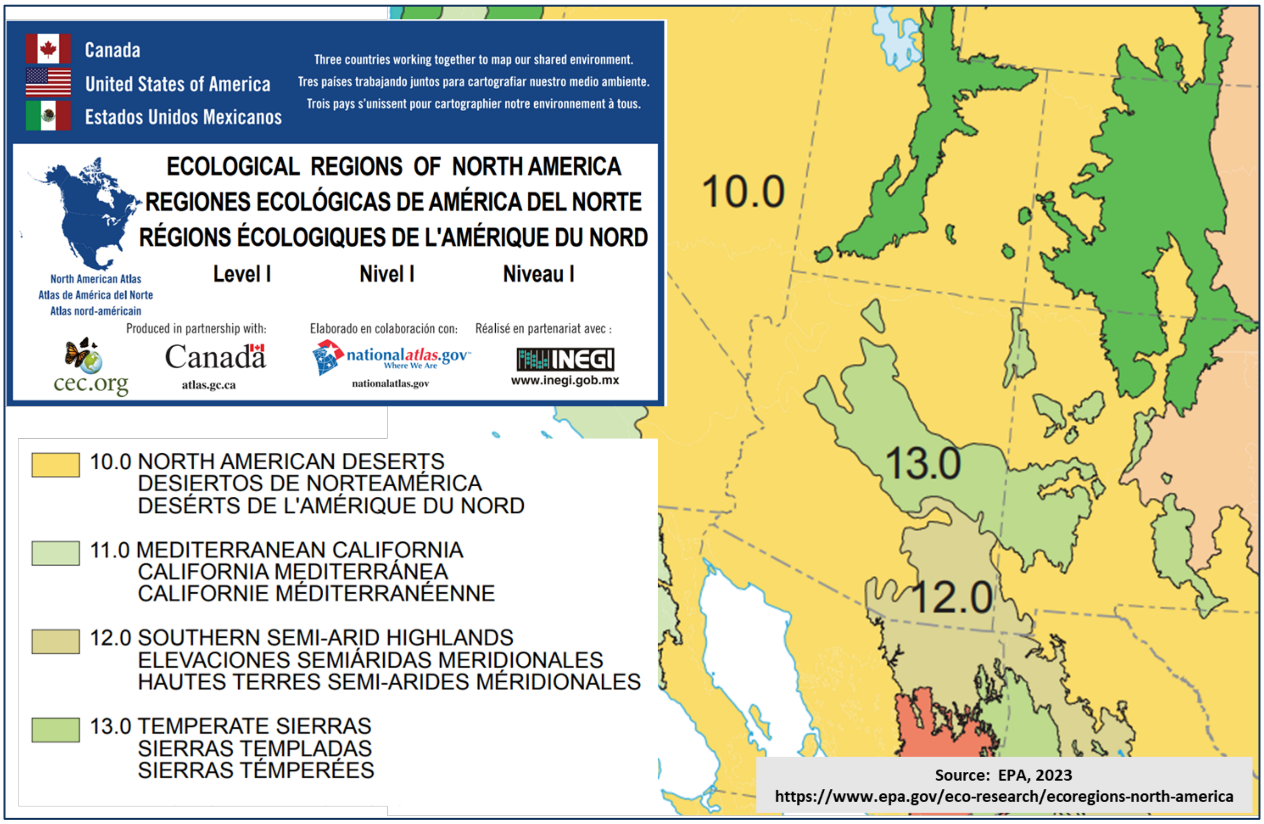


Figure 1. EPA Level I Ecoregions in Arizona

North American Deserts Ecoregion

The North American Deserts ecoregion is made up of four deserts: the Mojave Desert, the Great Basin Desert, the Chihuahuan Desert, and the Sonoran Desert. The Mojave Desert covers a small portion of the northwest corner of the state and is characterized by a rainy winter season with hard freezes. Vegetation in the Mojave Desert consists of low shrubs, Yucca brevifolia (Joshua tree), arborescent yucca, and annual flowers that are known to bloom during wet years. The Great Basin Desert is located in the northernmost region of the state and is known for its very cold winters. Vegetation lies dormant during the cold winters, limiting plant growth to the summer season. The vegetation consists of low, small-leafed shrubs. There are no trees or cacti in the Great Basin Desert, and the environment is often dominated by Artemisia tridentata (sagebrush). The Chihuahuan Desert is located in the southeastern corner of the state at a higher elevation than the other three deserts. The vegetation consists of varying species of low shrubs, succulents, small cacti, and few trees. Precipitation is predominantly in the summer, but winter rain at the northern end of the desert can cause a springtime bloom of annual flowers. The Sonoran Desert is the largest desert in Arizona and encompasses most of the state's southern half. The Sonoran Desert also houses the majority of the state's population, along with over 2,000 plant species and nearly 550 species of vertebrates. Mild winters allow for trees, grasses, cacti, shrubs, and wildflowers to persist and stay in season year-round.

Southern Semi-Arid Highlands Ecoregion

The Southern Semi-Arid Highlands ecoregion is located at the southeastern corner of Arizona where the Sonoran and Chihuahuan Deserts intersect. Natural vegetation varies and is dependent on elevation, but the ecoregion is relatively high in plant and animal diversity. Low elevation areas consist of desert grassland and desert scrub, while oak and juniper trees are abundant in areas with intermediate elevation. Trees that grow needles instead of leaves and cones instead of flowers form coniferous forests at the highest elevations within the ecoregion. The ecoregion is diverse, with mountains of volcanic origin and with valleys and plains that are coated in alluvial sediment.

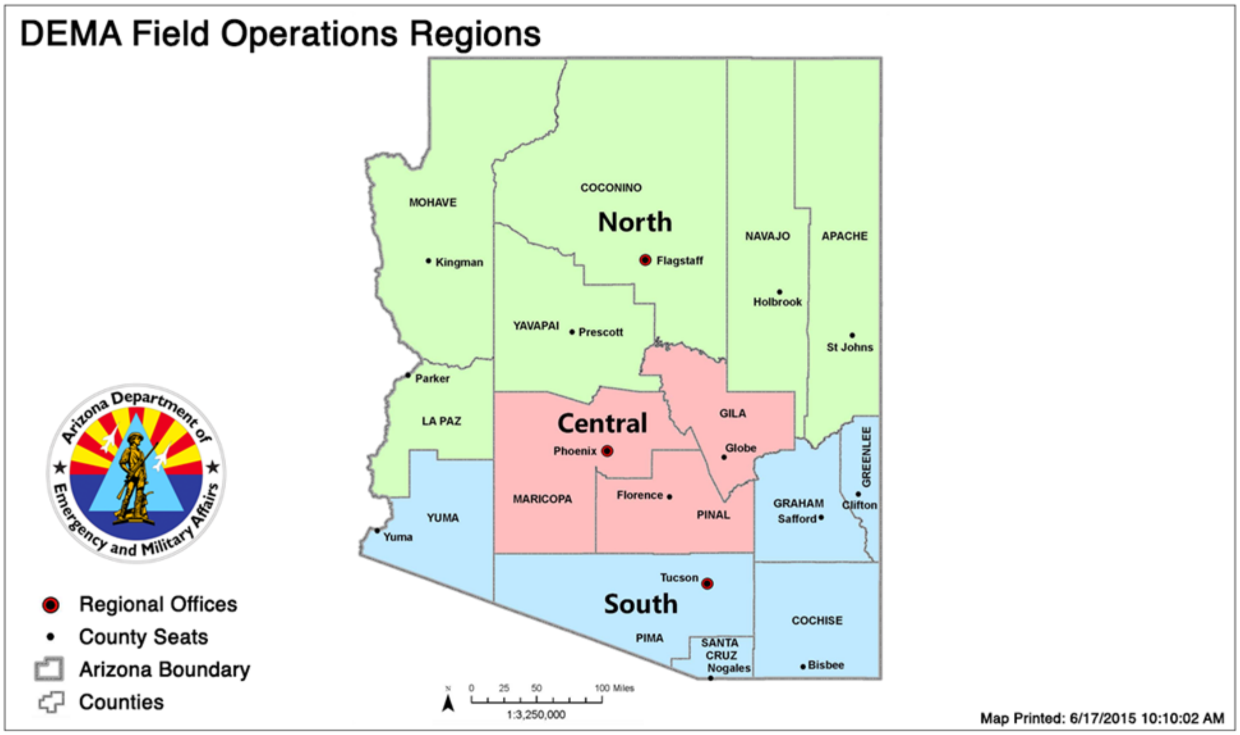
Temperate Sierras Ecoregion

The Temperate Sierras ecoregion is a montane forest that is surrounded by lower elevations of arid and semi-arid deserts. In Arizona, the ecoregion is flanked by deserts with the Great Basin Desert to the north/northeast, the Mojave Desert to the west, the Sonoran Desert to the south/southwest, and the Southern Semi-Arid Highlands ecoregion to the southeast. The ecoregion's vegetation is primarily comprised of conifers and oak trees that can grow up to 164 feet in height.

OPERATIONAL REGIONS

County and tribal information will not be independently presented within the Plan. Information from approved county and tribal hazard mitigation plans will be consolidated and presented as operational regions described below.

DEMA/EM has divided Arizona's 15 counties into three operational regions in order to pursue a Whole Community approach that best serves the residents of the state by ensuring continuity between and amongst all counties and Tribal Nations. The three operational regions, shown in Map 1 below, are designated as North, Central, and South, and a DEMA/EM Field Coordinator represents each region. The Field Coordinators serve as liaisons, provide technical assistance to county and tribal emergency managers, and coordinate response and recovery/mitigation measures during and after emergencies or disasters. The Field Coordinators also liaise between DEMA/EM and other local, county, state, and federal agencies. Ecological boundaries do not define the operational regions but have unique characteristics.



Map 1. DEMA/EM Field Operations Regions

North Region

The North Region has the largest land mass of the three operational regions and consists of six counties and 11 sovereign Tribal Nations (note that some of the sovereign Tribal Nations in the North Region transcend the boundaries of operational regions). The North Region is the home of the Grand Canyon and the City of Flagstaff. The region is located at the highest elevation in Arizona and is made up of the North American Deserts and the Temperate Sierras ecoregions.

Central Region

Housing the Phoenix Metropolitan area, the Central Region is the population center of the State of Arizona and consists of three counties and eight sovereign Tribal Nations (note that some of the sovereign Tribal Nations in the Central Region transcend the boundaries of operational regions). The North American Deserts ecoregion comprises most of the Central Region's geography. However, the northeast portion of the region is in the Temperate Sierras ecoregion, and the southeast corner is in the Southern Semi-Arid Highlands ecoregion.

South Region

The South Region has unique characteristics as it spans the width of the state and borders the country of Mexico. The region consists of six counties and five sovereign Tribal Nations (note that some of the sovereign Tribal Nations in the South region transcend the boundaries of operational regions and the US - Mexico border). The South Region is the home of Tucson, and it has a split geography that consists of the North American Deserts ecoregion to the west and the Southern Semi-Arid Highlands ecoregion to the east.

NATIVE AMERICAN TRIBES IN ARIZONA

American tribes. These Native American tribes include the following, which are generally highlighted on Map 2:

- Ak-Chin Indian Community;
- Cocopah Tribe;
- Colorado River Indian Tribes;
- Fort McDowell Yavapai Nation;
- Fort Yuma-Quechan Tribe;
- Gila River Indian Community;
- Gila River Indian Community;
- Havasupai Tribe;
- Hualapai Tribe;
- Hopi Tribe;
- Kaibab-Paiute Tribe;
- Navajo Nation;
- Pascua Yaqui Tribe;
- Salt River Pima-Maricopa Indian Community
- San Carlos Apache Tribe;
- San Juan Southern Paiute Tribe;
- Tohono O'odham Nation;
- Tonto Apache Tribe;
- White Mountain Apache Tribe;
- Yavapai-Apache Nation;
- Yavapai Prescott Indian Tribe; and
- Zuni Tribe.

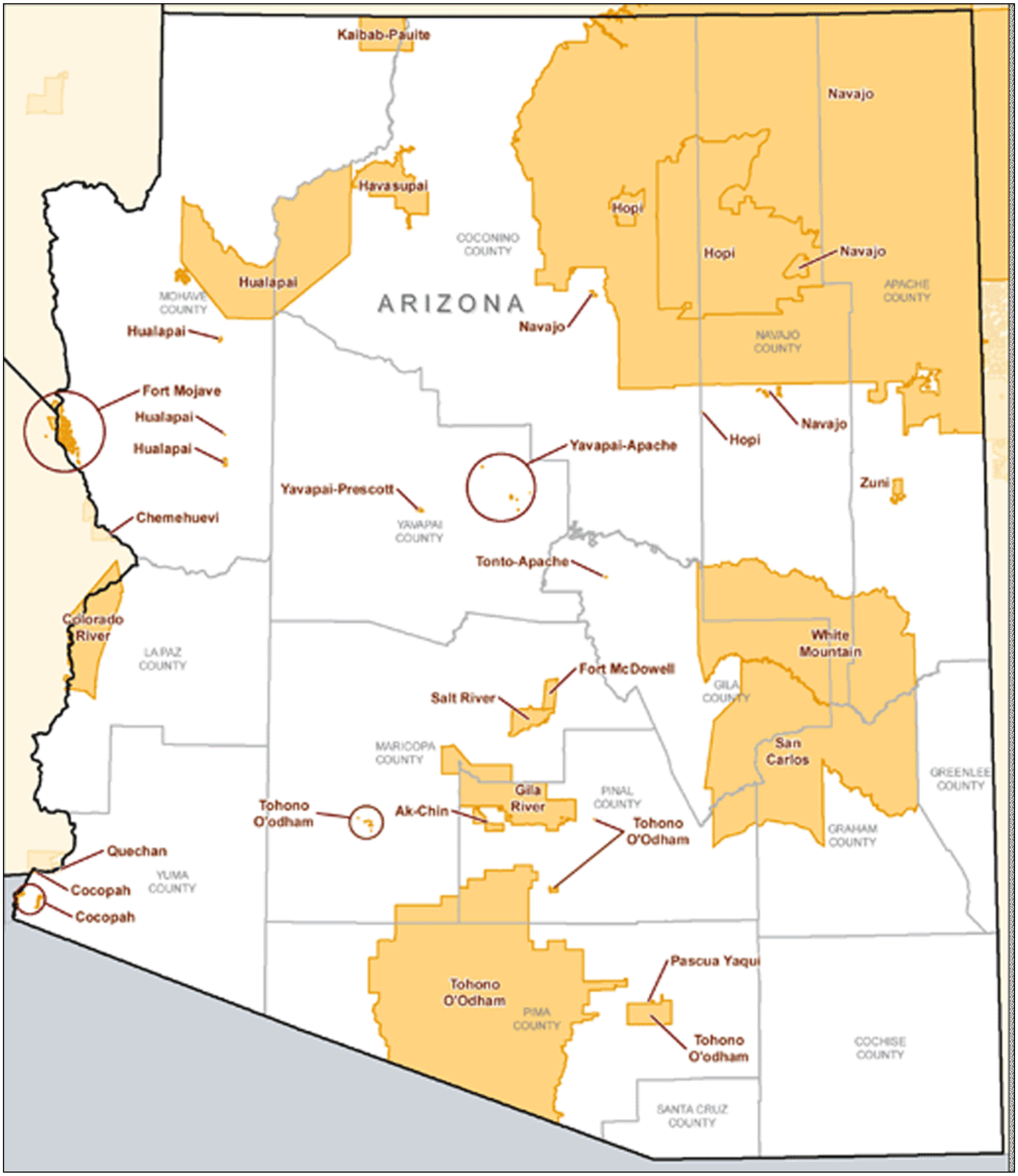
Tribal Nations have shaped Arizona and its culture in many ways - even the name Arizona comes from the Papago word, Airzonac, which means "small springs." Native American art, designs, and styles have strongly influenced Arizona architecture and can be seen across the state. Arizona's strong agriculture ties (the state has more than 20,000 farms and ranches) relate back to the agricultural roots established by the tribes and are based on the well-developed irrigation systems that they built over a thousand years ago. Today, the majority of newly reported farms and ranches come from tribal lands.

Many counties (Apache, Coconino, Gila, Maricopa, Mohave, Navajo, Pima, Yavapai, and Yuma) are named after various Native American tribes that make up the state. One county, Cochise County, is named after the great Chiricahua Apache chief who led an uprising against the US government, which began in 1861 and persisted until a peace treaty was reached in 1872. Even cities such as Tucson and Yuma take their names from the Native American tribal languages.

In the lower 48 states, the entire land mass of the tribal lands covers over 56 million acres or nearly 5% of the total land area of the United States. Tribal land in Arizona totals more than 20,000,000 acres, or approximately 43,300 square miles - about 27% of all land within the state. This means that over a third of all tribal lands in the lower 48 states are found in Arizona, including the largest tribal reservation, the Navajo Nation. At approximately 27,000 square miles, the Navajo Nation is roughly the size of the state of West Virginia.

Approximately 371,878 people in Arizona are Native American, which makes up over 5.2% of the state's population. Of that, over 264,000 individuals still live on tribal reservation land. That makes Arizona home to six of the top 20 most populated tribal reservations, including the Navajo Nation, the White Mountain Apache Tribe of the Fort Apache Reservation, the Gila River Indian Community, the San Carlos Apache Tribe, the Tohono O'odham Nation, and the Hopi Tribe.

Tribal Nations possess a sovereign nation status that allows them to have a direct government-to-government relationship with the Federal Government. Despite this, Arizona tribes regularly plan and prepare with the state and their neighboring jurisdictions.



Map 2. Map of Tribal lands in Arizona

As a result of their sovereign status, Tribal Nation governments have constitutions, articles of association, and other bodies of law, are able to make laws governing the conduct of persons (including non-tribal members) on their lands, establish bodies such as tribal police and courts, exclude or remove non-members from their lands, regulate hunting, fishing, and land use, establish taxes for items purchased on tribal lands, and establish environmental protections.

Tribal economic bases can vary greatly from tribe to tribe. Some tribal enterprises include commercial endeavors like agriculture and timber. The most well-known tribal enterprise is tribal gaming, but not all tribes have casinos. The largest component of many tribal economies is tourism. The more well-known tourism opportunities include:

- Staying in one of the many tribal resorts across the state;
- Visiting one of the many tribal shopping centers;
- Attending events at a tribal entertainment arena; and
- Even watching a Spring Training game at the Salt River Fields in the Salt River Pima-Maricopa Indian Community.

There are many other unique opportunities offered as well, including staying in campgrounds at the bottom of the Grand Canyon with the Havasupai, traveling the Hopi Arts Trail to connect with artists and galleries on the Hopi mesas, or visiting the Skywalk on the Hualapai reservation at Grand Canyon West. These enterprises bring thousands of tourists to tribal lands and Arizona throughout the year.

As Arizona tribes continue to increase their self-governance, some have taken over the administration of their educational institutions, law enforcement, healthcare, and maintenance of infrastructure while others rely upon various federal agencies to provide these services. This means that planning and working with our tribal partners often includes various federal entities as well.

CLIMATE

The climate varies across the State of Arizona and is dependent upon the level of elevation. Elevation is not the only factor that influences the climate in today's world, as the ever-evolving environment has become an area of focus that must be considered to mitigate disasters successfully. Climate change demands attention as hazards can potentially increase in frequency and intensity and pose a greater risk to Arizona. Future conditions are unknown, but the climate trend shows an increase in the average temperature throughout Arizona.

Temperature and Precipitation

Arizona experiences biannual precipitation during both summer and winter months. Winter precipitation occurs from November through March, and the frequency of rainfall has been known to cause heavy snow in the North and Central regions. Summer rainfall occurs from July through September, and the combination of precipitation and high temperatures gives way to Arizona's monsoon season. Monsoon season in Arizona is characterized by thunderstorms with heavy rain, high winds, and lightning that can cause flash flooding, dust storms, and wildfires.

North Region

The North Region has the highest elevation of the three regions, with the vast majority of the region resting at an elevation between 5,000-8,000 ft and mountainous peaks reaching above 12,000 ft. The westernmost and southwesternmost portions of the region generally follow the Colorado River and drop to elevations well below 5,000 feet with a low point of approximately 500 ft. The high elevation creates a climate lower in temperature and higher in precipitation compared to the state's Central and South regions. The average yearly maximum and minimum temperatures for the region are 74.5 and 39.1°F, and areas of the North Region have been known to reach temperatures below freezing point with the potential of dropping below zero during winter months. The North Region receives the highest precipitation in the state, with some areas receiving as much as 35-40 inches of rain per year.

Central Region

The Central Region rests at an elevation between 1,000-5,000 ft, with small portions of the northeast ranging between 5,000-8,000 ft and small portions of the southwest dropping to 425 ft. Temperatures in the region have an average yearly maximum of 86.5°F and a minimum of 62.4°F, but the temperature has been recorded as reaching above 120°F during the summer months. The Central Region contains the Phoenix Metropolitan area, which comprises approximately 4.85 million people. The elevation, population density, and the built environment have led to significant temperature increases in the area. The Phoenix Metropolitan area receives an annual five to 10 inches of rain, while the more mountainous portions of the region in the north receive as much as 30 inches per year.

South Region

Most of the South Region rests at an elevation between 1,000-5,000 ft, with small eastern portions of the region reaching above 8,000 ft and small western portions of the region reaching below 1,000 ft to a low point of 70 feet. The average yearly maximum and minimum temperature of the entire region is 82.8 and 52.8°F, with higher elevation areas in the east having a cooler climate than the rest. Precipitation in the region coincides with the elevation as the eastern portion of the region receives an annual 10-30 inches of rain while the western portion receives 0.01-10 inches of rain per year.

DEMOGRAPHICS

*All demographic statistics are based on the United States Census Bureau 2020 Decennial Census.

The demographics of Arizona will be presented in a manner that highlights vulnerable populations, as social vulnerability is a concern that must be addressed throughout all phases of emergency management. Various population groups have different capacities, capabilities, concerns, and needs, all of which need to be considered in order to promote mitigation and create resilient communities. There are many different categories of vulnerable populations, but this Plan will only discuss the vulnerable populations of older adults above the age of 65, children below the age of 18, those living in poverty, and individuals with limited English proficiency.

Arizona is ranked as the thirteenth most populous state and is one of the fastest growing in terms of numeric and percentage population growth. Arizona's population has grown by 11.9% between 2010-2020; as of 2020, the population reached approximately 7.15 million. The growth rate can be partly attributed to an increased birth rate and Arizona being a retirement state. Arizona has an elderly population (65+) of 18.8% and an under the age of eighteen population of 21.6%.

The unique location of Arizona has created diversity, resulting in demographics that deviate from the national averages. An African American/Black population of 5.5%, a White/Caucasian population of 52.9%, and an Asian population of 3.9% are all lower than their national averages of 12.4%, 61.6%, and 6.0%, respectively. The State of Arizona is unique as it houses 22 sovereign Tribal Nations and borders the country of Mexico, both of which contribute to an increased prevalence of Hispanic/Latino and Native American population groups. Arizona's 32.5% Hispanic/Latino population and 5.2% Native American population are both significantly higher than their national averages of 18.7% and 1.1% respectively.

North Region

The North Region has a growth rate of approximately 5% and currently houses 10.96% of the state's population with 783,884 residents. The North Region is the smallest in terms of population size but has the highest population concentrations of White/Caucasians (62.9%), Native Americans (4.4%), elderly (26.8%), and individuals living in poverty (19.7%). Conversely, the North Region has the lowest population concentrations of Black/African Americans (1.2%), Hispanic/Latinos (8.35%), Asians (1.15%), and individuals under the age of eighteen (18.5%).

Central Region

The Central Region has a growth rate of approximately 13% and currently houses 68.5% of the state's population, with 4,899,104 residents. The fast growth rate can be observed, in part, by a high concentration of individuals under the age of eighteen (2.3%) and a low concentration of elderly (16.8%) persons. The Central Region represents the majority of the population, and the population concentrations of the region are similar to that of the state's overall demographics. The region has the lowest poverty rate (11.3%), with a population that consists of 53.2% White/Caucasian, 6.7% Black/African American, 31.9 % Hispanic/Latino, 3.4% Native American, and 4.6% Asian.

South Region

The South Region has a growth rate of approximately 4.6% and currently houses 20.53% of the state's population with 1.468.526 residents. The region has a unique demographic as the minority groups are the majority and make up 50.4% of the population. The region has a poverty rate of 20.9% with a population that consists of 46.4% White/Caucasian, 4.0% Black/African American, 43.5% Hispanic/Latino, 4.0% Native American, and 2.9% Asian. The region has an 21.1% elderly population and a 20.9% population of individuals below the age of eighteen.

ECONOMY

Gross domestic product (GDP) is the monetary value of goods and services produced within a country's or state's borders in a specific time frame. GDP includes all private and public consumption, private inventories, government outlays, investments, paid-in construction costs, and the balance of exports and imports. Arizona's GDP is $459.0 billion in 2022, ranked 18th among all states. In 2022, the top five industries were, in order:

1. Finance, insurance, real estate, rental and leasing;
2. Professional and business services;

3. Government and government enterprises;
4. Educational services, health care, and social assistance; and
5. Manufacturing.
6. The housing market and employment rates are also indicators of economic health. These aspects are discussed on a regional basis, focusing on each region's largest population center.

North Region

In 2023, Flagstaff saw the nonfarm payroll jobs increase by 2,400, or 3.5%, to 68,900 jobs. Additionally, the unemployment rate in Flagstaff rose from 3.9% to 4.8% in 2023. The sales housing market conditions are considered slightly tight, with a 2016 vacancy rate of 2.7%, and housing demands are expected to increase in the coming years. The current and future vacancies will satisfy the projected housing demand increase.

Central Region

The nonfarm payroll jobs of Phoenix, Scottsdale, and Mesa increased by 56,200, or 2.5%, to 2.34 million in 2023. The unemployment rate for the same three cities in the Central Region rose from 2.9% to 3.9%. The sales housing market was considered slightly tight, with a vacancy rate decrease from 4.3% to 1.8%. Housing demands are expected to increase in the future to more than 83,500 unit sales. There are approximately 9,125 units under construction, which will meet a portion of the housing demand.

South Region

Tucson saw the nonfarm payroll job increase by 6,200, or 1.6%, to 388,700 jobs. Nonfarm payroll jobs have surpassed the prerecession high of 385,600 jobs in 2007. The unemployment rate in Tucson rose from 3.2% to 4.4% in 2023. The sales housing market conditions are slightly tight as of July 2022, with an estimated vacancy rate of 1.4%, down significantly from 2.9% in April 2010. Home sales and prices rose 17% and 19% during the 12 months ending July 2021. During the next three years, demand is estimated for 10,550 new homes. The 2,700 homes currently under construction will satisfy a portion of that demand.

REFERENCES

Desert Research Institute, (n.d.). *Climate of Arizona.* Desert Research Institute, https://wrcc.dri.edu/narratives/ARIZONA.htm

Dimmitt, M. (2018). *Biomes & Communities of the Sonoran Desert Region.* Arizona Sonora Desert Museum, http://www.desertmuseum.org/books/nhsd_biomes.php

National Weather Service, (2017). *Advanced Hydrologic Prediction Service.* National Oceanic and Atmospheric Administration, http://water.weather.gov/precip/

Slutsky, A. (2015, June 18). Monsoon Brings Variable Weather to Arizona. Department of Emergency and Military Affairs.

United States Environmental Protection Agency (EPA), 2023, Ecoregions of North America, https://www.epa.gov/eco-research/ecoregions-north-america

United States Census Bureau, (2016, December 20). *Utah is Nation's Fastest-Growing State, Census Bureau Reports. United States Census Bureau*, https://www.census.gov/newsroom/press-releases/2016/cb16-214.html

United States Census Bureau, (2023). *Quick Facts.* US Department of Commerce, https://www.census.gov/quickfacts/fact/table/yavapaicountyarizona,AZ/PST045216

SECTION 3: PLANNING PROCESS

PLANNING TEAM AND ACTIVITIES

The planning effort for the 2023 Plan update began in 2022 when DEMA/EM began reviewing areas of the Plan to update and applied to the FEMA Hazard Mitigation Grant Program (HMGP) for funding to hire a contractor to assist in a complete update of the Plan. DEMA/EM was awarded FEMA HMGP funding in early 2023 and contracted with JE Fuller in March 2023 with a project contract completion date of October 2023. DEMA/EM began public outreach of the upcoming update late in 2022 through the quarterly DEMA/EM Preparedness Newsletter sent to local partners, state agencies, tribal EMs, and stakeholders. DEMA/EM also posted a notification and a copy of the Plan through its website. The entire update process for this Plan took approximately one year, with the last seven months involving the planning team, partners, stakeholders, and subject matter experts (SMEs).

For this Plan update, DEMA/EM created a core planning team consisting of the DEMA/EM Planning Branch and JE Fuller. An extended planning team (planning team) consisting of the core planning team, various SMEs, partners and other stakeholder agencies was also formed. The core planning team was responsible for the overall design and development of this Plan, while the SMEs served as decision-makers and provided information that formed and guided the development of the hazard profiles and mitigation strategy. The core planning team communicated regularly with SMEs via phone, virtual meetings, and email to obtain hazard information regarding the history, location, extent/severity, future conditions, and how to map the hazards most effectively. Some state agency SME's also provided mitigation action assessments, capabilities, and new mitigation action. For example, the Arizona Geological Survey (AZGS) was one of the SMEs on the planning team that provided information to develop the earthquake, fissure, landslide, and subsidence hazard profiles. Four virtual planning team meetings were held to discuss and gain consensus on the vision of this Plan, potential changes, and the importance of having a plan that can increase resiliency through the reduction and/or elimination of a hazard's impacts. The first virtual planning team meeting was a kickoff in April 2023, and the last was in June 2023. Afterwards, the planning team reviewed the Plan to ensure accuracy and completeness and make last-minute changes. Meeting notes, slide decks, and planning team attendee lists for each of the four meetings are included in Annex A. Milestones and activites are documented in the Annex A materials.

The core planning team worked on one hazard at a time, gathering information and data from SMEs and other sources to compile a hazard profile. The DEMA/EM Planning Branch first reviewed the compiled hazard profiles for completeness and accuracy before sending them to the SMEs for their review and approval.

Ms. Alexandria "Daisy" Maese, DEMA/EM Planning Branch Manager, led the planning team and effort to review, update, and redesign this Plan. DEMA/EM recognizes the importance and necessity of building a planning team comprising various stakeholders and subject matter experts from different sectors. For the Plan update, DEMA/EM sent email invitations to stakeholders statewide requesting their participation in the planning process. This included, but was not limited to, the DEMA/EM Non-governmental Organization and Private Sector Liaison, the AZ

Department of Transportation (ADOT), the AZ Department of Economic Security(AZDES), the AZ Department of Homeland Security (ADOHS), the AZ Department of Gaming, the AZ Statewide Independent Living Council (AZSILC), the AZ Department of Administration (ADOA), the AZ Department of Agriculture(AZDA), the AZ Department of Land Management (ASLD), the AZ Department of Health Services (ADHS), the AZ Geological Survey (AZGS), the DEMA/EM Tribal Liaison, the AZ Department of Environmental Quality (ADEQ), the AZ Department of Water Resources (ADWR), the AZ Department of Forestry and Fire Management (AZDFFM), the National Weather Service (NWS), Arizona State University (ASU), ASU Office of Climatology (State Climatologist) and the DEMA/EM Infrastructure Coordinator. Most invitees were able to participate in the planning effort to varying degrees depending upon their subject matter expertise and availability.

With this update, a particular focus was spent consulting and coordinating with agencies and organizations with climate change and climate adaptation expertise (ASU, NWS, and State Climatologist), state agencies with programs, policies, and assistance that support underserved communities (ADHS, ADOA, AZSILC, AZDES, etc.) and other representatives serving these communities to augment the climate change assessments and address the socially vulnerable and underserved communities. Multiple meetings were convened with these groups specifically to discuss and address these areas.

Although the listed planning team participants for this Plan update are limited, the overall breadth and depth of the planning team was extensive. The identified SMEs served as representatives of their respective agencies, and they often collaborated with other members of their agencies to make collective decisions and to gather and provide the most accurate information. This process resulted in a structure that branched out and formed an extensive planning team network that encompassed various participants.

The planning team that generally participated on a semi-regular basis is listed in Table 1 sorted by first name in alphabetical order. Note that returning members from prior plan update cycles are in **bold** text.

Table 1. Planning team for 2023 Plan update

Name	Agency/Organization	Roles/Responsibilities
Adriana Akinwande	DEMA/EM	Vulnerable Populations/Communities
Alexandria Maese	DEMA/EM	DEMA/EM Lead Planner and Project Manager
Andrew Traylor	DEMA/EM	Hazard Mitigation Assistance Grants & State Mitigation Program
Ann M. Youberg	**AZ Geological Survey**	**Earthquake/Fissure/Landslide/Subsidence Profiles**
Anthony Lythgoe	Arizona Department of Economic Security	Vulnerable Populations
April Lawless	AZ Dept of Health Services	Vulnerable Populations & Infectious Diseases Profile
Arcangel Barrangan	AZ Dept of Environmental Quality	HAZMAT & Terrorism Profiles
Bill Boyd	AZ Dept of Forestry & Fire Management	Wildfire Profile & State Land Information

Name	Agency/Organization	Roles/Responsibilities
Brian Cosson	**ADWR**	**AZ NFIP State Coordinator; Flood Profile; Mitigation Actions**
Carl Satterwaite	DEMA/EM	HAZMAT & Terrorism Profiles
Celine Sanchez	ADHS	Vulnerable Populations & Infectious Diseases Profile
Chris Stanton	USACE - Arizona Silver Jackets	Dam/Levee/Flood Profiles
Christopher Pittmann	DEMA/EM	Plan Review & Editor
Craig Sewell	Emergency Planning and Preparedness Administration - Office of Inspector General	Team Participant
David Carey	Arizona Statewide Independent Living Council	Access & Functional Needs Community
David Egliskis	AZ Dept of Transportation	Critical Infrastructure
David Roby	DEMA/EM	GIS Support & Critical Facilities
David Tenney	Arizona Game and Fish Department	Wildfire Profile & State Land Information
Don Weaver	**AZ Dept of Forestry & Fire Management**	**Wildfire Profile & State Land Information**
Duke Jones	**DEMA/EM**	**Public Assistance Program & Plan Review**
Dustin Kirk	DEMA/EM	Planning team participant
Dwayne Uhlig	AZ Dept of Agriculture	Agriculture Economic Impacts
Ericka Huston	DEMA/EM	Plan Review & Editor
Erik Lohman	**AZ Dept of Administration**	**Critical Facilities & Mitigation Actions**
Erinanne Saffell	ASU Climate Office	Future Conditions
Fernando Careaga	Bureau of Public Helath Emergency Preparedness	SME and Mitigation Actions
Gabriel Wright	DEMA/EM	Vulnerable populations/communities
Jesse Robinson	DEMA/EM	Terrorism Profile and Mitigation Actions
Jill Miller	DEMAEM	HAZMAT & Terrorism Profiles
John Mure	DEMA/EM	Public Assistance Program
Karl Gehrke	**AZ Dept of Forestry & Fire Management**	**Wildfire Profile & State Land Information**
Keith Krukowski	ADWR	Flood SME
Laura Malone	AZ Dept of Environmental Quality	HAZMAT & Terrorism Profiles
Maren Mahoney	Arizona Governor's Office - Office of Resiliency	Vulnerable Populations/Communities
Mary Evans	JE Fuller	Hired Contractor
Melanie Gall	ASU Emergency Management	Drought/Severe Wind/Extreme Heat/Winter Storm Profiles
Melissa Guardaro	ASU	Drought/Extreme Heat Profiles
Michael Stidham	AZ Dept of Homeland Security	Terrorism Profile and Mitigation Actions
Mike Hammarstorm	DEMA/EM	Planning Team Participant
Mike Shelton	**AZ Dept of Water Resources**	**Dam/Levee/Flood Profiles & NFIP/CRS/RL/SRL Info**
Mikya Assefa		State Owned Facilities
Morgana Laurie	DEMA/EM	DEMA/EM GIS to support with facility locations.
Paul Rosevear	DEMA/EM	DEMA/EM GIS to support with facility locations.
Ravi Murthy	**AZ Dept of Water Resources**	**Dam/Levee/Flood Profiles**

Name	Agency/Organization	Roles/Responsibilities
Raychel Miranda	DEMA/EM	HAZMAT & Terrorism Profiles
Rikki Sechrist	ADEQ	HAZMAT Profile
Ruth Penn	AZ Dept of Health Services	Infectious Diseases & Vulnerable populations
Scott Ogden	**JE Fuller**	**Hired Contractor**
Sonia Carpena	DEMA/EM	HAZMAT & Terrorism Profiles
Stephanie Miller	Arizona Statewide Independent Living Council	Access & Functional Needs Community
Tom Frieders	National Weather Service	Climate Info: Severe Wind/Winter Storm/Drought/Flood Profiles
Travis Schulte	DEMA/EM	Tribal Information

It was noted by several participants on the Planning Team, that the update of the Plan coincided with several other planning efforts that are either led by an Arizona state agency, or are part of a larger regional/national effort that an Arizona state agency is participating in. Examples listed by Arizona state agency are summarized in Table 2.

Table 2. Coincident state planning efforts

State Agency	Coincident Planning Effort
AZGS	• USGS led update to national shakemaps • Post-Fire Debris Flow Planning Studies for several AZ counties
ADHS/ADOA/ASU	• Broadband/Digital Equity Planning (cooperation on defining socially vulnerable/underserved community profiles for the state).
AzDFFM	• Statewide Fire Risk Update
AZ DEMA	• Update to the 2019 Arizona State Emergency Response and Recovery Plan
AZ Governor’s Office of Resiliency	• Develop an Extreme Heat Preparedness Plan by March 2024.

SECTION 4: RISK ASSESSMENT

OVERVIEW

The purpose of the risk assessment is to identify and characterize Arizona's hazards, determine which regions are most vulnerable to each hazard, and estimate potential losses to vulnerable state facilities from those hazards. Elements of the risk assessment are generally summarized in the following sections.

HAZARD IDENTIFICATION

General

The hazards identified in the 2018 Plan were closely examined and screened by the Planning Team using the following considerations:

- Prior knowledge of the relative risk associated with each of the hazards;
- Information from the hazard event datasets, including any recent events occurring within the current plan update cycle;
- Comparison to risk assessment outcomes identified in local jurisdiction plans;
- The ability to effectively mitigate the hazard;
- The known or expected availability of information on the identified hazard;
- Duplication of the hazard's risk in other hazard definitions; and
- Whether or not the hazard is already being sufficiently addressed through other planning efforts of the state.

Profiled Hazards

The Planning Team reviewed the 2018 State Plan hazards, as well as the profiles and historic hazard events summarized in each of the 15 county-based multi-jurisdictional hazard mitigation plans (herein referred to as county plans), to inform on the list of hazards profiled and assessed in this Plan. The county plan data provides information from a local perspective that aids in identifying and screening hazards to determine statewide risk. The presumption is that the importance given to hazards by local communities can inform the prioritization of hazards at the state level. According to the county plans, the top hazards predominately and consistently identified were:

- Drought
- Extreme Heat
- Flooding
- Severe Wind
- Wildfires

The following list of hazards represents the result of the Planning Team's review and screening/identification process. The profiling and vulnerability assessment sections in the following pages address each hazard in detail. The top five hazards taken from the county plans are supportive of the hazards the Planning Team determined as the most important statewide:

- Dam Failure
- Drought
- Earthquake
- Extreme Heat
- Fissure
- Flooding
- Hazardous Materials Incidents
- Infectious Disease
- Landslide
- Levee Failure
- Severe Wind
- Subsidence
- Terrorism
- Wildfires
- Winter Storm

CLIMATIC EFFECTS

FEMA issued new state mitigation planning guidance in April 2022[1] that continues the requirement for all state hazard mitigation plans to address climate change as part of plan updates. FEMA's National Advisory Council noted that the effects of climate change could manifest as a "threat multiplier." When looking at potential exposure to hazard events, it is typical to look at the past probability of the event occurrence as a predictor of the future risk. However, climate-related trends may affect these future event probabilities and the effectiveness of mitigation measures.

While the scope and severity of these climate-related impacts are difficult to predict, scientific research has pointed to several important trends that should be considered as part of a natural hazard vulnerability and risk analysis. In 1989, the U.S. Global Change Research Program (USGCRP) was established by Presidential Initiative and later mandated by Congress in the Global Change Research Act of 1990 with the stated purpose of assisting "the Nation and the world to understand, assess, predict, and respond to human-induced and natural processes of global change." In November 2018, the USGCRP released the Fourth National Climate Assessment (NCA), a comprehensive compilation of the latest body of work and science on climate change. The NCA results and discussion are divided into regions to focus the discussions and conclusions from a regional perspective. The Southwest region includes the states of Arizona, California, Colorado, Nevada, New Mexico, and Utah. According to Chapter 25 of the NCA[2], the Southwest regional climate change impacts noted in the recent research include increased heat, drought, and insect outbreaks that result in more wildfires, declining water supplies, reduced agricultural yields, health impacts in cities due to heat, and flooding and erosion in coastal areas. Further detail and discussion of climate change impacts on the Plan hazards are included in the following hazard subsections.

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[1] FEMA, 2022, State Mitigation Planning Policy Guide, FP 302-094-2, released April 19, 2022 and effective April 19, 2023.

[2] Gonzalez, P., G.M. Garfin, D.D. Breshears, K.M. Brooks, H.E. Brown, E.H. Elias, A. Gunasekara, N. Huntly, J.K., Maldonado, N.J. Mantua, H.G. Margolis, S. McAfee, B.R. Middleton, and B.H. Udall, 2018: Southwest. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 1101–1184. doi: 10.7930/NCA4.2018.CH25. On the Web: https://nca2018.globalchange.gov/chapter/southwest

ARIZONA REGIONS

Hazard vulnerability and risk in this Plan is presented and summarized at a regional level. The regional boundaries are based on DEMA/EM's Field Operations Regions, which use county boundaries to define the region. The vulnerability and impact of each Plan hazard is summarized by these three regions. Counties that comprise each region are as follows. See Map 1 for a graphic illustration.

- **North Region –** Apache, Coconino, La Paz, Mohave, Navajo, and Yavapai Counties;
- **Central Region-** Gila**,** Maricopa, and Pinal Counties; and
- **South Region-** Cochise, Graham, Greenlee, Pima, Santa Cruz, and Yuma Counties.

SOCIALLY VULNERABLE / UNDERSERVED COMMUNITES

Added focus on achieving equitable outcomes through the mitigation planning process for all communities in the state is now included as a new requirement in the recent FEMA planning guidance. The State of Arizona is committed to reducing risk statewide for all communities and improving access to mitigation assistance for populations and communities that may otherwise face social or financial barriers.

Several federal agencies have been developing social vulnerability indexes using statistics compiled from U.S. Census Bureau and American Community Survey datasets in response to recent Executive Orders issued by the White House in the last few years[3].

The Center for Disease Control and Prevention's (CDC) Agency for Toxic Substances and Disease Registry (ATSDR), Geospatial Research, Analysis, & Services Program (GRASP) created a Social Vulnerability Index (SVI)[4] to help public health officials and emergency response planners identify and map the communities that will most likely need support before, during, and after a hazardous event. The SVI data has been spatially compiled to U.S. Census Tract boundaries and ranks the tracts on 16 social factors, including unemployment, racial and ethnic minority status, and disability. Rankings are based on percentile estimates or flag counts and are relative to the state's data only. Percentile ranking values range from 0 to 1, with higher values indicating greater vulnerability. Tracts in the top 10% (i.e., at the 90th percentile of values) are given a flag value of 1 to indicate high vulnerability. Tracts below the 90th percentile are given a flag value of zero.

The data is also aggregated into four theme-related subgroups, each with its rank values and a final overall index value for the full data set. Thus, each tract receives a ranking for each Census variable, for each of the four themes, and a final overall ranking.

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[3] EO 13985 on Advancing Racial Equity and Support for Underserved Communities Through the Federal Government (January 2021), EO 14008 on Tackling the Climate Crisis at Home and Abroad (January 2021), and the Justice40 Initiative (guidance issued July 2021).

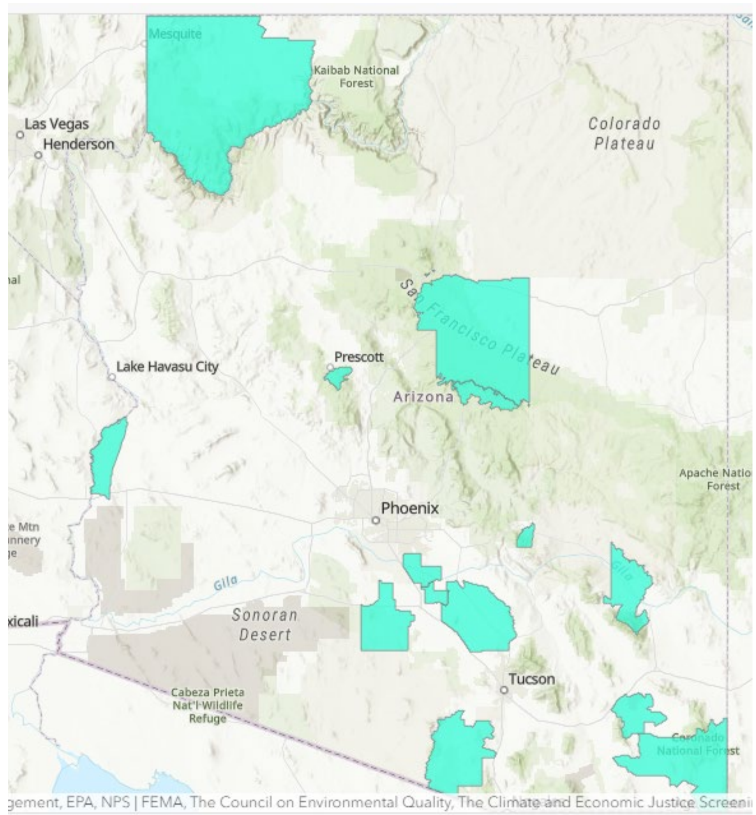
[4] Data and documentation can be accessed at the following URL: CDC/ATSDR Social Vulnerability Index (SVI)

Tract level data for each of the 16 social factors were derived from the American Community Survey (ACS), 2016-2020 (5-year) data statistics. A graphical summary of the 16 factors and 4 themes is illustrated in Figure 2.

Two maps presenting the SVI percentile and flag count rankings for each of the Census Tracts within the state are shown on Map 3 and Map 4.

In December 2022, the Community Disaster Resilience Zones (CDRZ) Act was signed into law, amending the Robert T. Stafford Disaster Relief and Emergency Assistance Act and requiring FEMA to utilize a natural hazard risk assessment index to identify census tracts which are most at risk from the effects of natural hazards and climate change. The zones are defined by Census Tract and are qualified by one or more of the following criteria:

- The composite National Risk Index[5] score ranks in the top 50 nationally or in the top 1% within their state.
- Is identified as a disadvantaged community by the Climate & Economic Justice Screening Tool[6].



As of this Plan, 14 zones have been identified for Arizona[7] in the first designation effective September 6, 2023, and can be seen graphically to the right and on the CDRZ tool at [Home | FEMA Community Disaster Resilience Zones (arcgis.com)](). A second designation for tribal lands and territories will be in Fall 2023.

[5] For more information on the National Risk Index, see: National Risk Index for Natural Hazards | FEMA.gov

[6] For more information on the Climate & Economic Justice Screening Tool, see: Climate and Economic Justice Screening Tool | U.S. Climate Resilience Toolkit

[7] For more information on the CDRZ, see: Community Disaster Resilience Zones | FEMA.gov

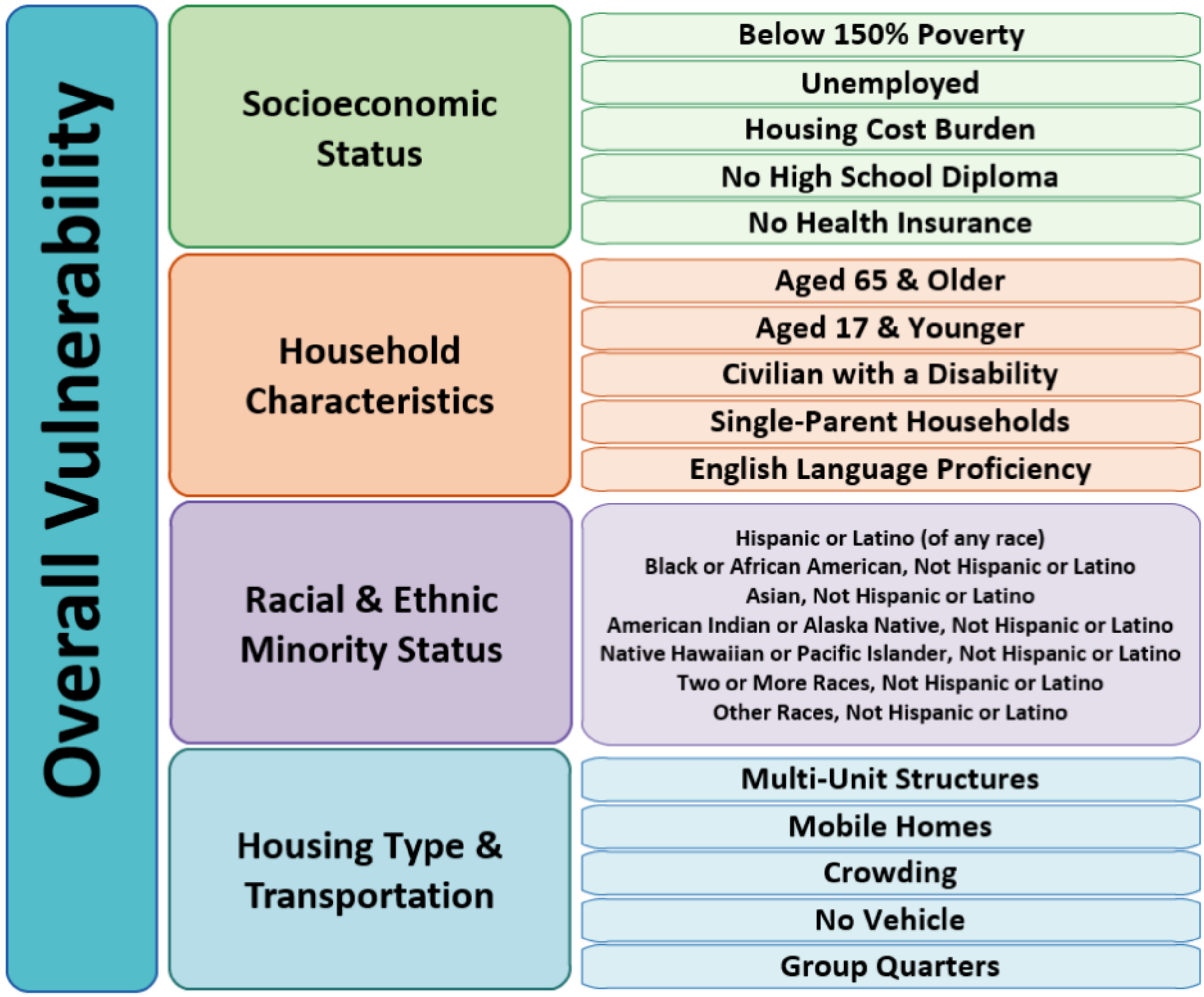
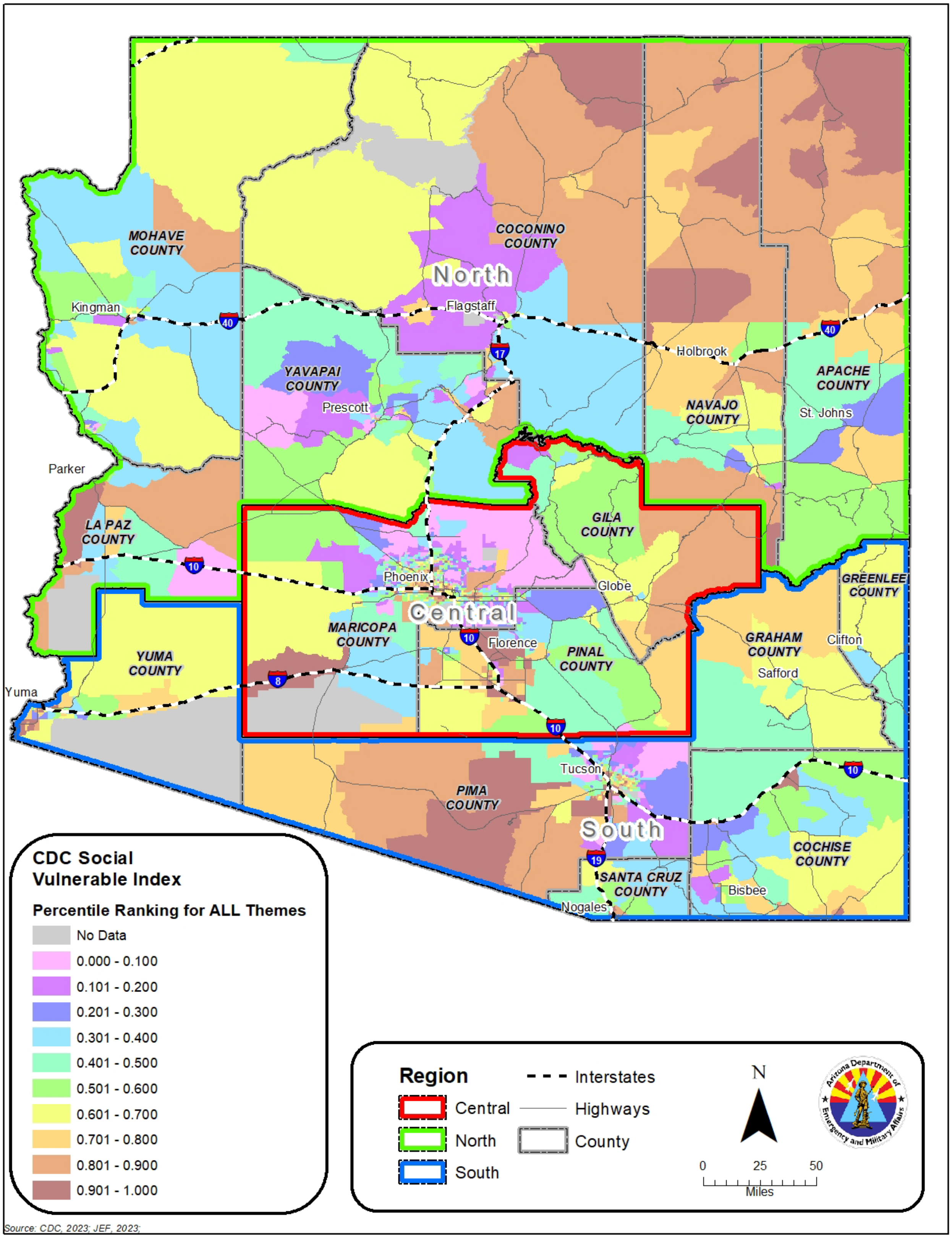
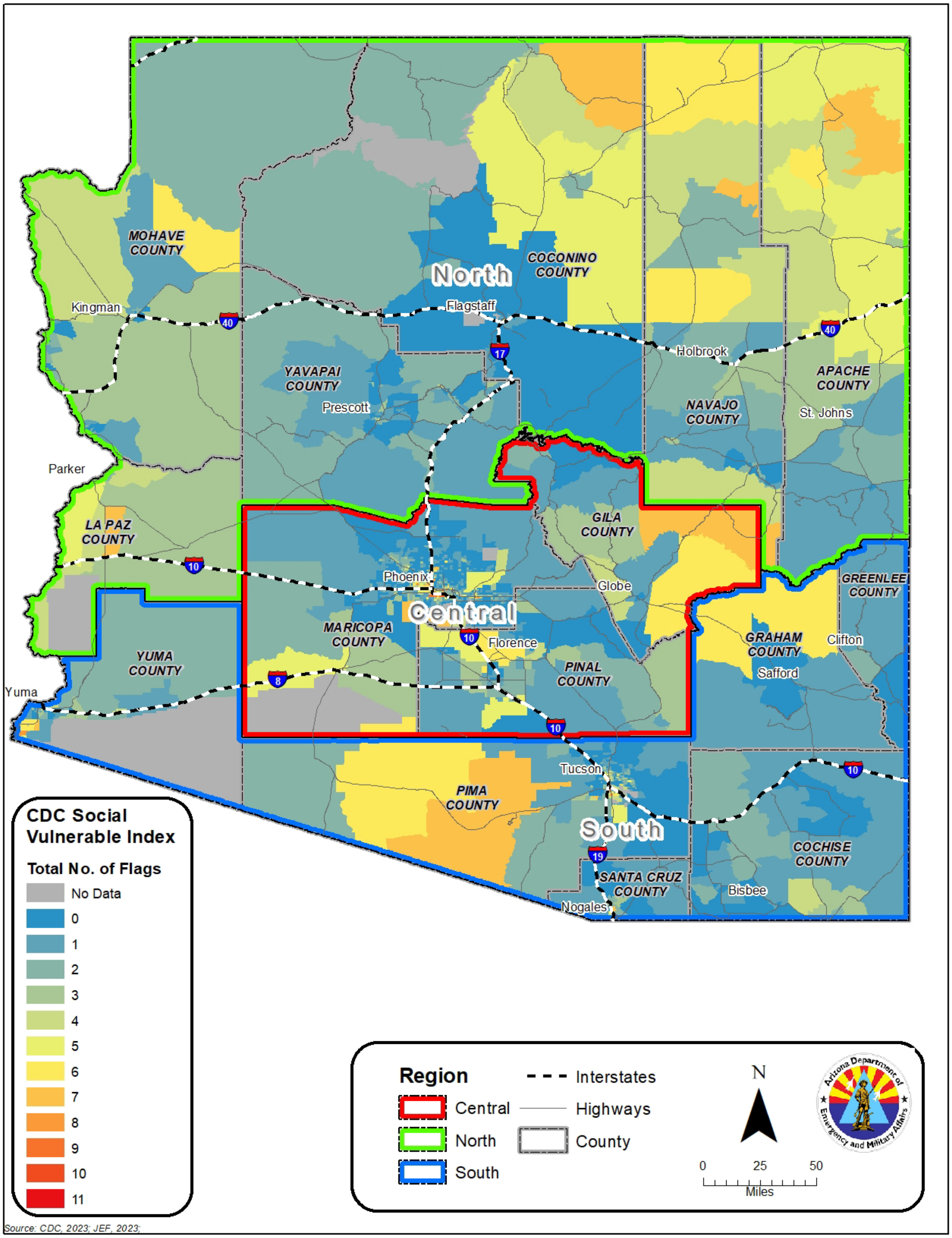


Figure 2. Graphic of SVI social factors and themes

It is understood that use of Census Tracts as a geographic unit to fully capture social vulnerability is limited in value, since Census tracts are designed to be (generally) homogenous with respect to demographic conditions and, while data at the block group or census block may be more appropritate, is not always appropriate or available for rural areas. As more data becomes available, future abilities to do a better job at capturing SVUC vulnerabilities is anticipated.



Map 3. SVI percentile ranking for all themes



Map 4. SVI flag counts for all themes

State Asset Inventory

The Planning Team adopts the following definition for the state's asset inventory for this Plan update: Any natural or man-made feature that has value including, but not limited to, people; buildings; lifeline infrastructure like bridges, roads, and sewer and water systems; electricity, gas, and communication resources; medical and emergency response facilities, educational facilities,or environmental, cultural, or recreational features like parks, dunes, wetlands, or landmarks.

State-Owned Structural Assets

Critical facilities and infrastructure are those systems within the state whose incapacity or destruction would have a debilitating impact on the state's ability to recover following a major disaster or to defend the people and structures of the state from further hazards. The seven general categories that define critical facilities and infrastructure for this plan are defined in Table 3.

Table 3. Critical facilities and infrastructure categories

Asset Type	Description
Communications Infrastructure	• Fiber optic lines • Radio, cellular, and microwave towers • Large, trunk-line cables, switch offices
Electrical Power Systems	• High voltage transmission lines • Transform substations, generation stations
Gas and Oil Facilities	• Conveyance or delivery pipelines • Major storage locations (10,000 gallons or larger) • Production facilities, refineries • Natural gas pipelines (4-inch and larger) • Fuel and oil dispensing locations owned by the state
Transportation Networks	• Interstates, US or state highways, major local arterial roadways • Railways, rail yards, train depots • Airports • Major bridges, culverts, and storm drains that protect transportation infrastructure
Water Supply Systems	• Water treatment plants, sewer treatment plants, water supply wells/reservoirs • Primary delivery pipelines (10-inch and larger) • Booster or pump stations • Storage tanks, water towers
Government Services	• City, county, and state administrative buildings • Facility yards • Military bases, correctional facilities • Emergency operation centers, IT support centers

Asset Type	Description
Emergency Services	• Fire, police, and sheriff stations • Hospitals, trauma or urgent care centers • Evacuation centers, ambulance centers

State-owned structures and buildings compiled for the asset inventory were updated using a GIS database provided by the Arizona Department of Administration (ADOA) and updates to the dataset used in the 2018 Plan. The Planning Team further parsed and attributed the ADOA data to categorize each facility into one of the types listed in Table 3 or as “other” facilities. A total of 4,227 critical structures and facilities were identified an detailed by region in Table 4 below.

Table 4. Summary of facilities statewide and by Region

State Facility Type	North Region	Central Region	South Region	Total
Communications Infrastructure	33*	13	22	68*
Electrical Power Systems	6	19	3	28
Emergency Services	102	143	29	274
Gas and Oil Facilities	30	29	14	73
Government Services	990	1,598	993	3,581
Transportation Networks	1	9	1	11
Water Supply Systems	105	60	27	192
Other Facilities	1,010	1,741	1,017	3,768
* One facility is located outside the state boundary				

Replacement values for ADOA facilities were either assigned directly from the original ADOA data or calculated using the facility’s building size estimate and an assumed unit replacement cost of $300 per square foot for the structure and contents.

Human Assets

Human assets include the entire statewide population. In addition to the SVUC indexing, several subsets of the population are individually evaluated in this Plan update includingolder adults over the age of 65, children below the age of 18, and individuals below the federal poverty level.

Spatial data for analyzing human vulnerability are the Census Tract values included with the CDC SVI database and represent the ACS, 2016-2020 (5-year) data statistics. Table 5 summarizes the CDC SVI population’s statistics by state and region that form the basis of the human asset database.

Table 5. Human asset statistics by Region and statewide

Region	Population			
	Total	17 and Younger	65 and Older	150 % of Poverty Level
Central	4,987,549	1,032,550	797,381	1,176,871
North	764,112	217,952	187,791	149,751
South	1,422,403	374,952	277,032	313,023
State Totals:	7,174,064	1,625,454	1,262,204	1,639,645

State Loss Estimation

The estimation of potential losses is expressed in terms of population exposure and dollar losses due to damage to state-owned facilities and infrastructure. Wherever possible, a quantitative approach was used. The assessment for each hazard is typically based on a commonly accepted event type, such as a 100-year flood or a National Weather Service severe thunderstorm. The vulnerability assessment builds upon the hazard profile information by intersecting the state-owned assets and population estimates with the hazard profile data to generate a list of exposed assets. Exposure to loss ratios are then applied to estimate the potential amount of damage/loss that could be caused by each hazard event to state-owned critical facilities and infrastructure.

Some of the hazards profiled in this Plan will not include quantitative exposure and loss estimates. The vulnerability of people and state-owned facilities/infrastructure associated with some hazards is nearly impossible to evaluate, given the uncertainty associated with where these hazards will occur. Instead, a qualitative review of vulnerability will be discussed to provide insight into the nature of losses that are associated with the hazard.

The following are summaries of the data included and updated in the vulnerability analysis section of each hazard profile, as appropriate. A description is provided for each table that details the update process and the steps taken to develop the data.

State-Owned Asset Loss Estimates by Region

Exposure and loss estimations for state-owned structures and facilities located within geospatially definable risk zones for hazards, such as flooding, wildfire, earthquake, fissure, subsidence, and dam/levee inundation zones, are estimated using GIS tools and methods. For other hazards with non-definable or uncertain risk extents, it is assumed that all state-owned facilities are equally exposed unless otherwise noted.

Where appropriate, loss estimates for state-owned structures and facilities are estimated by applying a loss ratio to the replacement values. Loss ratios, when used, are described and summarized within the hazard section. Losses are then aggregated by region. Where estimations of losses are not appropriate, aggregated exposure values will be reported.

Population Sector Exposure Estimates

Estimates of human populations exposed to the Plan hazards identified within geospatially definable risk zones are estimated using GIS tools and methods. For other hazards with non-definable or uncertain risk extents, it is assumed that all population sectors are equally exposed unless otherwise.

Socially Vulnerable/Underserved Community (SVUC) Assessment

An assessment of the hazard risk and impact on SVUC populations is performed for each hazard addressed in this plan using either geospatial analysis or a subjective discussion.

For hazards with GIS mappable hazard areas (flooding, for example), the CDC SVI data is intersected with the hazard mapping to quantify the area of the Census tract situated within a hazard area, if at all. The assigned CDC SVI values for the hazard intersected tract areas were then used to aggregate the intersected areas to five SVI percentile ranges of 0 to 0.25, 0.25 to 0.5, 0.5 to 0.75, 0.75 to 0.90, and 0.9 to 1.0[8]. The intersected tract areas were then summed for each range and divided by the total to obtain a percentage of impact. This was done for each combination of hazard category (high, medium, etc.) and Region (North, Central, South) of the state. The SVI data evaluated included the four aggregated themes shown in Figure 2 and the overall SVI that reflects all 16 variables in the CDC dataset. The results are all compiled into one table for each hazard and category and included in the vulnerability assessment portion of each hazard profile.

Changes in Development

Development changes over the last 5-years have been moderate across the state in response to a steady growth in jobs, capital expenditures, and wages. There is also significant variability across the state in the rate of growth. Using population estimates published by the Arizona Commerce Authority[9] as a general indicator of growth, Table 6 summarizes the average 5-year growth for each Arizona county.

Table 6. Population estimates and 5-year growth percentage by county

County	Region	Population Estimate					5-yr Growth
		2018	2019	2020	2021	2022	
Apache	North	67,932	65,907	66,050	66,411	66,848	**-1.60%**
Cochise	South	125,374	125,253	125,718	126,463	126,648	**1.02%**
Coconino	North	144,982	146,611	145,697	147,434	149,647	**3.22%**
Gila	Central	53,311	53,321	53,303	53,525	53,838	**0.99%**
Graham	South	38,057	38,397	38,635	39,025	39,010	**2.50%**
Greenlee	South	9,717	9,505	9,562	9,593	9,652	**-0.67%**
La Paz	North	17,043	16,680	16,587	16,820	16,860	**-1.07%**
Maricopa	Central	4,293,823	4,366,987	4,436,704	4,507,419	4,586,431	**6.81%**
Mohave	North	208,393	211,782	213,985	216,527	221,105	**6.10%**

[8] Note that the SVI percentile range of 0.9 to 1.0 is the same criteria used by CDC to assign a flag to census tract for high vulnerability.

[9] Web access at: [Population Estimates (azcommerce.com)]

County	Region	Population Estimate 2018	2019	2020	2021	2022	5-yr Growth
Navajo	North	107,423	106,868	106,769	107,748	108,580	**1.08%**
Pima	South	1,028,511	1,038,205	1,045,589	1,058,318	1,072,298	**4.26%**
Pinal	Central	409,472	419,310	428,220	439,128	453,924	**10.86%**
Santa Cruz	South	47,569	47,707	47,787	48,468	49,039	**3.09%**
Yavapai	North	229,607	233,104	237,073	241,173	245,389	**6.87%**
Yuma	South	201,032	202,457	204,722	207,318	209,920	**4.42%**
Arizona	**(all)**	**6,982,246**	**7,082,093**	**7,176,401**	**7,285,370**	**7,409,189**	**6.11%**

Arizona currently has the 2nd highest statewide population growth in the nation, with the majority of that growth occurring around or near the major population centers of each county at an average rate of 6.1% over the last five years. It is anticipated that the trends of the past five years are anticipated to continue or possibly slow over the next five years, with most of the growth continuing to concentrate around existing population centers. General growth-related descriptions by region are discussed below. Detailed hazard-related growth impacts are included in each hazard profile.

North Region

Apache, La Paz, and Navajo counties have experienced little to no significant growth, although some communities within those counties (Eager, Parker, Show Low, Snowflake, and Taylor) have experienced minor growth in primarily residential development. The remaining counties of Coconino, Mohave, and Yavapai Counties have experienced moderate growth with rates between 3% and 7%.

Central Region

Significant growth has occurred in Maricopa and Pinal counties over the past five years, with several communities leading the nation in growth. Most of the development changes are primarily in the continued build-out of previously planned residential, industrial, and commercial areas, although expansion of urban fringes has been increasing in the last couple of years. Growth in Gila County has been mostly limited to residential developments in the Payson and Star Valley areas.

South Region

Cochise and Greenlee counties have experienced little to no significant growth, with most changes due to small residential development areas. Graham, Pima, Santa Cruz, and Yuma Counties have experienced moderate growth of over 2.5%, with residential development being the greatest change and some industrial growth in the Pima, Santa Cruz, and Yuma areas. A continuation of the current growth trends is expected for all counties in the south region, primarily near or within the Tucson and Yuma Metropolitan areas.

Local Vulnerability Summary

All of Arizona's 15 counties have developed risk assessments in their local hazard mitigation plans that address their specific geographic areas. The results of these local risk assessments are summarized and, where appropriate, incorporated into the state-level vulnerability analysis. When the local plan data is not readily available, or the county did not assess a particular hazard, a "No Data Available" note is applied. This summary considers one or more of the following elements in the local county plans:

- Probability of the hazard occurring in the jurisdiction;
- Potential extent and severity of the hazard in the area;
- Size of the population at risk in the jurisdiction;
- Growth and development changes for the jurisdictions, especially in areas that may be affected by the hazard;
- Existence and location of large populations with special needs such as the elderly, young, those meeting the federal poverty level, and non-English speaking communities; and
- Critical facilities and infrastructure that are vulnerable to the hazard.

HAZARD PROFILES

The hazard profile section of the 2018 Plan was thoroughly reviewed and updated by the Planning Team as a whole and, specifically, by Planning Team members according to their area of expertise. The Planning Team contributed updated information to be used for the hazard mapping and profiling. The hazard profiles address the following:

- **Description** - A general description of the hazard characteristics on a statewide basis.
- **History** - Information about previous significant hazard and occurrences in Arizona.
- **Probability -** A description and classification of the hazard probability based on historic records and/or statistical analysis of past events.
- **Extent** - Extent is the expected range of intensity for each hazard. It answers, "How bad can it get?". Implementation of extent is accomplished through GIS depictions that overlay areal range with intensity.
- **Warning Time -** How much notice is there before an event.
- **Future Conditions** - This section will discuss how conditions may change in the future in relation to climate change and the built environment. It will discuss the effects these future conditions may have on the frequency of occurrence and severity of the hazard risk.
    - ***Climate Considerations*** – A regional based discussion of the potential for climate change impacts for the hazard being profiled.
    - ***Changes in Development*** - All three response regions (North, Central, and South) have a brief discussion of changes in development as they pertain to the hazard being assessed.
- **Profile Maps** - Maps to illustrate the historic probability and extent posed by the hazard. The following information is characterized on a map for each region:
    - Number of presidential and/or gubernatorial disaster declarations;

  - Recorded losses based on declaration data;
  - Historically most damaging event for that region; and
  - Rate of Occurrence/Probability - Data on the rate of occurrence each year is based on an average of listed declared events from DEMA/EM dating back to 1966.

- **Vulnerability Assessment -** All three response regions (North, Central, and South) have a brief vulnerability analysis description and summary for each hazard and are mapped. The vulnerability assessment, loss estimations, and loss-to-exposure ratios are mapped, discussed, and summarized by region, where appropriate. Each section discusses the following points:
  - ***State-Owned Facilities Exposure and Loss Estimates***
  - ***Vulnerable Population Groups*** – A discussion and a map of each region showing the impacts of the hazard in relation to the following population groups: Limited English Proficiency, residents over 65 years of age, residents under 18 years of age, and those meeting the federal income poverty level.
  - ***SVUC Impact Assessment*** – A summary of the SVUC impacts of each hazard risk category
  - ***Local Jurisdiction Vulnerability*** – A summary of the local plan vulnerability assessments for the counties within each region as depicted in the latest version of the county plans on record. It is noted that numbers reported are subject to the detail used by each county in their assessments if performed at all.

- **Vulnerability Maps**: Graphical presentations by region of the vulnerable assets. Information on the map includes:
  - Number of State-Owned Critical Facilities Exposed and Estimated Losses;
  - Population sectors exposed; and
  - Local jurisdiction critical facility exposure and/or loss estimates.

- **Specific Areas of Concern** – Discusses the highest vulnerability regarding specific communities and regions.

- **Resources** - Provides resources available for information on the hazard per the following sub-categories:
    - **Sources** – A listing of sources for further investigation and understanding regarding the hazard.
    - **References** – A bibliography of literature, website, agency, and other published data sources used to develop the hazard profile.

DAM FAILURE

Dams are structures that impound water above the natural prevailing grade using artificial structures such as earthen and/or rock embankments, concrete walls/structures, cement stabilized aggregate (CSA) or roller compacted concrete (RCC) embankments. Dams are normally constructed across or perpendicular to a watercourse (or watercourses) and will impound the intercepted water in a relatively static pool. The majority of dams in Arizona provide flood control, with many of the dams also serving as storage for irrigation and municipal water supplies. Several of the larger dams also provide hydro-electric generating capacity.

A dam failure results in an uncontrolled release of water to downstream areas, with potentially catastrophic impacts. Failures may be attributed to a variety of modes and causes. The three most common are foundation leakage and piping, overtopping, and spillway erosion. According to the National Research Council (NRC, 1983) these three modes have been responsible for 74% of the nation's historic dam failures.

Lynx Lake Dam and emergency spillway showing recent dam safety mitigation measures to raise the dam crest. *Source: JE Fuller, 2009*

Arizona's Dam Safety Program has existed since 1929. Funding for the program was minimal and sporadic until legislative approval of a consistent budget began in 1971, authorizing permanent staffing and the development of a comprehensive statewide Dam Safety Program.

The Arizona Revised Statutes (A.R.S.) §45-1201 assigns the responsibility for supervision of the safety of non-federal dams to the Director of the Arizona Department of Water Resources (ADWR). The mission of the ADWR Dam Safety Section is to maximize the protection of the public against loss of life and property by reducing the likelihood of catastrophic failure of dams within the state's jurisdiction. State statute defines a jurisdictional dam as an artificial barrier for the impounding or diversion of water either 25 feet or more in height or having a storage capacity of more than 50 acre-feet, with the following exceptions:

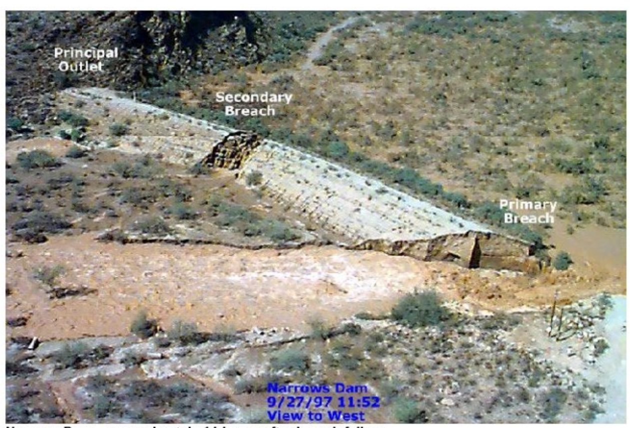
- Any barrier for the purpose of storing liquid-borne material (e.g., mine tailings dams);
- Any barrier that is a "release-contained barrier;"
- Any barrier that is federally owned and operated;
- Sole use transportation structures;
- Any barrier that is:
    - Less than six feet in height, regardless of storage capacity, or
    - Between six and 25 feet in height with a storage capacity of less than 50 acre-feet, or
    - Greater than 25 feet in height with 15 acre-feet or less of storage capacity.
- For an artificial barrier and/or appurtenant works structure to be considered a "release-contained barrier," following criteria should comply:

- Has storage capacity that in the event of failure would be contained within the property that the release-contained barrier owner owns controls, operates, maintains or manages.
- The property on which the release would be contained is not open to the public.
- Owner will maintain downstream containment structures or sites with sufficient containment throughout the useful life of the release-contained barrier.

HISTORY

The occurrence of dam failures has been limited in Arizona. Since 1966, there have been only three state declarations that directly pertained to dam related issues and no federal declarations. The following represent Arizona's historic dam failures or significant failure-threatening events that received a state declaration:

- July 25, 2021 – Millet Swale dam breached during a monsoon rain event. The breach appeared to start as a leak along a defect through the embankment and enlarged in size until a full-depth breach developed. This dam was previously classified as high hazard potential and unsafe by the Arizona Department of Water Resources. The dam breached under a relatively low reservoir level, and according to Navajo County officials, downstream road closures and evacuations were already in place because of the flooding from the monsoon storm and unrelated to the release from the reservoir. As a result, no fatalities or injuries were reported, and property damage from the dam breach was not significant.
- April 19, 2004 - A state declaration was made for River Reservoir No. 3 Dam in Apache County (one of the Greer Lakes) due to concerns over observed seepage and internal erosion. Increases in seepage flow and eroded embankment soils reached a magnitude that appeared to indicate an imminent failure was possible. The County Sheriff mobilized personnel to monitor the dam on a 24-hour basis to provide early warning of a dam failure and to facilitate the evacuation of residents in the threatened downstream communities. No failure occurred, and over the next year the reservoir was drained and the dam was repaired.
- September 1997 - Centennial Narrows Dam in Maricopa County failed due to flooding from Hurricane Nora. This failure is significant because the single-purpose flood control dam most likely failed due to piping flow through transverse cracks in the dam. There were no significant damages downstream. The dam remains breached and is no longer in service (FCDMC, 1997).



Narrows Dam – approximately 14-hours after breach failure.
Source: Flood Control District of Maricopa County, 1997

- September 1978 - A state declaration was made for responding to the potential failure of the Tsaile Dam on Navajo Nation upstream of Chinle, AZ and Canyon del Muerto in the Canyon de Chelly National Monument. Seepage from the dam was forming sink-holes on the downstream face. The dam was drained, and interim repairs were made in 1982 and 1983 (USBR, 2011). Full dam safety repairs and modifications were performed by the Navajo Nation and US Bureau of Indian Affairs with construction completed in late 2015.
- February 22, 1890 - The most significant dam failure experienced in the state occurred in Walnut Grove. The dam failed due to overtopping, and the ensuing flood caused an

estimated 150 deaths and extensive destruction of property. The failure was blamed on the inadequate capacity of the spillway and poor construction (DEMA/EM, March 1998). Located 30 river-miles north of Wickenburg on the Hassayampa River, the rockfill structure was 110 feet high, 400 feet long, had a base width of 140 feet, a top width of 10 feet, and a spillway of 5-20 feet long. The lake was 2.5 miles long by one-mile wide covering over 1,100 acres with an average water depth of 60 feet. The day before the breach, rain and snowmelt caused water in the lake to rise rapidly at a rate of about 1.5-feet per hour. A sheet of water three feet thick reportedly poured over the dam top for six hours. Between 1–2 am on February 22, 1890, the dam broke and the lake drained in less than two hours. The 80-foot wave front rushed down Box Canyon and reached Wickenburg, 30 miles downstream, in two hours. The flood-wave at Wickenburg was reported to be 40-foot high.

PROBABILITY/EXTENT

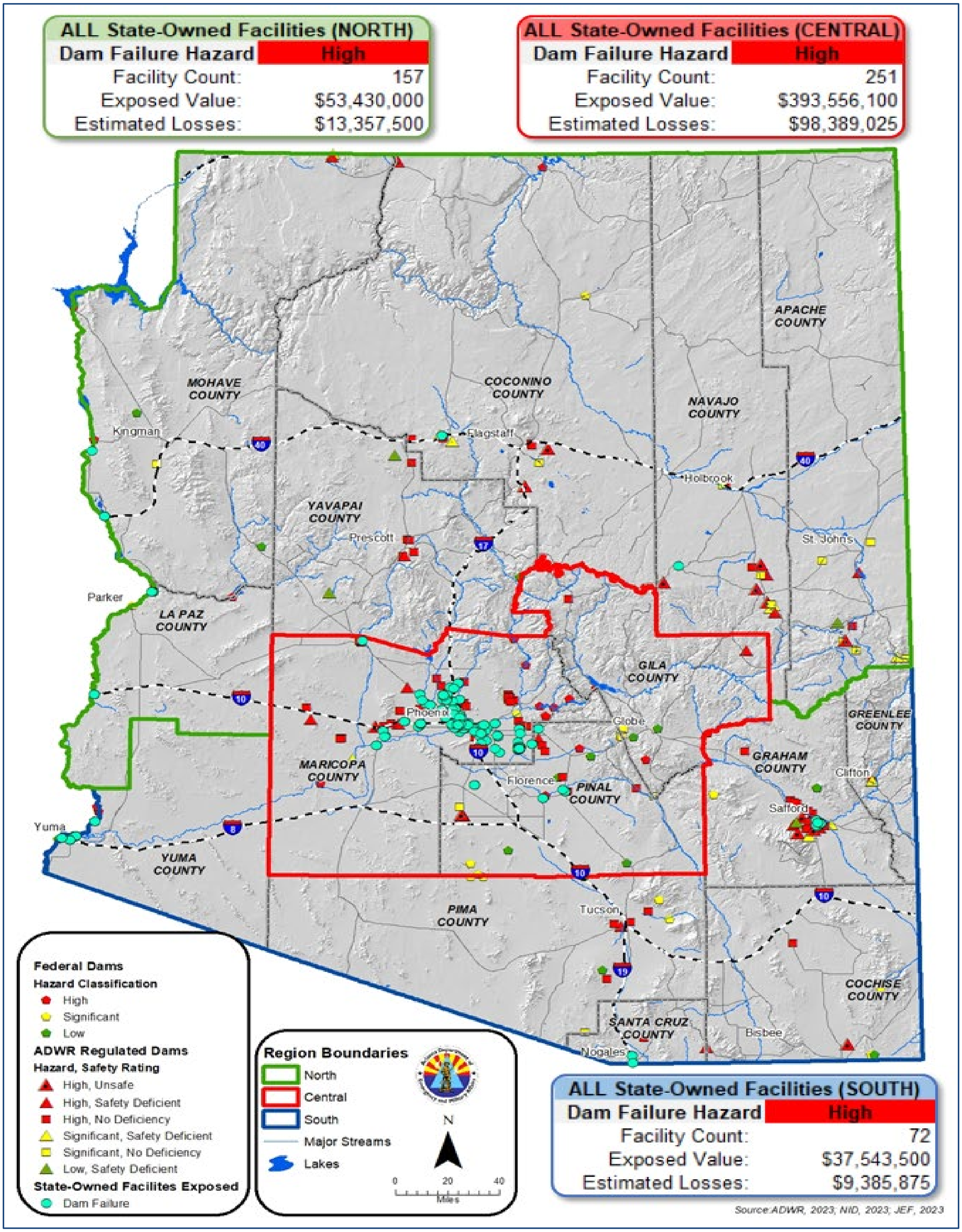
A single dam failure event can result in catastrophic losses depending on the dam's location, size, storage capacity, and the downstream population and infrastructure. The state classifies hazard potential for each state-regulated dam using downstream hazard and dam safety ratings. Table 7 and Table 8 summarize the hazard classes and dam safety ratings used for Arizona-regulated dams. Federally owned dams not regulated by the state use similar hazard classes and are all high-hazard dams.

Table 7. Downstream hazard classes for state regulated dams

Hazard Potential Classification	Loss of Human Life	Economic, Environmental, Lifeline Losses	EAP Required
Very Low	Not Likely	Limited to Owner or 100-year floodplain	No
Low	Not Likely	Low and generally limited to owner	No
Significant	Not Likely	Yes	Yes
High	Likely	Yes (not necessary for this classification)	Yes
Note: The hazard potential classification is an assessment of the consequences of failure, but not an evaluation of the probability of failure. *Sources: ADWR and USACE (NID)*			

The magnitude and extent of a dam failure are estimated by analyzing and mapping the flood inundation limits resulting from a projected failure event. State-regulated significant or high-hazard dams are required to develop an Emergency Action Plan (EAP). Significant and high-hazard federal dams within Arizona typically have EAPs with failure inundation limits.

Map 5 shows the state jurisdictional and federal dam locations, with each attributed by hazard classification and safety rating (if regulated). Dam information is derived from The National Inventory of Dams (NID, 2023) and ADWR databases. This map does not include the dams owned by the City of Phoenix Water Services Department, as the City requested the locations be confidential due to homeland security issues. Dam failure inundation limits derived from Emergency Action Plans (EAPs), permit-related inundation studies, and other sources have been developed for



Map 5. Dam locations and safety classifications statewide

analyzing vulnerability. However, inundation limits are not shown on the Plan maps to honor data security requests by several contributing agencies. State-owned facilities/structures impacted by dam failure inundation potential are shown on the map. It is noted that the inundation limit database is a work in progress. For this Plan update, dam failure inundation limits for three dams (Black Canyon, Big Lake, and Lee Valley) were added to the study file. Inundation limits for many Maricopa County dams have also been recently revised by the Flood Control District of Maricopa County to depict the hazard more accurately.

Table 8. State regulatory dam safety ratings

Safety Rating	Definition
Safe	The dam has sufficient structural integrity and flood routing capacity to make failure of the dam unlikely
Safety Deficiency	One or more conditions exist at the dam that impair or adversely affect the safe operation of the dam.
Unsafe	The safety deficiencies in a dam or spillway could result in failure of the dam with subsequent loss of human life or significant property damage.

A full list of high hazard potential dams (HHPDs) identified for Arizona in the NID and ADWR databases is provided in Annex C. There are total of 59, 65, and 40 HHPDs in the North, Central and South regions, respectively. The list includes information regarding ownership, primar purpose, regulatory jurisdiction, condition assessment, and emergency action plan status.

WARNING TIME

Once initiated, a dam failure can occur very rapidly, with a sudden, uncontrolled release of the stored or impounded water. Warning times for downstream populations are dependent upon the speed of the flood wave and distance from the breach, usually measured in hours. Indicators of a potential problem or failure can manifest days, months, or even years before an actual failure. Extreme weather events with the potential to trigger or cause a failure will also have at least hours of warning, if not a few days.

FUTURE CONDITIONS

Climate Considerations

From a dam safety perspective, the primary climate change impacts will be related to potential changes in the way precipitation and resultant flood patterns may vary and influence the potential for increased wildfire activity. The Fourth National Climate Assessment (NCA) report (Gonzales et al., 2018) notes that one of the anticipated impacts of climate change for the Southwest is a reduction in average annual precipitation and streamflow volumes. The report and supporting documents also indicate that winter storm intensities are anticipated to increase, which may lead to increased event-based flooding. The NCA report also notes that winter precipitation will be less in the form of snow and more frequent rain, which may indicate more frequent winter flooding.

The potential for reduced vegetation could also exacerbate the overall flooding conditions for watersheds upstream of dam facilities due to increased drought and post-wildfire flooding conditions.

Changes in Development

The two, primary development related impacts to dam failure are:

- A phenomenon referred to as "development creep." Development creep happens when development begins to encroach into the areas either protected by or downstream of dams. This encroachment can change the dam's hazard rating and safety requirement due to increased people and structures within a failure inundation area. The encroachments can also increase the population's and infrastructure's exposure to the risk of post-failure inundation.
- Potential changes in watershed rainfall-runoff characteristics due to the addition of significant impervious areas can translate into increased runoff volumes that may exceed or challenge the design capacities of the dam structures.

Hazard specific changes in vulnerability to state CFI due to changes in development are slightly increased due to secondary impacts of dam failure. For example, additional development damaged by a dam failure may increase the debris loading on a downstream state owned CFI. It is difficult to quantify the vulnerability increase, but in concept, the risk exists..

North Region

Areas of anticipated significant growth that may extend into dam failure areas are identified in Flagstaff (Coconino), Prescott Valley and Chino Valley (Yavapai), Bullhead City, and Lake Havasu City (Mohave), plus several populated areas within the unincorporated sections of Coconino, Mohave and Yavapai Counties. None of the anticipated developments is expected to alter any of the current dam hazard and safety ratings.

Central Region

The federal and local dams impacting Maricopa County have been actively studied and evaluated for failure inundation limits, with a large portion of the populated Phoenix Metropolitan area being situated within an identified dam failure inundation zone. Over the next five years, development will at least partially occur within these mapped areas. However, the risk of failure for most of the dams impacting the area is low due to the high level of maintenance and mitigation of potential failures. Planned growth in Pinal County areas subject to dam failure inundation is low to moderate and anticipated in or near Apache Junction, Coolidge, Florence, Maricopa, and portions of the San Tan Valley.

South Region

Moderate growth is expected to continue in Pima and Yuma Counties, primarily near or within the Tucson and Yuma Metropolitan areas, expanding the exposure to existing dam failure inundation zones. Future growth into dam failure zones within Cochise, Graham, Greenlee, and Santa Cruz Counties is not anticipated to be significant.

VULNERABILITY ASSESSMENT

The estimation of potential exposure to the identified dam failure inundation hazards was accomplished by using GIS mapping and analysis tools to intersect the vulnerable population and state-owned critical facilities and infrastructure (CFI) data with the inundation limits depicted on the maps above, which are considered the high hazard areas for this analysis. The loss calculations assume that exposed structures are subject to a loss-to-exposure ratio of 0.25 (or 25% damaged). The exposure loss estimates presented are based on a region-wide single event and aggregated to the entire region.

Eight of the 15 county multi-jurisdictional hazard mitigation plans included dam failure in their risk assessment. Further details are summarized by region in the sections below.

North Region

The North Region, depicted in Map 6, is the second-most vulnerable state region when considering the history of events, the exposure estimates, and the number of local plans that included dam failure in their risk assessment.

State-Owned CFI Exposure and Loss Estimates

A total of 28 state-owned CFI, or 2.7% of the statewide exposure, is located within dam failure inundation zones. The critical facilities exposed to dam failure inundation represent an exposed replacement value of $5.4 million, with an estimated $1.4 million in potential losses.

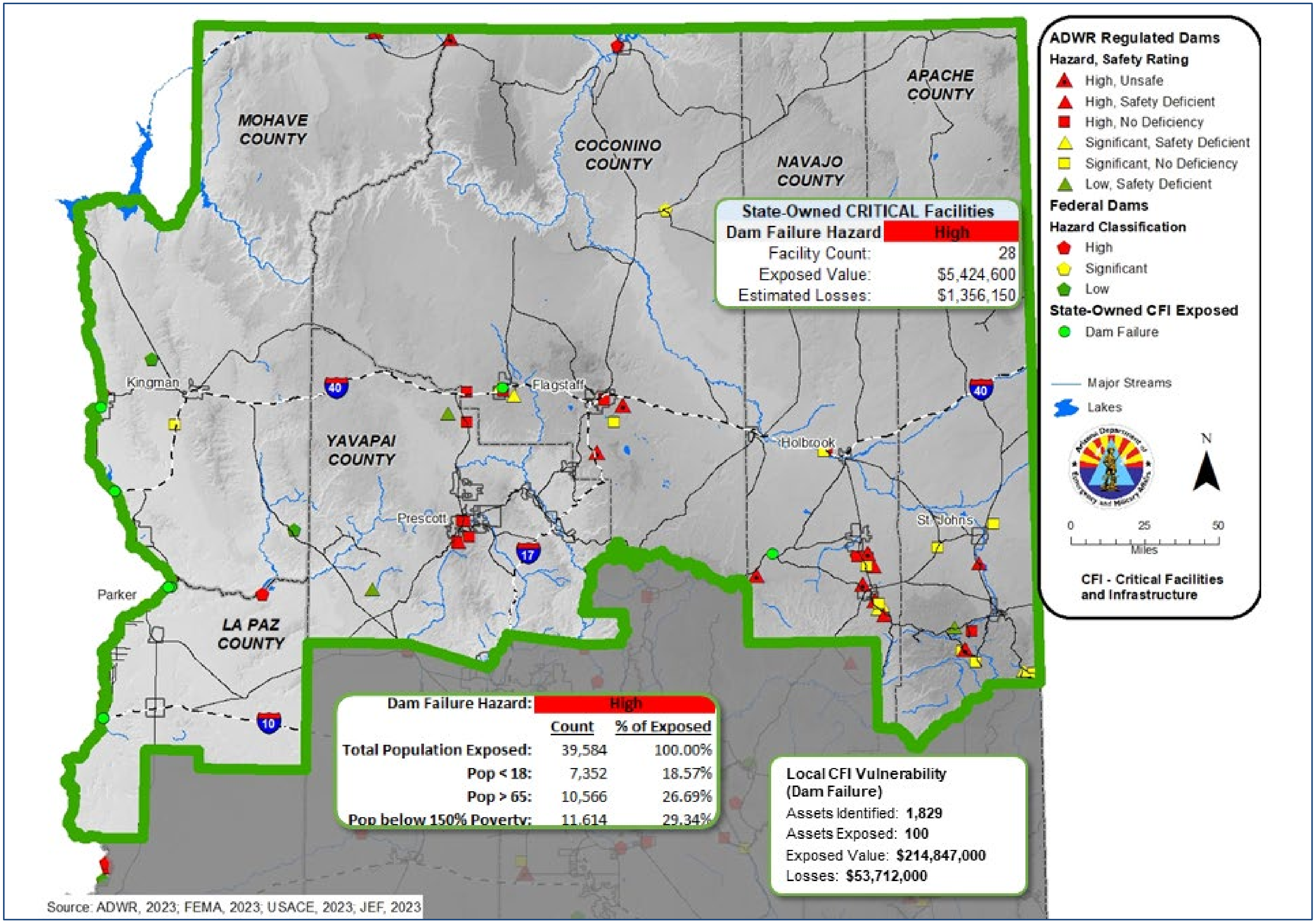
Additional state-owned facilities vulnerable to dam failure inundation hazards are the Arizona Department of Transportation (ADOT) operated and maintained freeways, highways and state routes located within the inundation zones. The drainage facilities (bridges, culverts, and channels) constructed with the ADOT roadways are expected to have a limited capacity to handle the magnitude of flows associated with a dam failure.

Vulnerable Population Groups

The 2022 estimated population for the North Region is 808,429 people. Approximately 4.90% of the population, or 39,584 persons, are exposed to dam failure inundation hazards. Exposure estimates for at-risk population groups like persons under 18 years of age, over 65 years of age, and those living at or below 150% of the poverty level are summarized on Map 6.

SVUC Impact Assessment

Dam failure impacts on North Region SVUC are summarized by CDC SVI themes and percentile rankings in Table 9. The highest percentages of regional exposure are highlighted using bold text.



Map 6. Dam Failure Vulnerability for North Region

Table 9. Dam Failure SVUC exposure for North Region

Region	CDC-SVI Assigned Percentile Rank	Percent of Impacted Area by SVI Percentile Rank Range				
		THEME 1 Socio-Economic Status	THEME 2 Household Characteristics	THEME 3 Racial and Ethnic Minority Status	THEME 4 Housing Type/ Transportation	THEMES (ALL) Overall Ranking
North	NO DATA	0.000%	0.000%	0.000%	0.000%	0.000%
North	0-0.25	1.625%	4.761%	25.840%	0.606%	1.625%
North	0.25-0.50	14.767%	18.189%	19.978%	21.809%	23.824%
North	0.50-0.75	21.440%	14.448%	7.831%	29.580%	11.726%
North	0.75-0.90	**48.423%**	14.348%	**46.351%**	1.688%	16.191%
North	0.90-1.00	13.745%	**48.254%**	0.000%	**46.317%**	**46.635%**

The strongest majority of exposure is to areas with an index ranking above 0.75, suggesting the areas of highest exposure to the dam failure hazard in the North Region occur in tracts where social vulnerability is high.

Local Jurisdiction Vulnerability

Local hazard mitigation plans for the North Region identified a total of 100 assets with a replacement value of $215 million as exposed to dam failure inundation. Potential losses to local CFI for dam failure inundation were estimated at $53.7 million.

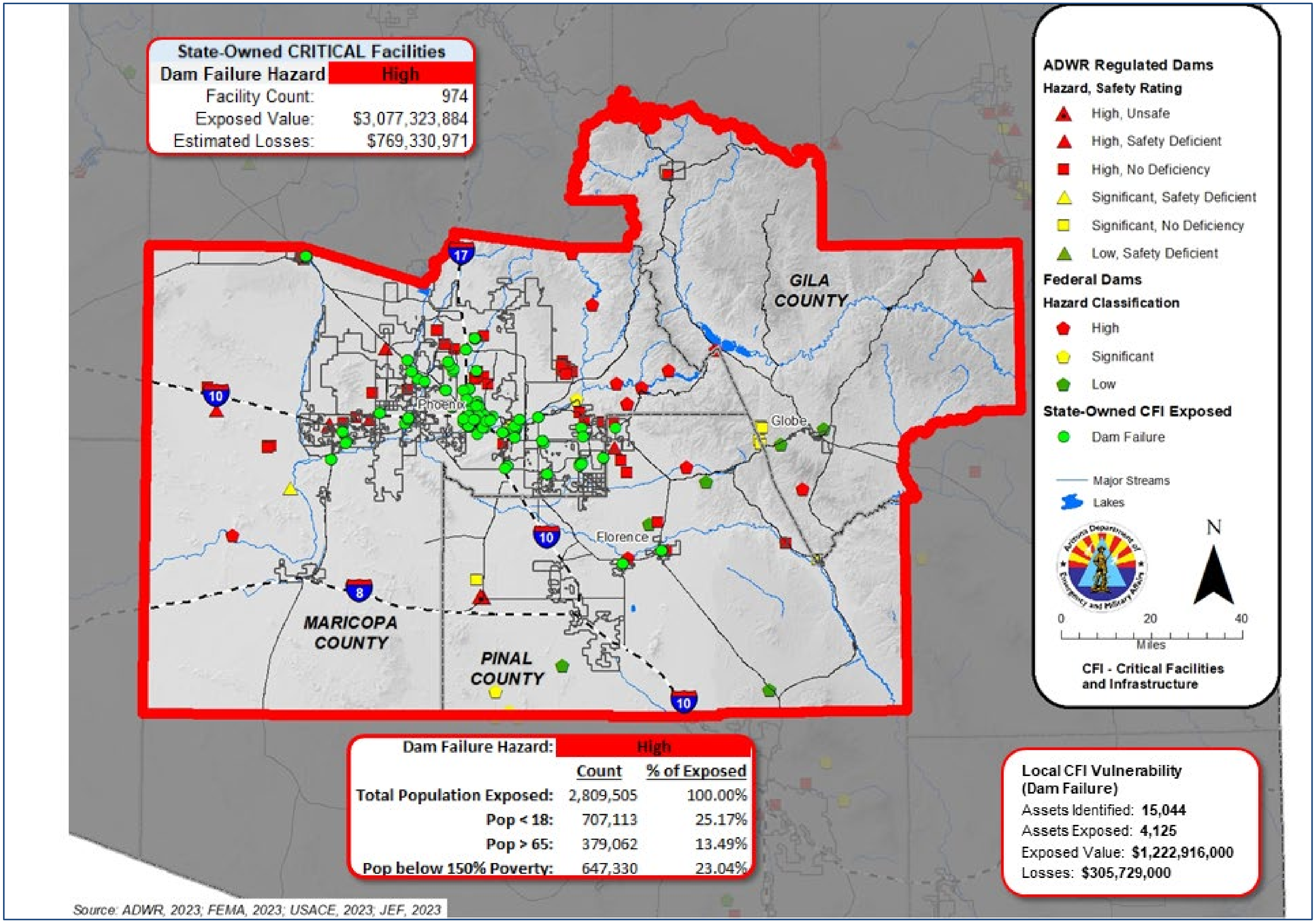
Specific Areas of Concern

Several high-hazard dams in the North Region have been identified as unsafe or safety deficient and either have outdated EAPs or require dam failure inundation limits to be digitized and added to the current database. These dams are located upstream of or near communities like Show Low, Taylor, Snowflake, and Munds Park. CFI and human exposure to the inundation limits from these dams are not accounted for in the numbers presented herein.

One area of concern regarding several dams located near or within North Region communities is the possibility of post-wildfire flooding that could significantly overwhelm existing capacities. For example, Coconino County has conducted advanced post-wildfire planning and risk assessments for the City of Williams, which has two municipal water supply reservoirs that are at risk of being overwhelmed with debris flow and flooding in a post-wildfire scenario.

Central Region

Among the three state regions, the Central Region, depicted in Map 7, has the most significant vulnerability when considering the history of events, the exposure estimates, and number of local plans that included dam failure in their risk assessment. Alternately, the Central Region arguably



Map 7. Dam Failure Vulnerability for Central Region

has the greatest amount of resources for active dam maintenance and repair, as well as modeling and mapping of hazard areas, which can greatly reduce the probability of a dam failure.

State-Owned CFI Exposure and Loss Estimates

A total of 974 state-owned CFI, or 92.9% of the statewide exposure, are located within dam failure inundation zones. The facilities exposed to dam failure inundation represent an exposed replacement value of $3.08 billion, with an estimated $769.3 million in potential losses.

State-owned and maintained roadways and infrastructure within the metropolitan Phoenix area are designed to meet local drainage requirements and, therefore, are protected to a 1% annual flood level. Although better than their rural counterparts, the numerous drainage facilities (bridges, culverts, and channels) constructed with the ADOT roadways are still not expected to have the capacity for handling the magnitude of flows associated with a dam failure.

Vulnerable Population Groups

The 2022 estimated population for the Central Region is 5,094,193 people. Approximately 55.15% of the population, or 2,809,505 persons, are exposed to dam failure inundation hazards. Exposure estimates for at-risk population groups like persons under 18 years of age, over 65 years of age, and those living at or below 150% of the poverty level are shown on Map 7.

SVUC Impact Assessment

Dam failure impacts on Central Region SVUC are summarized by CDC SVI themes and percentile rankings in Table 10. The highest percentages of regional exposure are highlighted using bold text. The strongest majority of exposure is to areas with index ranking between 0.25-0.75, which would suggest the areas of highest exposure to the dam failure hazard in the Central Region occur in tracts where social vulnerability is moderate.

Table 10. Dam Failure SVUC exposure for Central Region

Region	CDC-SVI Assigned Percentile Rank	Percent of Impacted Area by SVI Percentile Rank Range				
		THEME 1 Socio-Economic Status	THEME 2 Household Characteristics	THEME 3 Racial and Ethnic Minority Status	THEME 4 Housing Type/ Transportation	THEMES (ALL) Overall Ranking
Central	NO DATA	0.488%	0.488%	0.373%	0.585%	0.585%
Central	0-0.25	15.990%	29.337%	10.802%	16.248%	16.737%
Central	0.25-0.50	21.127%	13.289%	**24.306%**	**27.352%**	21.809%
Central	0.50-0.75	**31.383%**	**31.871%**	20.106%	32.750%	**36.716%**
Central	0.75-0.90	24.950%	20.844%	23.499%	6.920%	11.970%
Central	0.90-1.00	6.061%	4.151%	20.914%	13.154%	12.183%

Local Jurisdiction Vulnerability

Local hazard mitigation plans for the Central Region identified a total of 4,125 assets with a replacement value of $1.22 billion as exposed to dam failure inundation. Potential losses to local CFI for dam failure inundation were estimated at $305.7 million.

Specific Areas of Concern

There are two small flood retarding dams located in southwest Pinal County that are identified as unsafe and do not have mapped failure inundation limits reflected in the current database or this Plan. Both are relatively remote, but there are a small number of people located downstream, as well as a primary local highway.

South Region

The South Region, depicted in Map 8, is the least vulnerable state region when considering the history of events, the exposure estimates, and number of local plans that included dam failure in their risk assessment.

State-Owned CFI Exposure and Loss Estimates

A total of 46 state-owned CFI, or 4.4% of the statewide exposure, are located within dam failure inundation zones. The facilities exposed to dam failure inundation represent an exposed replacement value of $33.6 million, with an respectively estimated $8.4 million in potential losses.

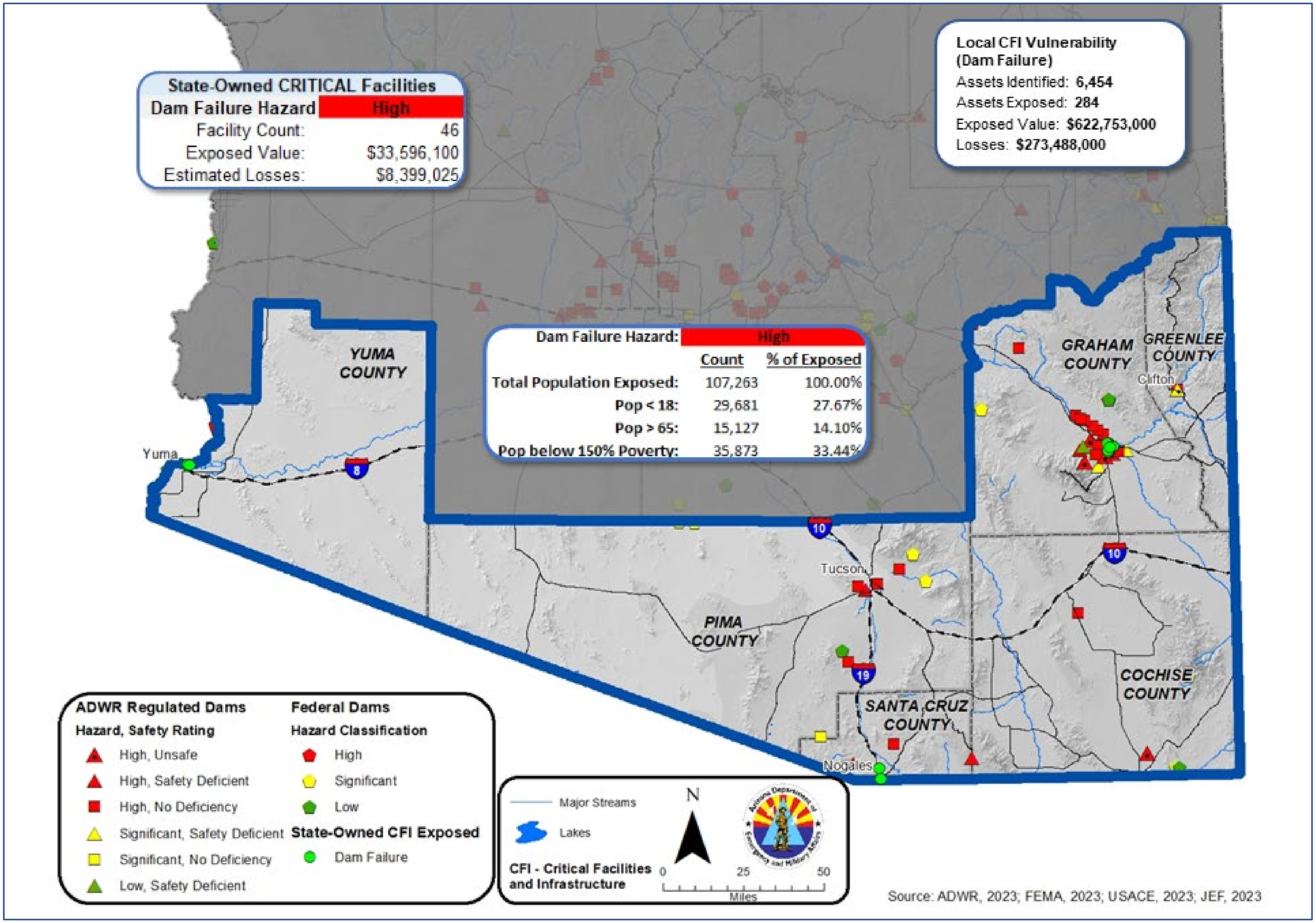
Additional state-owned facilities vulnerable to dam failure inundation hazards are the Arizona Department of Transportation (ADOT) operated and maintained freeways, highways, and state routes located within the inundation zones. The drainage facilities (bridges, culverts, and channels) constructed with the ADOT roadways are not expected to have the capacity to handling the magnitude of flows associated with a dam failure.

Vulnerable Population Groups

The 2022 estimated population for the South Region is 1,506,567 people. Approximately 7.86% of the region's total population, or 107,263 persons, are exposed to dam failure inundation hazards. Exposure estimates for at-risk population groups like persons under 18 years of age, over 65 years of age, and those living at or below 150% of the poverty level are shown on Map 8.

SVUC Impact Assessment

Dam failure impacts on South Region SVUC are summarized by CDC SVI themes and percentile rankings in Table 11. The highest percentages of regional exposure are highlighted using bold text. The strongest majority of exposure is to areas with an index ranking above 0.75, suggesting the areas of highest exposure to the dam failure hazard in the South Region occur in tracts where social vulnerability is high.



Map 8. Dam Failure Vulnerability for South Region

Table 11. Dam Failure SVUC exposure for South Region

Region	CDC-SVI Assigned Percentile Rank	Percent of Impacted Area by SVI Percentile Rank Range				
		THEME 1 Socio-Economic Status	THEME 2 Household Characteristics	THEME 3 Racial and Ethnic Minority Status	THEME 4 Housing Type/ Transportation	THEMES (ALL) Overall Ranking
South	NO DATA	0.000%	0.000%	0.000%	0.000%	0.000%
South	0-0.25	0.000%	1.072%	0.774%	3.251%	0.000%
South	0.25-0.50	37.770%	1.975%	15.951%	2.935%	5.191%
South	0.50-0.75	13.868%	37.155%	**60.544%**	**46.231%**	**63.429%**
South	0.75-0.90	**41.915%**	**42.034%**	6.780%	38.312%	15.488%
South	0.90-1.00	6.447%	17.763%	15.951%	9.065%	15.892%

Local Jurisdiction Vulnerability

Local hazard mitigation plans for the South Region identified a total of 284 assets with a replacement value of $622.8 million as exposed to dam failure inundation. Potential losses to local CFI for dam failure inundation were estimated at $273.5 million.

Specific Areas of Concern

There are four dams located upstream of Safford and Thatcher that ADWR currently designates as unsafe. There have also been several wildfires in recent years that have burned a portion of Mt. Graham, the base at which these dams are located. Failure of any one of these dams could be catastrophic for the downstream community and population.

High Hazard Potential Dam (HHPD) Data Limitations and Deficiencies Assessment

This risk assessment included an evaluation of data limitations and deficiencies regarding the state, tribal, and local ability to assess HHPD risk. One area of need identified by the Planning Team was the lack of a complete database of mapped downstream inundation limits due to a dam failure, that is normally included with emergency action plans (EAPs). In Arizona, the development of an EAP is the responsibility of the dam owner and is a requirement for all HHPDs. However, there are several HHPDs (see Annex C) that currently do not have an EAP. In many other cases, the EAP exists only in paper form and downstream inundation limits have either not been delineated or have not been digitized into a GIS type of file. DEMA/EM and ADWR have been slowly building the GIS database for EAP inundation limits for Arizona dams, but much work remains. Having an EAP with inundataion limits for every HHPD is key to an effective risk assessment and DEMA/EM and ADWR are committed to seeing this database complete for Arizona HHPDs.

RESOURCES

Sources

AZ Dept of Water Resources, Dam Safety Program, https://new.azwater.gov/dam-safety

FEMA, National Dam Safety Program, https://www.fema.gov/national-dam-safety-program

US Army Corp of Engineers, National Inventory of Dams, https://nid.sec.usace.army.mil/#/

References

Applied Weather Associates, LLC, 2013, *Probable Maximum Precipitation Study for Arizona*. Prepared for the AZ Dept of Water Resources,

AZ Dept of Water Resources, 1981, Reconnaissance Report of the Gila River Flood Control Project.

FEMA, 2001, How-To Guide #2: Understanding Your Risks – Identifying Hazards and Estimating Loss Potential. FEMA 386-2.

Flood Control District of Maricopa County, 1997, *Storm Report, Tropical Storm Nora - Sept 1997.*

Gonzalez, P., G.M. Garfin, D.D. Breshears, K.M. Brooks, H.E. Brown, E.H. Elias, A. Gunasekara, N. Huntly, J.K., Maldonado, N.J. Mantua, H.G. Margolis, S. McAfee, B.R. Middleton, and B.H. Udall, 2018: *Southwest. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 1101–1184. doi: 10.7930/NCA4.2018.CH25. On the Web: https://nca2018.globalchange.gov/chapter/southwest

Loomis, T. R., 2003, *A Brief History of Flooding in the Rural Areas of Arizona, Part II 1964 through 1993*, Arizona Floodplain Management Association Newsletter, Volume 20, Number 1, April 2003.

National Research Council, 1983, *Safety of Existing Dams: Evaluation and Improvement*. Washington, DC: The National Academies Press. https://doi.org/10.17226/289

Youberg, A., 2012, *Southwest Wildfire Hydrology and Hazard Workshop Proceedings*. AZ Geological Survey Open-file-report – 12-05, 50 p. 32 presentation available online at http://repository.azgs.az.gov/uri_gin/azgs/dlio/1405

US Army Corps of Engineers, Los Angeles District, 1994, *Flood Damage Report, State of Arizona, Floods of 1993*. US Department of the Interior, Bureau of Reclamation, Phoenix Area Office.

US Bureau of Reclamation, 2011, Draft Environmental Assessment, Tsaile Dam, Safety of Dams Rehabilitation Project, Apache County, Arizona.

DROUGHT

DESCRIPTION

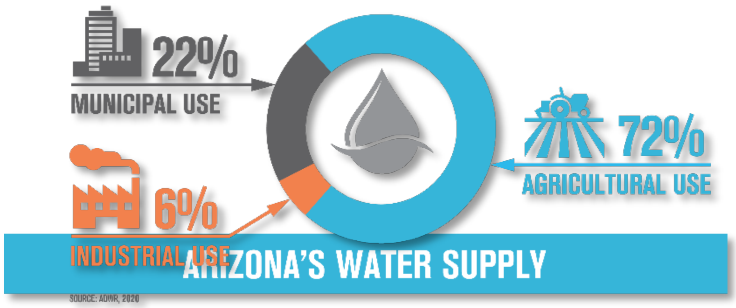
Lingering drought and demand from growing cities have lowered water levels on Lake Mead behind Hoover Dam. Photo by the John Locher/AP

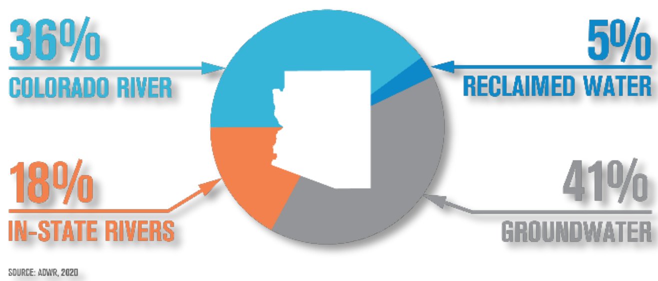
Drought is a weather-related phenomenon occuring in virtually all climatic zones, specifically in arid locations. Drought is a natural occurrence that can potentially affect humans, animals, and the environment negatively. It is different from normal aridity, which is a permanent characteristic of the climate in areas of low rainfall, but Arizona's arid conditions and low precipitation patterns make it susceptible to drought of moderate durations and intensities. Drought originates from an extended deficiency of normal precipitation that usually spans one or more seasons in length and can result in a water shortage for some activity, group, or environmental sector.

Arizona is also affected by drought conditions that extend beyond Arizona's borders and into the greater Colorado River watershed. Water from the Colorado River provides Arizona with a significant portion of its water supply, and the Colorado River watershed has experienced severe drought conditions since 2000. Colorado River water is stored in a system of federally constructed and regulated dams and reservoirs, including Lake Powell and Lake Mead, that harness its flows for use by several states before discharging to Mexico at the state's southwest corner. Arizona, California, Nevada, New Mexico, Utah, Colorado, Wyoming, and Mexico share the river's resources, and rights to use Colorado River water are quantified by a string of legal authorities known as the "Law of the River." Based on this body of law, Arizona has the right to use 2.8 million acre-feet annually of Colorado River water.

On the Colorado River, a federal water shortage was declared in August of 2021, while in the summer of 2022, the reservoir water surface elevation in Lake Mead had dropped to record low levels of 1,040 feet. This prompted states and federal partners to begin looking at voluntary and potentially mandatory reductions in consumption in order to avoid reaching "dead pool" levels within the reservoirs in Colorado. However, as of 2023, gains have been seen in storage within the major reservoirs along the Colorado due to parts of the west experiencing heavy rainfall over the winter period from late December to early March.

Drought is a complex natural hazard, and its impacts result from the interaction between the natural event (less precipitation than expected) and the demand people place on the water supply, which may include agricultural, municipal, industrial, and natural uses.





Drought differs from some of the other natural hazards in three ways. First, the onset and end of a drought are difficult to determine due to the slow manifestation 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, drought is not an event or incident-based hazard, but more of a long term condition with subtle, less obvious changes in conditions that develop over a period of years and may be spread over large geographical areas.

All economic activity within Arizona, including mining, irrigated agriculture, industry, tourism, and urban and rural growth, can occur only where dependable water supplies are available. As a result, Arizona places a high priority on managing its limited water to ensure that secure water supplies are available now and well into the future. According to ADWR[1] and illustrated in the graphic above, Arizona used approximately 7 million acre-feet of water in the 2019 water year, which was divided into three major categories of users: municipal (22%), industrial (6%), and agricultural (72%). Sources for the water included the Colorado River (36%), groundwater (41%), in-state rivers (18%) and reclaimed water (5%).

Throughout the last half-century, groundwater has been extracted more rapidly than it can be replenished, leading to a condition known as overdraft. Continued overdraft of the state's finite groundwater supplies will challenge the state's ability to ensure a secure water supply for the future.

In-state surface water from lakes, rivers, and streams is a major renewable resource for the state. Several storage reservoirs and delivery systems have been constructed throughout the state to make the best use of the surface water when and where it is needed, with the most notable being the systems located on the Salt, Verde, Gila, and Agua Fria rivers. Almost all of the natural surface water in Arizona has been developed.

Reclaimed water, or effluent, is the one water source in the state with the potential for increase. As the population and water use grow, more treated wastewater will be available for use. Reclaimed water is treated to a quality that can be used for purposes such as agriculture, golf courses, parks, industrial cooling, or maintenance of wildlife areas.

[1] ADWR, 2020, Water Your Facts | Arizona WaterFacts

Arizona has also begun to investigate the feasibility of using desalination or removing salt from brackish water to make fresh water to augment the water supply within the State. In January 2018, State legislators were briefed by a panel of experts on desalination issues and opportunities. In his final State address in January 2022, Governor Doug Ducey proposed setting aside $1 billion to bring desalinated water to Arizona.

While there is no specific project planned to bring desalinated water to the State as of yet, experts have discussed the possibility of using water for the Sea of Cortez in Mexico or treating brackish groundwater that exists within Arizona, most notably within a large aquifer beneath the City of Buckeye.

HISTORY

As of July 2023, Arizona has experienced 28 droughts declared as drought disasters/emergencies by the Governor's Office and the Secretary of the US Department of Agriculture (USDA). For 2023, Coconino and Mohave Counties were designated as primary disaster areas, with La Paz, Gila, Navajo, Apache, and Yavapai Counties being named as contiguous disaster counties.

Historically, the state has experienced several drought events. Average annual precipitation records dating from 1895 to 2022[1] (127 years of record), shown in Figure 3, provide a snapshot of

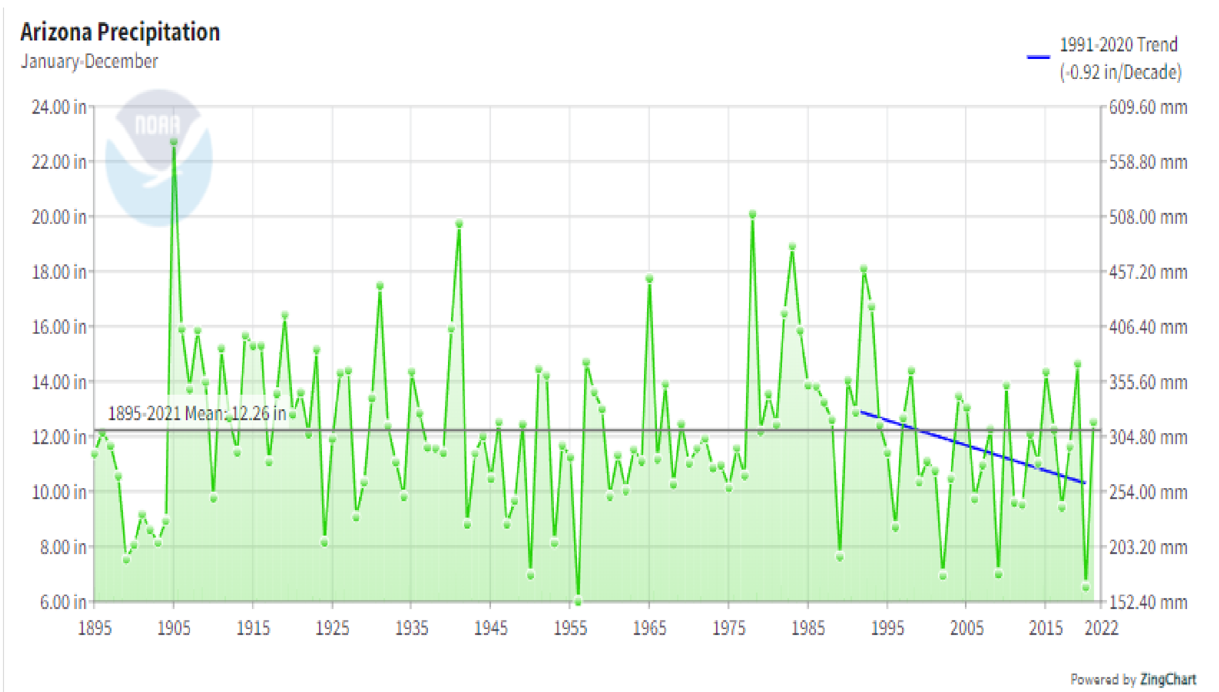


Figure 3. Annual precipitation averages statewide

[1] NOAA National Centers for Environmental information, Climate at a Glance: Statewide Time Series, 2023, https://www.ncei.noaa.gov/access/monitoring/climate-at-a-glance/statewide/time-series

past drought periods when evaluated on the basis of how the average annual precipitation for any given year varies from the normal of the whole data set.

Between 1849 and 1905, the most prolonged period of drought conditions in 300 years occurred in Arizona (NOAA, July 29, 2003). Another prolonged drought occurred during the period 1941-1965, during which time there were no spill releases into the Salt River (DEMA/EM, 2001). Another short dry period from 1968-1977 followed shortly after. The period from 1979-1983 appears to have been anomalously wet, while the rest of the historical records show that dry conditions are most likely the normal condition for Arizona.

The current drought began in 1994 and has persisted until now. The four wetter-than-normal years within that period have brought some relief but have not been enough to ameliorate the drought. A recent study of past droughts (A.D. 762-2005) in the southwest using tree ring data (Meko et al. 2007) found that droughts in the past have lasted as long as 60 years, with reduced streamflow lasting an average of 25 years. The data suggests that extended drought is normal condition in the southwest, and the wet decades of the 1970s and 1980s are uncharacteristic.

PROBABILITY/EXTENT

Given the past history, the probability of drought occurring (or, in the case of current conditions, continuing) in any location within the state is high. A drought's severity depends on numerous factors, including duration, intensity, and geographic extent, as well as regional water supply demands by humans, animals, and vegetation. Due to its multi-dimensional nature, drought is difficult to define in exact terms and poses difficulties regarding comprehensive risk assessments.

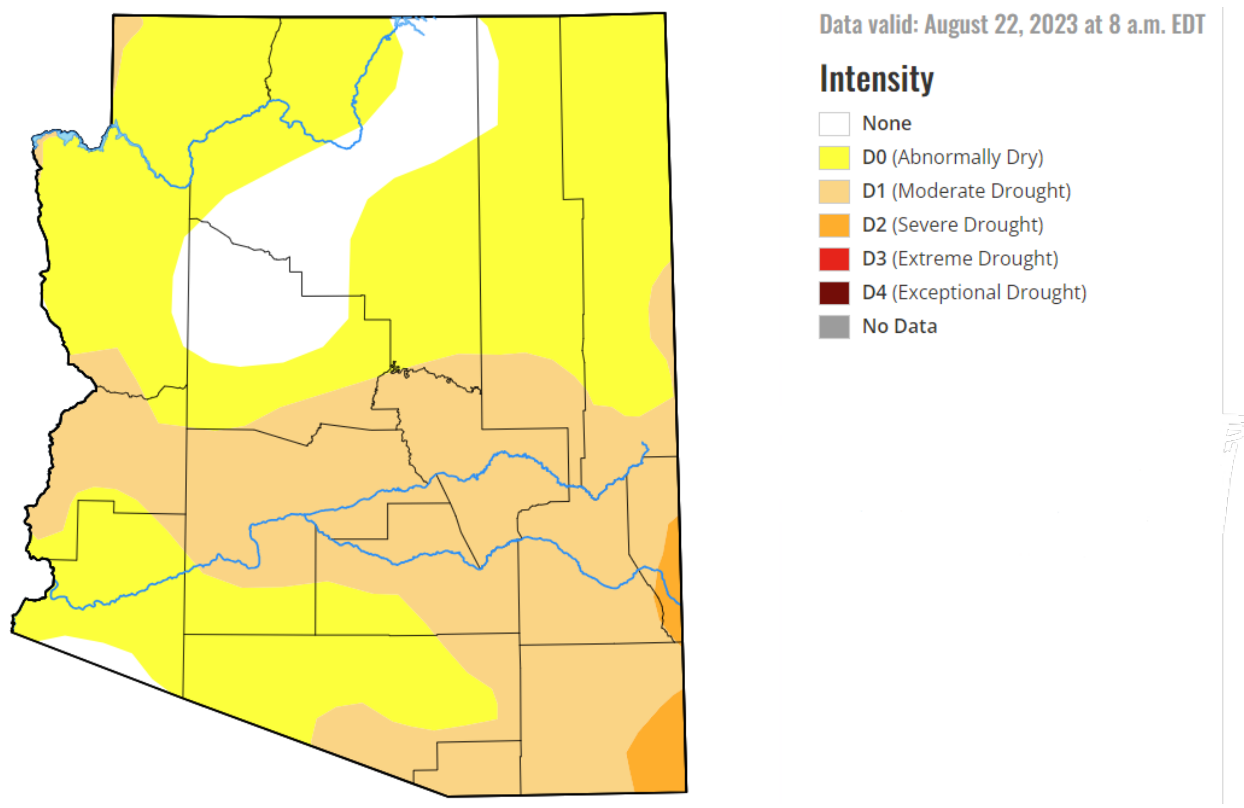
This is due to the "snapshot in time" nature of drought severity and predictive tools. What is valid for today will likely change in the next day, week, or month, depending on the season, the amount of precipitation, or lack thereof, and user demand.

The magnitude of drought is usually measured in time and the severity of the hydrologic deficit. The changing climate and continued population growth may increase the probability, extent, and severity of future drought events.

Below is a map from the U.S. Drought Monitor[1] detailing the intensity of drought throughout Arizona.

[1] National Drought Mitigation Center, U.S. Drought Monitor,

https://droughtmonitor.unl.edu/CurrentMap/StateDroughtMonitor.aspx?AZ



WARNING TIME

The US Seasonal Drought Outlook (USSDO), as well as other tools, provides information on anticipated drought trends within the United States. Future potential for changes to a current drought cycle uses meteorological modeling to develop predictions of near-future temperature and precipitation levels and then apply those data to assess future changes in drought severity. The USSDO, shown in Figure 4, is distributed by the National Weather Service's Climate Prediction Center[1].

In support of the USSDO, the Arizona Drought Monitoring Technical Committee (MTC) evaluates weekly, short-term, and long-term drought conditions. The MTC confers weekly to advise the US Drought Monitor authors on current drought conditions in Arizona and makes recommendations about the position of drought boundaries within the State.

[1] National Weather Service, Climate Prediction Center

,http://www.cpc.ncep.noaa.gov/products/expert_assessment/sdo_summary.php

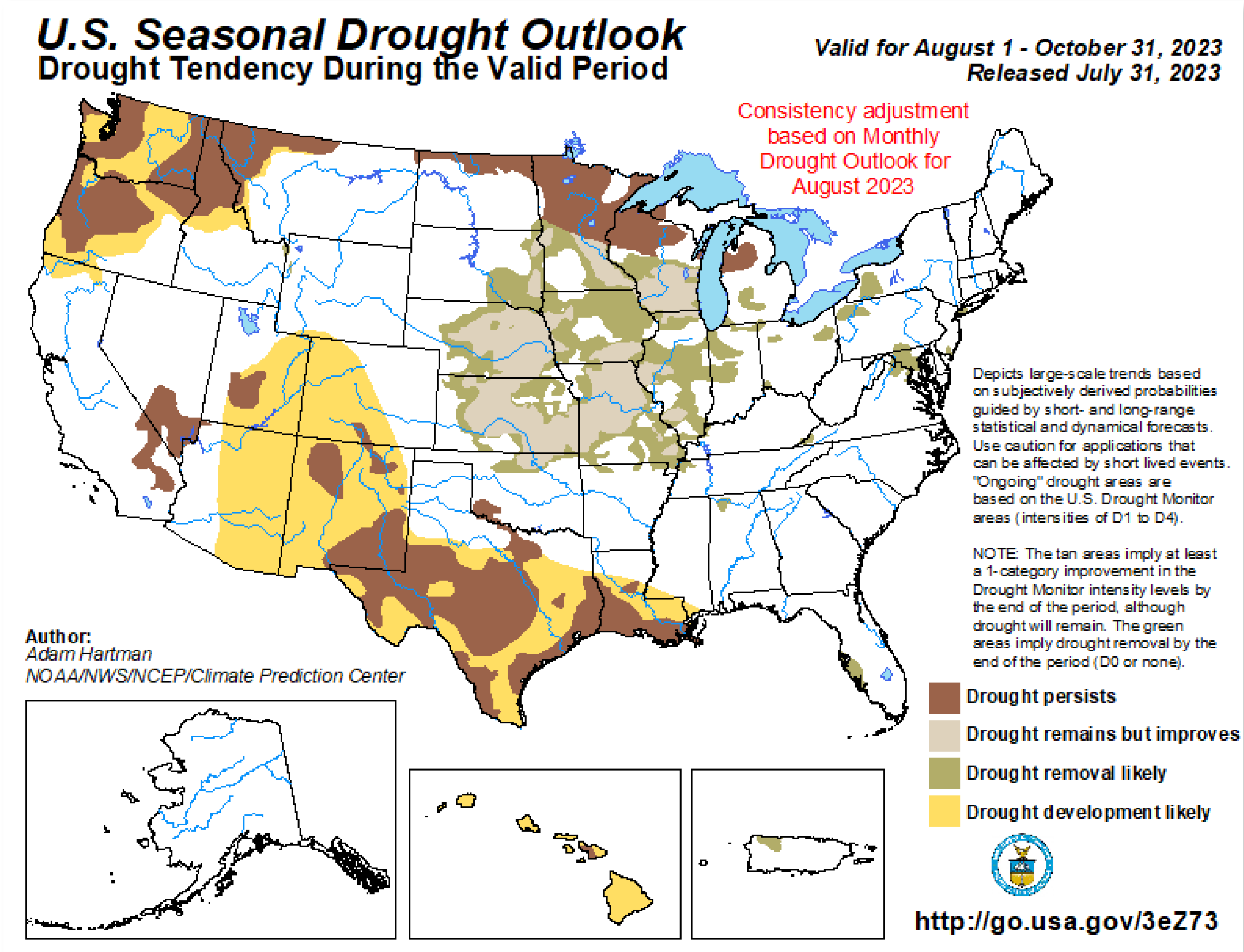


Figure 4. U.S. Seasonal Drought Outlook

Statewide long-term drought evaluates aspects of Arizona's water supply, including streamflow, groundwater, and reservoirs. Long-term drought is analyzed quarterly with 24-, 36-, and 48-month Standardized Precipitation Evapotranspiration Index (SPEI) and Standardized Precipitation Index (SPI) data. The SPI and SPEI are both tools to evaluate long-term drought. The SPI evaluates statewide precipitation over longer timeframes, while the SPEI evaluates longer timeframes of precipitation and potential evapotranspiration. Potential evapotranspiration incorporates aspects of wind and air temperature that influence evapotranspiration. The latest update to the Long-term drought status map shown in Figure 5 applies to the period from April to June 2023.

FUTURE CONDITIONS

Climate Considerations

The NOAA National Centers for Environmental Information has published Arizona's State Climate Summary for 2022, with information on observed and projected temperature, precipitation, and drought for the State. The temperature data analyzed spans from 1995 to 2020 and indicates a rise of 2.5 degrees Fahrenheit within the State since the beginning of the 20th century. These upward trends in temperatures and extreme heat are projected to continue.

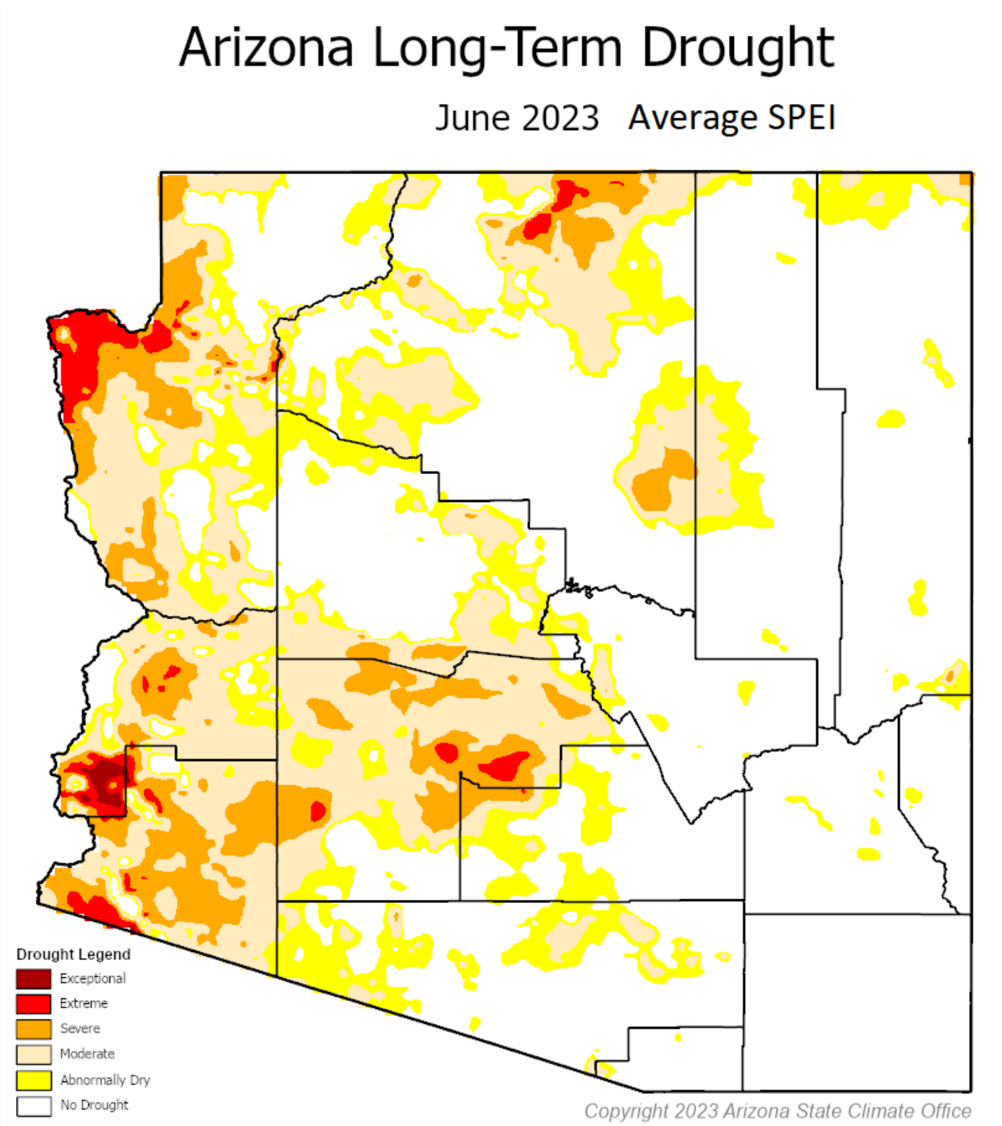


Figure 5. Arizona Drought MTC Long-Term Drought Outlook

Precipitation data for the State was evaluated from 1895 to 2020, with particular emphasis on the summer monsoon rainfall. Future trends in average monsoon rainfall were determined to be highly uncertain with high variability. Based on the data analyzed by the authors, the report concludes that naturally occurring droughts are expected to become more intense in Arizona during the cool season. This is due to increasing temperatures, which will intensify drought by increasing water evaporation, further reducing streamflow, soil moisture, and water supplies. The increased intensity of drought will also increase the frequency of other hazards, including dust storms and very large wildfires (Frankson, et. al. 2022).

Changes in Development

Increases in development accompanying the anticipated growth of Arizona's population and economy depend upon reliable water sources. For each of the state regions, the water demands imposed by additional population and industry and the ability to meet those demands will be directly impacted by drought. Most of the growth anticipated over the next plan cycle is expected to concentrate around current population centers. Reduced yields from increasing temperatures and increasing competition for scarce water supplies may displace jobs in some rural communities (Gonzales, et.al., 2018). Hazard specific changes in vulnerability to state CFI due to changes in development are neutral for drought related impacts.

North Region

The majority of the anticipated growth in the North Region is expected to expand from existing cities and towns. New growth will rely on either groundwater, or in-state surface water sources. The primary agricultural demand is livestock-related water sources for range animals, which are not expected to grow significantly due to range management constraints.

Central Region

The most significant development in the Central Region is expected to occur in the Phoenix Metropolitan Area primarily. Drought impacts are less constraining in the Central Region due to the multiple sources of water available to Maricopa and Pinal Counties. Gila County constraints are more similar to the North Region. The Southwest US produces more than half of the nation's high-value specialty crops, which are irrigation-dependent and particularly vulnerable to extremes of moisture, cold, and heat. A significant portion of that agriculture is located within the Central Region. In some areas, conversion of agriculture areas into residential and retail commercial development may change the water demand profile.

Restrictions on development within the Central Region have become more common as water supply reductions have increased within the State. Anecdotes exist in the Rio Verde Foothills Community outside of Scottsdale, Arizona, and the Phoenix Metropolitan area in the State's Central Region. The Rio Verde Foothills Community largely depended upon hauled water from the City of Scottsdale to meet the residential demand until January of 2023, when the City notified hauled water users that it would no longer allow for water from the City's municipal water-fill stations to be hauled outside of the incorporated limits of the City due decreased supply from the Colorado River. Many members of the Rio Verde Foothills Community, consisting of approximately 1,900 households, were left without access to water as a result. This led to the creation of the Rio Verde Foothills Standpipe District by the Governor of Arizona, which is tasked with entering into agreements to procure water for the community temporarily[1].

Also, as a result of tightening water supplies within Arizona, the State has halted new home approvals within parts of the Phoenix Metro Area. This action was taken based on a new state groundwater model released by the Governor's Office, which indicates that the aquifer supplying the metro area cannot provide the requisite 100-year supply based on

[1] Hupka, S. (July 21, 2023) Rio Verde Foothills gathers for its first local government meeting on water supply. *Arizona Republic.* Rio Verde Foothills gathers for its first local government meeting on water supply (yahoo.com)

projected growth. For this reason, the State's Department of Water Resources will stop approving new development that relies solely on groundwater, largely within the Buckeye and Queen Creek areas[1].

South Region

The most significant development in the South Region is expected to occur in the Tucson Metropolitan Area primarily. Drought is already causing development constraints where new development depends on access to a diminishing or highly regulated groundwater supply. Potential developments in Benson (Cochise County) have faced challenges in obtaining development rights, as the use of water might impact the health of the San Pedro River[2]. A significant portion of the previously mentioned high-value specialty crops are located in the Southern Region, especially in the Yuma Valley. In some areas, conversion of agriculture areas into residential and retail commercial development may change the water demand profile.

VULNERABILITY ASSESSMENT

All population sectors are equally exposed to drought. However, the severity and magnitude of the drought conditions fluctuate in time and geography depending on the season, the amount of precipitation or lack thereof, and user demand. No vulnerability maps are provided in this section. Instead, vulnerability is discussed on a more general basis for each region.

Drought generally is not a direct source of damage to state-owned facilities, and no losses are estimated for this Plan. The state does, however, experience economic loss in other ways. For example, during significant drought conditions, the AZ Game and Fish Department will haul water for critically impacted wildlife and perform special fishery management to compensate for reduced lake levels or streamflow. These efforts have a negative economic impact on the state.

North Region

The North Region is considered to be the second-most vulnerable due to the multiple in-state surface water sources, higher precipitation rates, and lower average temperatures. The portions of Mohave and La Paz Counties that are generally situated along the Colorado River (Bullhead City, Lake Havasu City, Parker, etc.) generally rely on Colorado River water as their principal water supply. The remaining areas are dependent on surface water and groundwater. Extended drought periods can impact forest health and wildfire susceptibility. Range animals (both livestock and wildlife) are vulnerable to extended droughts as forage and water sources dry up.

State-Owned CFI Exposure and Loss Estimates

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[1] Loomis, B. (June 1, 2023) Arizona will halt new home approvals in parts of metro Phoenix as water supplies tighten. *Arizona Republic*. [New groundwater model shows a shortfall; state will halt some growth (azcentral.com)]

[7] Kolsrud, E. (2017) *House Development Challenges Benson, San Pedro River*. Arizona Sonora News. http://arizonasonoranewsservice.com/house-development-challenges-benson-san-pedro-river/

All 1,010 state-owned facilities representing $1.2 billion in replacement value are exposed to drought. No losses are estimated.

Vulnerable Population Groups

The entire 2022 estimated population of 801,655 people is considered to be equally exposed to drought. This includes all of the sub-population groups under 18 years of age, older than 65, and at the poverty level.

SVUC Impact Assessment

Drought impacts on North Region SVUC are summarized by CDC SVI themes and percentile rankings in Table 12. The highest percentages of regional exposure are highlighted using bold text.

Table 12. Drought SVUC exposure for North Region

Region	CDC-SVI Assigned Percentile Rank	Percent of Impacted Area by SVI Percentile Rank Range				
		THEME 1 Socio-Economic Status	THEME 2 Household Characteristics	THEME 3 Racial and Ethnic Minority Status	THEME 4 Housing Type/ Transportation	THEMES (ALL) Overall Ranking
North	NO DATA	1.00%	1.00%	0.93%	2.51%	2.51%
North	0-0.25	11.66%	17.85%	29.90%	5.13%	7.82%
North	0.25-0.50	25.83%	17.57%	15.75%	23.55%	22.51%
North	0.50-0.75	**34.42%**	**24.63%**	21.96%	**38.82%**	**30.84%**
North	0.75-0.90	26.44%	19.87%	0.86%	18.29%	28.64%
North	0.90-1.00	0.66%	19.08%	**30.59%**	11.70%	7.68%

The strongest majority of exposure is to areas with an index ranking above 0.5, suggesting North Region area exposures to drought occur in tracts where social vulnerability is at least moderate.

Local Jurisdiction Vulnerability

None of the local jurisdictions in the North Region estimated losses for locally identified critical and non-critical facilities. All assumed that local facilities and populations were equally exposed. See the “Local Agricultural Vulnerability” section for further discussion on locally estimated losses in agricultural sectors.

Specific Areas of Concern

Drought-related declines in snowpack depths in the northern mountain areas will result in decreased surface water flows during the latter part of the summer and early fall, forcing a greater reliance on groundwater and reservoir storage. Depths to groundwater for many areas in the North Region make installing and operating wells very expensive. Increased reliance on these groundwater resources during times of severe drought or lowering of groundwater tables due to increased pumping rates could become a significant problem. Long-duration droughts will also dry forested areas, increasing the wildfire risk.

The Fort Mojave Indian Reservation sits on the border of Arizona, California, and Nevada in the North Region. The reservation is experiencing extreme drought conditions that will impact their culture and traditional practices as it places greater stress on traditional fish, plant, and animal species. The Hualapai Tribe is also located in the North Region and also faces impacts from lack of water supply due to drought. In 2022, the Hualapai Tribe Water Rights Settlement Act was signed, which provides a 4,000 acre-feet allotment of water from the Colorado River and authorizes the construction of a pipeline and other infrastructure to deliver water to the tribe's biggest enterprise, Grand Canyon West. Water will also be delivered to homes. In addition to this legislation, the Colorado River Indian Tribes Water Resiliency Act and the White Mountain Apache Tribe Water Rights Quantifications Act were signed in 2022. These pieces of legislation secure water rights and funding for the development of water infrastructure on tribal lands[1].

Central Region

The Central Region is considered to be the least vulnerable to drought due to the availability of multiple water sources (Colorado River, Salt River Project, and groundwater). The only exception to this ranking would be if a severe drought were to persist or develop in the Colorado River Watershed since Colorado River water comprises a significant portion of the water currently used in the Central Region. See the Specific Areas of Concern section for additional discussion.

State-Owned CFI Exposure and Loss Estimates

All 1,741 state-owned facilities representing $4.8 billion in replacement value are exposed to drought. No losses are estimated.

Vulnerable Population Groups

The entire 2022 estimated population of 5,069,600 people are considered to be equally exposed to drought. This includes all of the sub-population groups under 18 years of age, older than 65, and at the poverty level.

SVUC Impact Assessment

Drought impacts on Central Region SVUC are summarized by CDC SVI themes and percentile rankings in Table 13. The highest percentages of regional exposure are highlighted using bold text.

[1] Krol, D.U. (Jan. 6, 2023) Biden signs bills that secure long-sought water rights and land for 5 Arizona tribes. *Arizona Republic.* 5 Arizona tribes gain water rights, land from Biden legislation (azcentral.com)

Table 13. Drought SVUC exposure for Central Region

Region	CDC-SVI Assigned Percentile Rank	Percent of Impacted Area by SVI Percentile Rank Range				
		THEME 1 Socio-Economic Status	THEME 2 Household Characteristics	THEME 3 Racial and Ethnic Minority Status	THEME 4 Housing Type/ Transportation	THEMES (ALL) Overall Ranking
Central	NO DATA	6.15%	6.02%	6.01%	6.03%	6.16%
Central	0-0.25	13.03%	23.17%	**32.99%**	15.15%	14.84%
Central	0.25-0.50	17.02%	14.54%	12.75%	27.98%	20.04%
Central	0.50-0.75	**46.43%**	**35.53%**	21.66%	**36.57%**	**38.29%**
Central	0.75-0.90	16.21%	13.67%	12.71%	3.67%	16.32%
Central	0.90-1.00	1.17%	7.06%	13.88%	10.58%	4.34%

The strongest majority of exposure is to areas with an index ranking between 0.25 and 0.75, suggesting Central Region area exposures to drought occur in tracts where social vulnerability is moderate.

Local Jurisdiction Vulnerability

None of the local jurisdictions in the Central Region estimated losses for locally identified critical and non-critical facilities. All assumed that local facilities and populations were equally exposed. See the "Local Agricultural Vulnerability" section for further discussion on locally estimated losses in agricultural sectors.

Specific Areas of Concern

The Central Arizona Project (CAP) delivers approximately 1.4 million feet of Colorado River water to Maricopa and Pinal (Central Region) and Pima (South Region) Counties. Reliance upon Colorado River water may result in a significant water shortage should the current drought cycle persist or worsen. The Colorado River Basin is in the Midst of a 23-year drought that ranks as the region's worst in 1,200 years. The drought has already triggered cuts to the CAP water allocation. According to a report from the Interagency Coordinating Group (ICG, 2022), " *Lake Mead and Lake Powell are at the lowest reservoir elevations since they began filling. The period from 2000 through 2022 is the lowest 23-year inflow in the historic record and one of the lowest in the past 1,200 years. As a result of the exceptionally low runoff conditions over the past three years (2020, 2021, and 2022), drought response operations have been triggered at Lake Powell and Lake Mead, consistent with the 2007 Interim Guidelines and 2019 Drought Contingency Plans."* While higher than expected inflows to Lake Powell and Lake Mead have led to modest increases in water levels within the reservoirs, overall lowering of Lake Mead has triggered delivery reductions that follow a prescribed allocation that is based on a hierarchy of water rights. Those reductions have begun to trigger significant conservation and demand reduction measures for the state's largest population area.

South Region

The South Region is considered to have the highest vulnerability to drought in the state. This is largely due to the heavy reliance upon dwindling groundwater and limited surface water resources. Agencies within Pima County also receive Colorado River water via the CAP, but proportionately less than users in the Central Region. The Wellton-Mohawk Water District is the primary distributor of Colorado River water to Yuma County agricultural users.

State-Owned CFI Exposure and Loss Estimates

All 1,017 state-owned facilities representing $1.6 billion in replacement value are exposed to drought. No losses are estimated.

Vulnerable Population Groups

The entire 2022 estimated population of 1,487,942 people is considered to be equally exposed to drought. This includes all of the sub-population groups under 18 years of age, older than 65, and at the poverty level.

SVUC Impact Assessment

Drought impacts on South Region SVUC are summarized by CDC SVI themes and percentile rankings in Table 14 The highest percentages of regional exposure are highlighted using bold text.

The strongest majority of exposure is to areas with an index ranking between 0.25 and 0.90, and is generally weighted to ranking above 0.50, suggesting South Region area exposures to drought occur in tracts where social vulnerability is moderately high.

Table 14. Drought SVUC exposure for South Region

Region	CDC-SVI Assigned Percentile Rank	Percent of Impacted Area by SVI Percentile Rank Range				
		THEME 1 Socio-Economic Status	THEME 2 Household Characteristics	THEME 3 Racial and Ethnic Minority Status	THEME 4 Housing Type/ Transportation	THEMES (ALL) Overall Ranking
South	NO DATA	7.93%	7.93%	7.85%	7.93%	7.93%
South	0-0.25	5.22%	7.46%	15.40%	10.74%	5.32%
South	0.25-0.50	**36.64%**	24.95%	14.32%	10.81%	21.34%
South	0.50-0.75	26.20%	24.97%	**38.82%**	24.94%	**34.01%**
South	0.75-0.90	23.55%	**29.48%**	3.70%	**27.38%**	23.95%
South	0.90-1.00	0.46%	5.20%	19.91%	18.21%	7.44%

Local Jurisdiction Vulnerability

None of the local jurisdictions in the North Region estimated losses for locally identified critical and non-critical facilities. All assumed that local facilities and populations were equally exposed. See the "Local Agricultural Vulnerability" section for further discussion on locally estimated losses in agricultural sectors.

Specific Areas of Concern

Colorado River water reductions will impact the Tucson area in a manner similar to that of the Central Region. Persistence or worsening of the current drought will also force a significant increase in groundwater withdrawals that may translate into other hazards, such as increased fissure and subsidence development and the lowering of baseflow elevations in critical perennial streams and rivers. The South Region is particularly vulnerable to drought due to the heavy reliance on groundwater supplies. Cochise County, for example, relies almost exclusively on groundwater wells. The lack of surface water supplies has increased pumping, and past and present drought cycles have failed to recharge the aquifers. Severe subsidence, desiccation cracks, and earth fissures have developed in the area. Large cottonwoods and mesquite trees in the riparian area are dying near Willcox, Benson, and McNeal due to a lack of precipitation and a lowering of stream base-flow levels.

Local Agricultural Vulnerability –

Thirteen of fifteen local county hazard mitigation plans included drought as a top hazard and expressed vulnerability as a potential impact on certain sectors of the county's economy and natural resources, including:

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

One measure of vulnerability used in the county plans was the amount of USDA disaster payments received by local farmers and ranchers. Using the same data source[1], Figure 6 summarizes the reported disaster payments received by each county and summarized by region for the period of 1995 to 2021. It should be noted that claims attributed directly to drought are on the order of $1.2 million for the State over the period of 1995 to 2020. On average, North Region farmers and ranchers (mostly ranchers) received the highest amount at $3.0 million annually. The Central Region was next with $2.5 million per year. The South Region was the lowest, with $2.3 million per year.

[9] Environmental Working Group, 2023, data accessed at the following link: https://farm.ewg.org/index.php

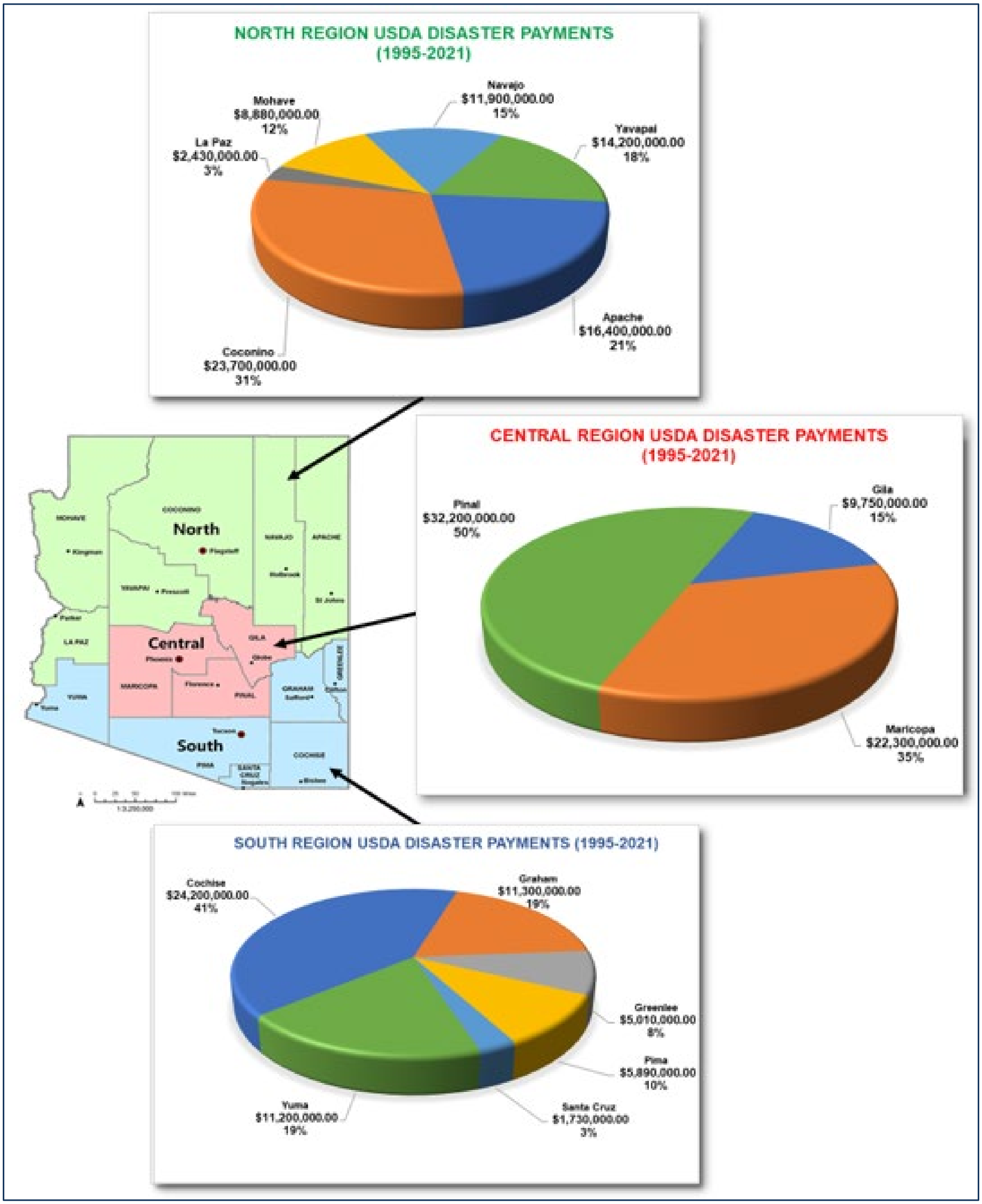


Figure 6. Arizona drought related USDA disaster payments by region

RESOURCES

Sources

AZ Dept of Water Resources – Arizona Drought Task Force

ASU – State Climate Office

UofA – Climate Assessment for the Southwest

References

AZ Governor Janet Napolitano, March 24, 2003. EO 2003-12: AZ Drought Task Force Plan.

ADWR, 2020, publication, Water Your Facts | Arizona WaterFacts

Environmental Working Group, 2017, *Farm Subsidy Database,* http://farm.ewg.org/progdetail.php?fips=04000&progcode=total_dis

FEMA 1997, *Multi-Hazard Identification and Risk Assessment – A Cornerstone of the National Mitigation Strategy.*

Frankson, R., K.E. Kunkel, L.E. Stevens, D.R. Easterling, T. Brown, N. Selover, and E. Saffell, 2022: Arizona State Climate Summary 2022. NOAA Technical Report NESDIS 150-AZ. NOAA/NESDIS, Silver Spring, MD, 5 pp.

Gonzalez, P., G.M. Garfin, D.D. Breshears, K.M. Brooks, H.E. Brown, E.H. Elias, A. Gunasekara, N. Huntly, J.K. Maldonado, N.J. Mantua, H.G. Margolis, S. McAfee, B.R. Middleton, and B.H. Udall, 2018: Southwest. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 1101–1184. doi: 10.7930/NCA4.2018.CH25

High Plains Regional Climate Center, https://hprcc.unl.edu/maps.php?map=ACISClimateMaps

Hupka, S. (July 21, 2023) Rio Verde Foothills gathers for its first local government meeting on water supply. Arizona Republic.

Kolsrud, E. (2017) *House Development Challenges Benson, San Pedro River*. AZ Sonora News

Krol, D.U. (Jan. 6, 2023) Biden signs bills that secure long-sought water rights and land for 5 Arizona tribes. Arizona Republic. 5 Arizona tribes gain water rights, land from Biden legislation (azcentral.com)

Loomis, B. (June 1, 2023) Arizona will halt new home approvals in parts of metro Phoenix as water supplies tighten. Arizona Republic

McKee, T.B., Doesken, N.J., Kleist, J. 1995. *Drought monitoring with multiple time scales.* Ninth Conference on Applied Climatology, American Meteorological Society, Jan 15-20, 1995, Dallas TX, pp. 233-236.

Meko, D. M., Woodhouse, C.A., Baisan, C.H., Knight, T., Lukas, J.J., Hughes, M.K., Salzer, M.W. 2007, *Upper Colorado River Flow Reconstruction.* From Report: David M. Meko, Connie A. Woodhouse, Christopher A. Baisan, Troy Knight, Jeffrey J. Lukas, Malcolm K. Hughes, and Matthew W. Salzer. 2007. *Medieval drought in the upper Colorado River Basin*, *Geophysical Research Letters* Vol 34, L10705, May 2007.

National Drought Mitigation Center, "US Drought Monitor." http://droughtmonitor.unl.edu/

NOAA National Centers for Environmental information, Climate at a Glance: Statewide Time Series, published July 2023, retrieved on August 8, 2023 from https://www.ncei.noaa.gov/access/monitoring/climate-at-a-glance/statewide/time-series

NWS, Climate Prediction Center website, http://www.cpc.ncep.noaa.gov/products/expert_assessment/sdo_summary.php

Steinemann, A.C., and Cavalcanti, L.F.N. 2006. *Developing multiple indicators and triggers for drought plans.* Journal of Water Resources Planning and Management, Vol 132(3):164-174.

US Dept of Agriculture, Aug 13, 1999. “Glickman Declares Pennsylvania, 13 Arizona Counties as Disaster Areas and Announces Additional Drought Assistance.”

US Dept of Agriculture, May 17, 2002, “Veneman Designates Arizona as Drought Disaster Area.”

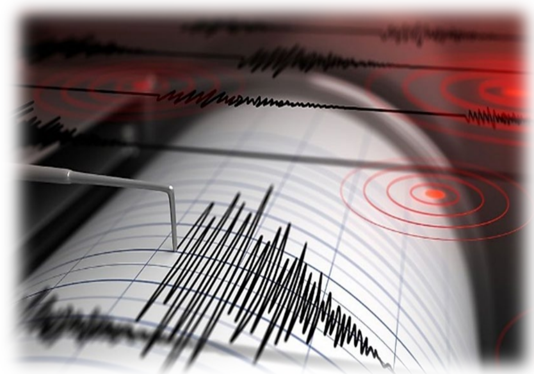
US Dept of Agriculture, AZ Agricultural Statistics Service, 2004, 2002 Annual Statistics Bulletin

US Dept of Agriculture, 2004, News Release No. fs0199.04

EARTHQUAKE

DESCRIPTION

Earthquakes have been described as shaking, ground-rolling vibrations caused by stress release along faults. Earthquakes can occur at any time of the year and may result in strong ground motion with a the possibility of a ground surface rupture, slope failure (landslide or rockslide), liquefaction, and dam/levee failures. These factors can lead to a particularly destructive effect from this hazard. Even minor earthquakes can cause critical damage and loss of life.



Surface Rupture – Surface rupture is caused by the differential movement of two sides of a fault and is ultimately expressed at the earth's surface. Linear structures such, as railways, highways, pipelines, and tunnels built across active surface faults, are extremely susceptible to being damaged by earthquakes. Displacement along faults, both regarding 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).

Liquefaction – 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 soil) for a brief period and cause 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, tip or collapse).

Earthquake energy – Earthquake energy 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 distance from the epicenter, depth, sub-surface, surface materials (e.g., soil, bedrock), topography, and building types. An earthquake is intensity also depends on the directivity of the seismic waves generated by the fault; therefore, location with respect to the fault and type of fault also determines the intensity.

Magnitude is a number that characterizes the relative size of an earthquake and is based on the measurement of the maximum motion recorded by a seismograph. Several scales have been defined, but the most commonly used are (1) local magnitude (ML), which is commonly referred to as "Richter magnitude," (2) surface-wave magnitude (Ms), (3) body-wave magnitude (Mb), and (4) moment magnitude (Mw). The Mw scale is the most commonly used and is an expression of the total energy released from an earthquake. All magnitude scales should yield approximately the same value for any given earthquake with only minor variations. Intensity is a measure of how strong the shock was felt at a particular location and is expressed by the Modified Mercalli

Intensity (MMI) scale. Peak ground acceleration (PGA) measures the rate of change of ground motion relative to the rate of acceleration due to gravity.

It is possible to approximate the relationship between PGA, the magnitude, and the intensity, as shown in Table 15. The relationships are dependent upon specifics such as the distance from the epicenter, the depth of the epicenter, and the type of surficial material. For example, an earthquake with 10% PGA would roughly correspond to an intensity of V or VI, a magnitude of 5.0-5.9, and could be described as "felt by everyone, overturning unstable objects, and/or moving heavy furniture."

Table 15. Earthquake PGA, magnitude and intensity comparison

PGA (%g)	Magnitude	Intensity (MMI)	Description (MMI)
<0.17	1.0 - 3.0	I	**I.** Not felt except by a very few under especially favorable conditions.
0.17 - 1.4	3.0 - 3.9	II - III	**II.** Felt only by a few persons at rest, especially on building upper floors. **III.** Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motorcars 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.

PGA (%g)	Magnitude	Intensity (MMI)	Description (MMI)
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, 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 & level are distorted. Objects thrown into the air.
Source: Wald, Quitoriano, Heaton, and Kanamori, 1999.			

HISTORY

There has been no federal and only one state disaster declaration related to earthquakes. The state declaration was for flooding that resulted from a 1979 Imperial Valley earthquake (see below). The southeastern and southwestern corners of the state have been subject to the greatest intensity earthquakes. The earthquakes affecting the southeastern corner have originated in Mexico. Most of the earthquakes felt in southwestern corner have originated in the southern California and northern Mexico. Northern Arizona earthquakes have most commonly occurred between Flagstaff and the Grand Canyon. The following are a few examples of significant historic earthquakes that have occurred in or significantly impacted the state:

- 2014 - An Mw 5.3 earthquake occurred southeast of Safford with thousands of aftershocks, including an Mw 4.0.
- 2010 - A magnitude 7.2 earthquake centered in Baja California, Mexico about 19 miles southeast of Mexicali. The earthquake was felt in the Yuma area and caused minor damage and relatively short power outages for residents in Yuma, Gadsden, and Somerton areas.
- 1979 - A magnitude 6.6 earthquake centered in the southern Imperial Valley near El Centro, California, sent earth wave ripples through the Yuma Valley area and caused minor flooding. This resulted in a state declaration.
- 1940 - A magnitude 7.1 Imperial Valley earthquake caused $50,000 in damage in the Yuma area. Four water service lines were broken, and the irrigation system was badly damaged. In Somerton, roads were buckled and bridges were dislodged, and a major portion of the

geologic floodplain area experienced liquefaction due to the elevated water tables and sandy soils. The tremors were also felt in Phoenix and Tucson (DuBois, et.al., 1980).

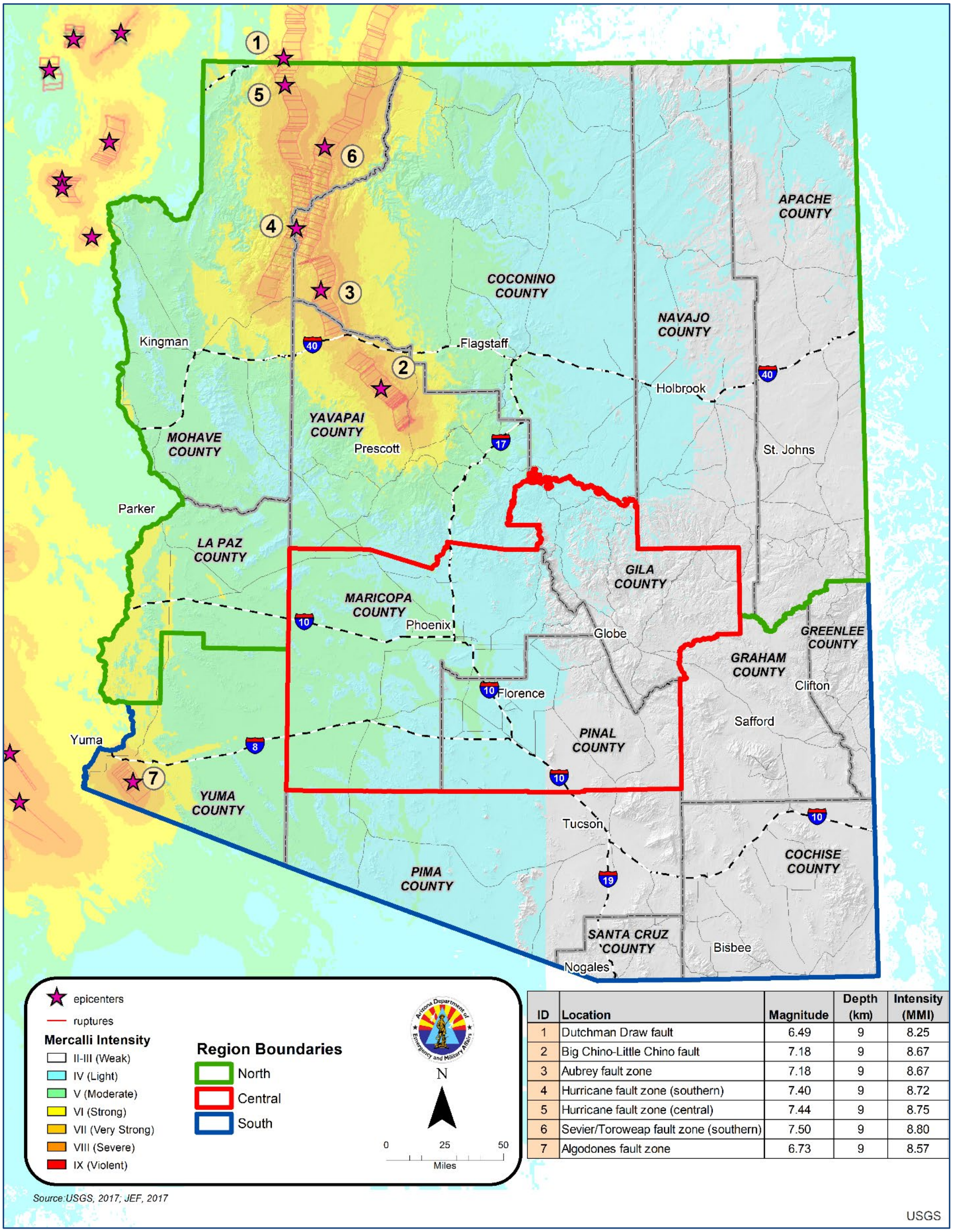
- 1910 - A series of 52 small earthquakes caused a construction crew in the Coconino Forest near Flagstaff to break camp and leave the area as boulders rolled down on the camp from nearby mountains. The shocks grew in intensity over a two-week period until September 24, when a magnitude 6.0 shock was felt throughout northern Arizona. Adobe houses were cracked, and some chimneys fell over (USGS, Sept. 12, 2003).
- 1906 - A magnitude 6.2 earthquake occurred in Flagstaff and was the first damaging earthquake documented to have centered within Arizona borders. The quake caused Flagstaff schools to shut down and was the first of a string of earthquakes to impact the northern area in the early 1900s (AzCentral.com, 2017).
- 1887 - The Sonoran earthquake caused significant destruction in southern Arizona towns, including Tucson, and was one of the largest earthquakes in North American history. At the time this earthquake occurred, there were only about 90,000 people living in the Arizona Territory. The epicenter was located approximately 100 miles south of Douglas, Arizona, along the Pitaycachi fault in Mexico, and caused great destruction and 51 deaths near its epicenter. The earthquake, estimated to be a magnitude 7.4, was so large that it was felt from Guaymas, Mexico to Albuquerque, New Mexico (DuBois & Smith, 1980; McGarvin, 1987; DEMA/EM, March 1998; Bausch & Brumbaugh, May 23, 1994).

PROBABILITY/EXTENT

Each year, the Arizona Geological Survey’s seismic network seismometers record hundreds of earthquakes in Arizona. However, most of these events are low-magnitude earthquakes that are generally not felt and do not produce damage. Accordingly, the probability of a damaging earthquake occurring is low to medium for much of the state. The exception to this is the extreme southwest corner of the state (Yuma area), which has a greater probability of being damaged by an earthquake due to the proximity of the high-hazard seismic areas and active faults located in California and northern Mexico.

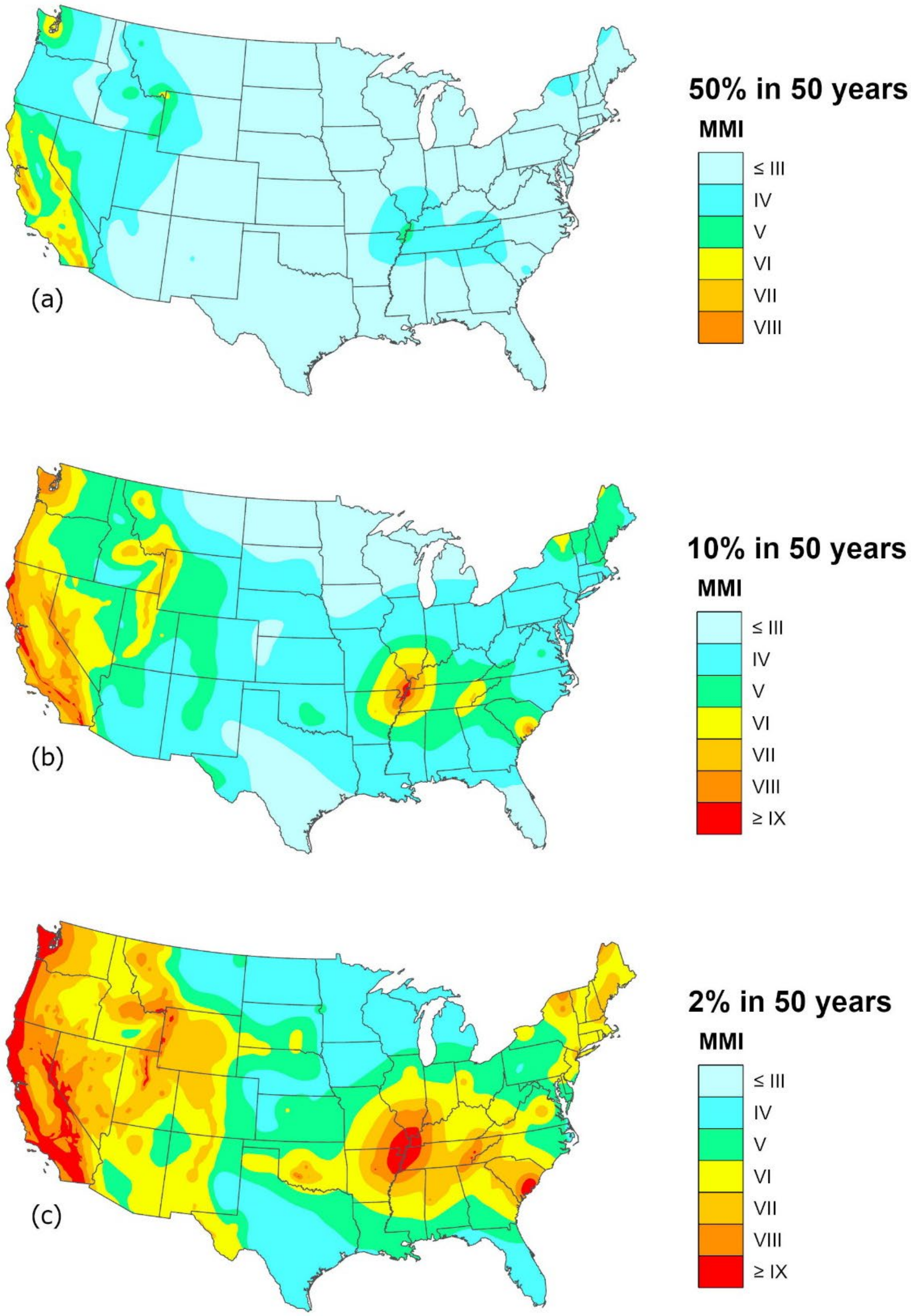
In the 2014 release of the NHSM (Petersen et al., 2014), the USGS included what they called scenario ShakeMaps. A scenario ShakeMap is a predictive tool that represents the potential of a future earthquake by assuming a particular magnitude, epicenter location, and fault-rupture geometry and estimating shaking intensity and magnitudes using a variety of strategies. Map 9 shows seven scenario locations that were chosen to represent the areas with the highest probability of seismic activity in or near the state.

It is noted that in 2019, the USGS updated the national seismic hazard maps (NSHM) (Rukstales et al., 2019) for the conterminous United States and is currently working on a 2023 update to be released in late 2023. One of the products included with the 2019 is release are gridded rasters depicting peak ground acceleration ground motion values for 50, 10, and 2 percent probability of exceedance in 50 years that have been converted to equivalent modified Mercalli intensity (MMI) using the relationships of Worden and others (2012). Plots of the map results are shown in Figure 7.



ID	Location	Magnitude	Depth (km)	Intensity (MMI)
1	Dutchman Draw fault	6.49	9	8.25
2	Big Chino-Little Chino fault	7.18	9	8.67
3	Aubrey fault zone	7.18	9	8.67
4	Hurricane fault zone (southern)	7.40	9	8.72
5	Hurricane fault zone (central)	7.44	9	8.75
6	Sevier/Toroweap fault zone (southern)	7.50	9	8.80
7	Algodones fault zone	6.73	9	8.57

Map 9. USGS ShakeMap scenarios for or near Arizona



2018 Modified Mercalli Intensity (MMI) hazard maps of the conterminous United States showing estimates of earthquake shaking in terms of (a) 50% probability of exceedance (PE) in 50 years (likely), (b) 10% PE in 50 years (infrequent) and (c) 2% PE in 50 years (rare). Maps are based on peak ground acceleration, NEHRP site class B/C (V_{s30} = 760 m/s).

Figure 7. MMI maps showing 50, 10, and 2% probabilites of exceedance in 50-years

The Arizona Geological Survey (Pearthree and Bausch, 1999) prepared a map depicting earthquake hazard zones in Arizona using historical seismicity, damages, and proximity to active or young faults. Four categories of hazard (High, Moderate, Moderate-to-Low, and Low) were developed. During the review and update of this Plan, AZGS officials recommended some slight adjustments to the zone boundaries in the Prescott and south of Kingman areas to acknowledge the risk posed by newly mapped quaternary faults in those regions. The updated zones are depicted statewide on Map 10 and include notations on the area of adjustment. Detailed hazard profiles for the North and South regions are shown on Map 11 and Map 12. No map is provided for the Central region due to the lack of risk.

WARNING TIME

Warning time for earthquake events is essentially none, although multiple, small-magnitude warning tremors may precede some large-magnitude events.

FUTURE CONDITIONS

Climate Considerations

The impact of climate change on earthquakes in Arizona is negligible throughout all three of the state’s regions. There has been some speculation that rises in sea levels are changing pressure and weight distribution around coastal fault areas and may have the potential to trigger seismic activity along those locations. The current literature has not established the translation of those impacts to Arizona seismic activity. AZGS officials also noted that concerns about induced earthquakes related to climate change mitigation through carbon sequestration practices, have been raised. As of this plan update, there is not any known carbon sequestration occurring in Arizona.

Changes in Development

For most of Arizona, increased development will have only a minor impact on the state’s vulnerability to earthquake events. Hazard specific changes in vulnerability to state CFI due to changes in development are essentially neutral for earthquake related hazards.

North Region

The majority of current and anticipated growth in the North Region is expected to expand from existing cities and towns with concentrations around Flagstaff,, Prescott and Kingman areas. Prescott and Flagstaff area development is exposed to a moderate earthquake hazard and has the greatest vulnerability increase.The Kingman area is within a moderately low to low earthquake hazard and development is not expected to appreciably change the vulnerability.

Central Region

The most significant development in the Central Region is expected to occur in the Phoenix Metropolitan Area, which has a low earthquake risk. Accordingly, development changes for the Central Region are not expected to appreciably change the risk.

South Region

The most significant development in the South Region is expected to occur in the Tucson Metropolitan Area, which generally has a low earthquake hazard. Limited growth in the Yuma (Yuma County) and Douglas (Cochise County) will expand the earthquake related risk to those communities, with the greatest risk being the westernmost Yuma Valley area. Jenny and Reynolds (1989) noted that if an earthquake of similar magnitude to the 1887 Sonoran event were to occur under the presently developed conditions, the damages to southeastern Arizona communities' population and infrastructure would be extensive.

VULNERABILITY ASSESSMENT

Vulnerability to earthquake hazards for this Plan is estimated using the Pearthree (1999 with 2023 adjustments) hazard zones. Structure losses are estimated using average historic, event-based building loss ratios published by FEMA for each Arizona county with the 2023 National Risk Index (FEMA, 2023). The ratios are applied to the high and moderate (medium) hazard zone exposure CFI replacement costs. The estimation of potential exposure to the identified high and moderate (medium) earthquake hazard zones was accomplished using GIS tools to intersect the human and state-owned CFI data with the earthquake hazard limits depicted statewide on Map 10. No losses or exposure estimates are made for assets located in the moderate-to-low and low earthquake hazard areas. Accordingly, only estimates have been made for the North and South regions, as depicted on Map 11 and Map 12.

Six counties (Cochise, Coconino, Mohave, Pima, Pinal, and Yavapai) included earthquakes as a significant hazard in their local county risk assessments.

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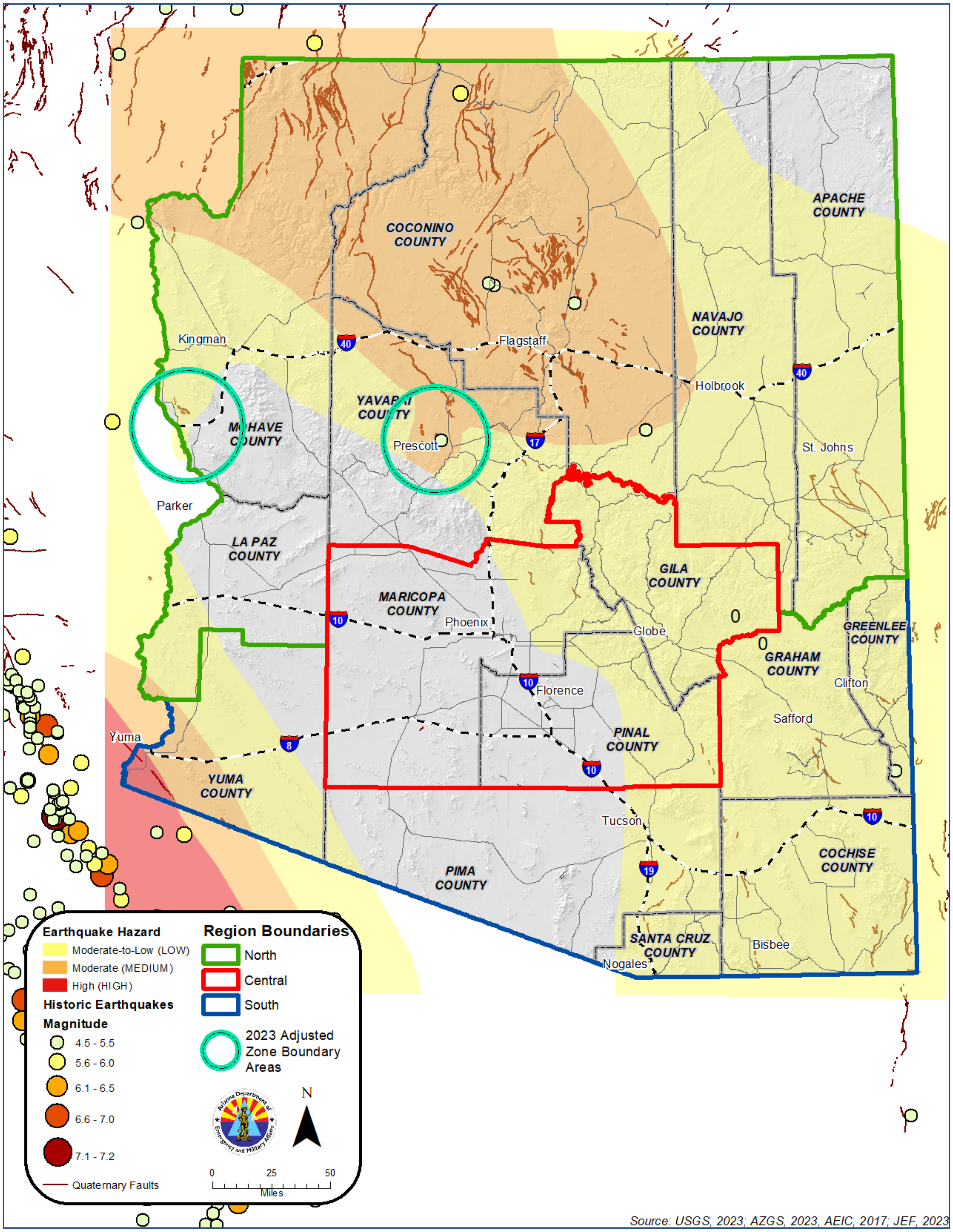
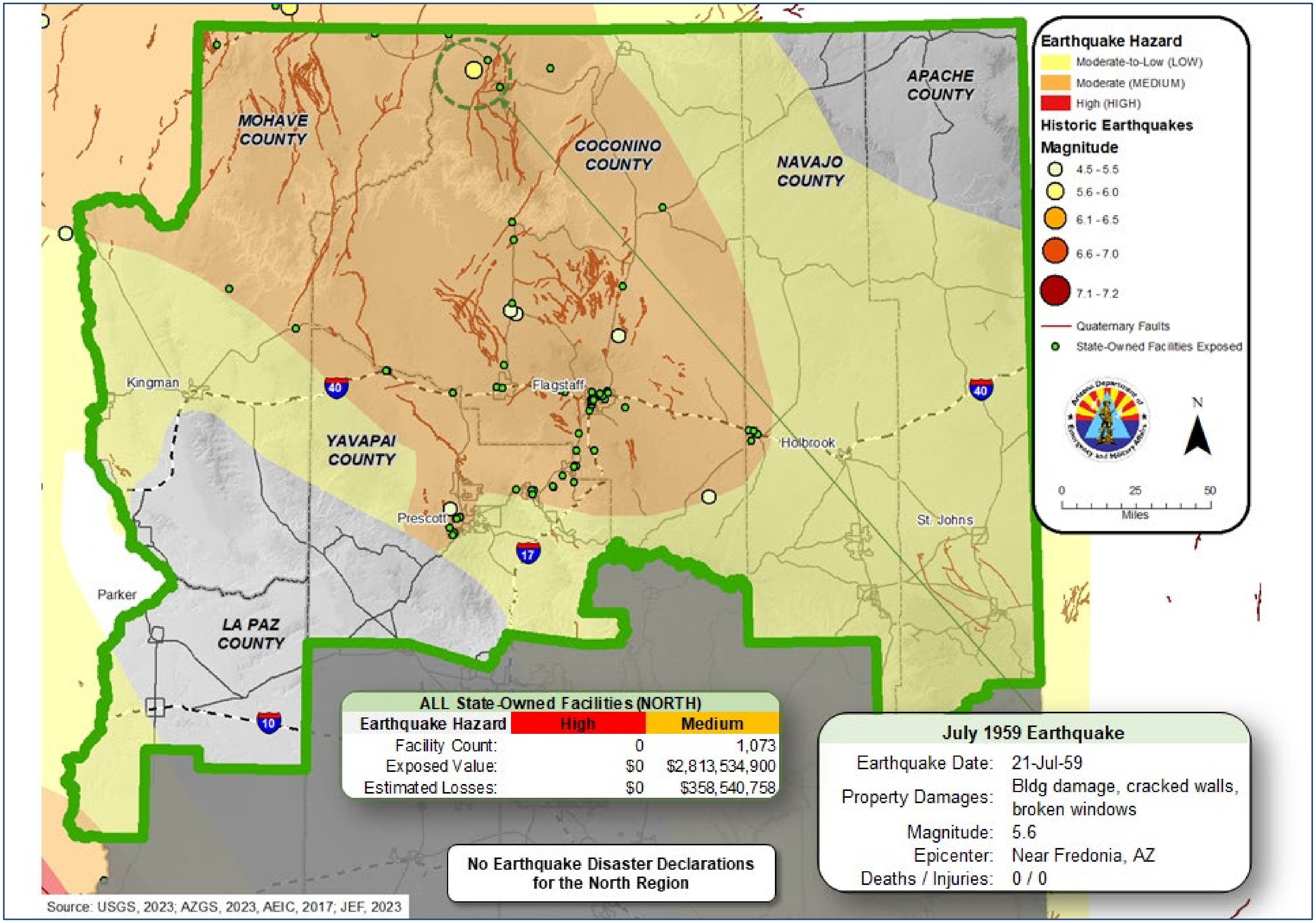
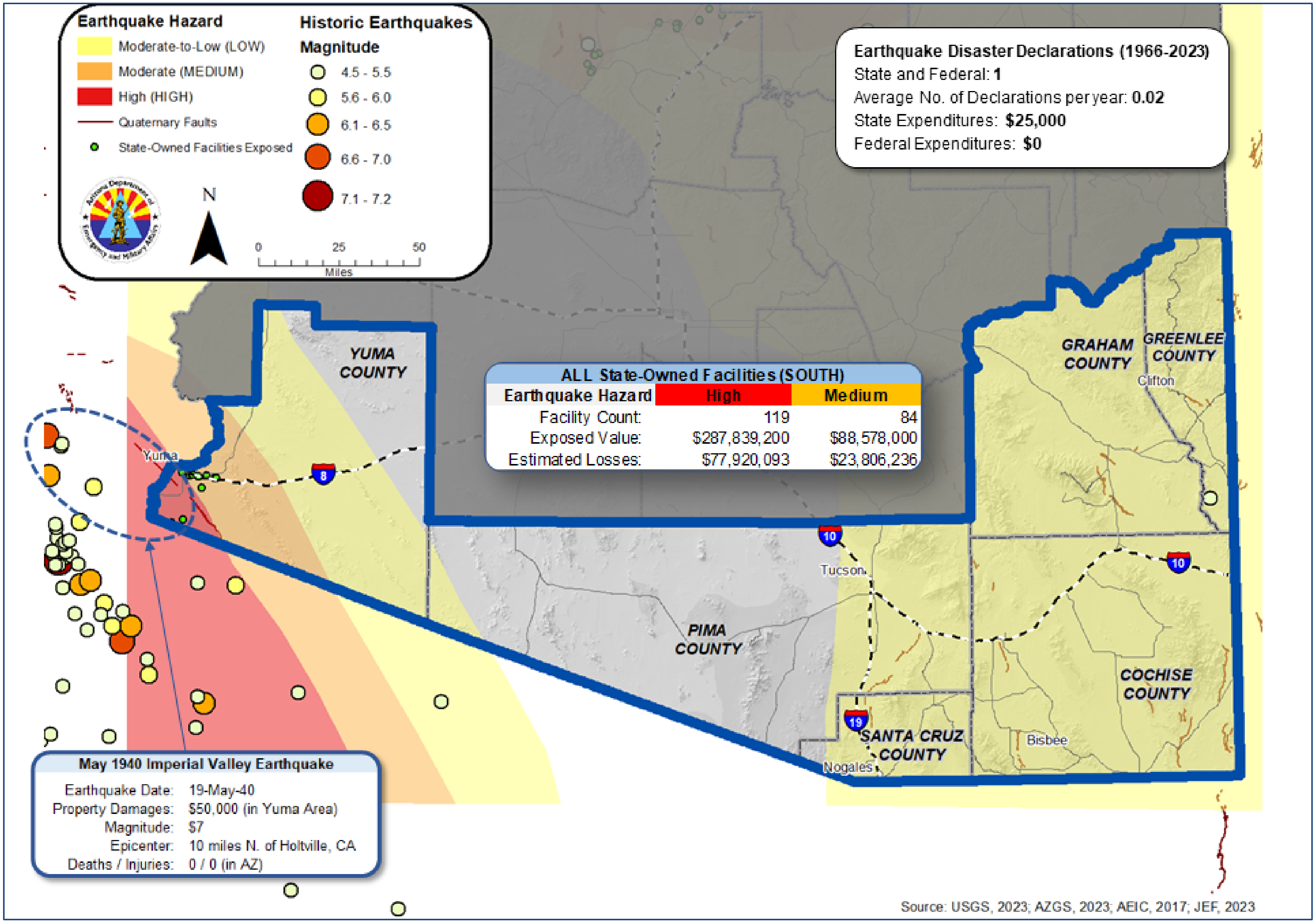


Map 10. Earthquake hazard zones for Arizona



Map 11. Earthquake hazard for North Region



Map 12. Earthquake hazard for Soutth Region

North Region

The North Region, depicted in Map 13, is the second-most vulnerable region of the state, primarily due to the elevated earthquake hazard, number of young faults, seismic history, and population at risk. There is no exposure to high-hazard zones in the North Region, only moderate (medium) and moderate-to-low (low) zones.

State-Owned CFI Exposure and Loss Estimates

A total of 681 state-owned CFI, 95.1% of the total statewide medium hazard exposure, are located in the North Region. The exposed facilities represent total replacement values of $789.5 million, with an estimated $97.0 million in potential average annual losses.

Additional state-owned facilities vulnerable to earthquakes are the Arizona Department of Transportation (ADOT) operated and maintained freeways, highways, and state routes, including the numerous bridges and culverts. Typical impacts might include pavement cracking and displacement, structure cracking, miss-alignments, and potential bridge failure.

Vulnerable Population Groups

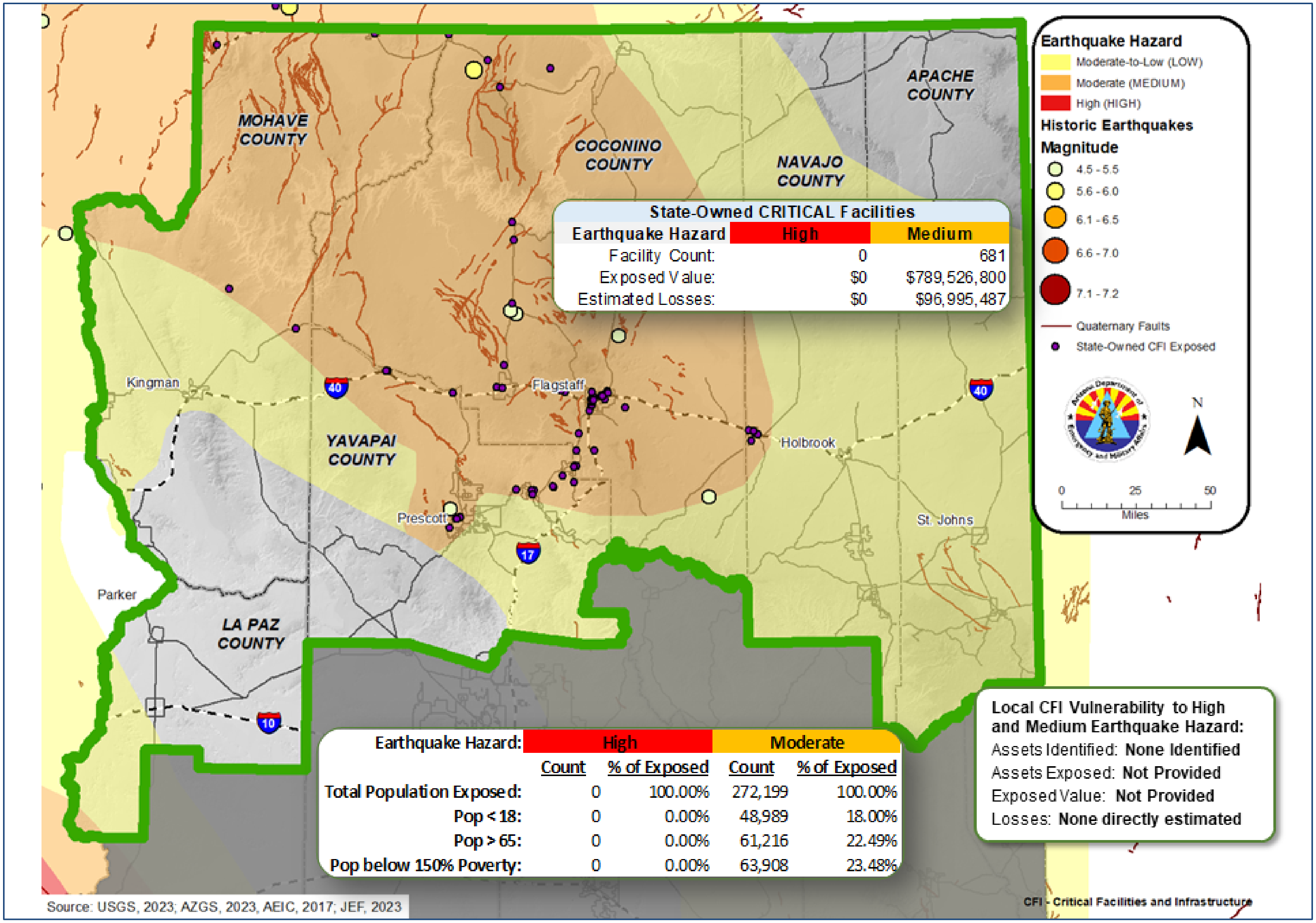
The 2022 estimated total population for the North Region is 764,112 people. Approximately 272,199 persons, 35.62% of the total population, are located within moderate (medium) earthquake hazard areas and none in a high hazard area.

SVUC Impact Assessment

CDC SVI themes and percentile rankings summarize earthquake moderate (medium) hazard impacts on North Region SVUC in Table 16. The highest percentages of regional exposure are highlighted using bold text. The results indicate that the SVUC exposure is moderate for the region, with the majority of impacts centering on 50th-percentile communities and populations.

Table 16. Earthquake moderate (medium) hazard SVUC exposure for North Region

Region	CDC-SVI Assigned Percentile Rank	Percent of Impacted Area by SVI Percentile Rank Range				
		THEME 1 Socio-Economic Status	THEME 2 Household Characteristics	THEME 3 Racial and Ethnic Minority Status	THEME 4 Housing Type/ Transportation	THEMES (ALL) Overall Ranking
North	NO DATA	0.24%	0.24%	0.07%	4.17%	4.17%
North	0-0.25	17.78%	**32.67%**	25.33%	6.10%	12.06%
North	0.25-0.50	**31.99%**	17.71%	15.86%	**35.14%**	19.37%
North	0.50-0.75	30.03%	12.52%	**38.76%**	19.23%	**43.70%**
North	0.75-0.90	19.71%	17.03%	0.38%	19.97%	19.98%
North	0.90-1.00	0.24%	19.83%	19.60%	15.36%	0.72%



Map 13. Earthquake vulnerability for North Region

Local Jurisdiction Vulnerability

None of the local jurisdictions in the North Region estimated earthquake-related losses for locally identified critical and non-critical facilities. Discussions focused on disruption to transportation and major utility corridors and potential damage to local water and wastewater infrastructure.

Specific Areas of Concern

There are several small dams located in areas upstream of significant population centers that would likely not survive a significant ground-shaking event. Failure of these structures would both create a significant floodwave and cause a significant loss of surface water for municipal use. For example, Lake Mary Reservoir is constructed along an active fault graben and provides the City of Flagstaff with a significant portion of its potable drinking water. Activation of the fault could destroy the reservoir, release floodwaters downstream, and cause a significant loss to Flagstaff water supplies. Failures or significant damage to major interstate and rail transportation corridors would be economically crippling as well.

Central Region

The Central Region is the least vulnerable region in the state, largely due to a low earthquake hazard and essentially no significant seismic activity in the last couple of centuries. No vulnerability map is provided for the Central Region.

State-Owned CFI Exposure and Loss Estimates

None of the state-owned CFI is located within a high or medium earthquake hazard zone, and no losses are estimated.

Vulnerable Population Groups

None of the 2022 estimated population of 5,094,193 people are located within a high or moderate (medium) earthquake hazard area. This extends to all of the sub-population groups under 18 years of age, older than 65, and poverty level.

SVUC Impact Assessment

No SVUC impacts due to high or moderate (medium) earthquake hazards were provided for the Central Region.

Local Jurisdiction Vulnerability

None of the local jurisdictions in the Central Region considered earthquakes as a significant hazard in their risk assessments. Accordingly, no local critical and non-critical facilities loss estimates were done.

Specific Areas of Concern

The losses and damages could be catastrophic if a significant earthquake occurs in or near the Phoenix Metropolitan Area. However, the probability of such an occurrence happening is very low.

South Region

The South Region, shown in Map 14, is the most vulnerable region in the state. This is largely due to the high risk associated with the elevated levels of seismic activity, active faults, a history of strong earthquakes in the nearby Imperial Valley and Baja California areas, and their impacts on the extreme southwest corner of the South Region. Most of the Yuma County population centers are located within a high or moderate (medium) earthquake hazard area.

State-Owned CFI Exposure and Loss Estimates

A total of 100 and 35 state-owned CFI, or 100% and 4.9% of the statewide exposure, are located within a high or moderate (medium) hazard area. The exposed facilities represent total replacement values of $272.1 million and $43.5 million, with an estimated $73.7 and $11.7 in potential single event-based losses. Additional state-owned facilities vulnerable to earthquakes are ADOT-operated and maintained freeways, highways, and state routes, including numerous bridges and culverts. Typical impacts include pavement cracking and displacement, structure cracking, miss-alignments, and potential bridge failure.

Vulnerable Population Groups

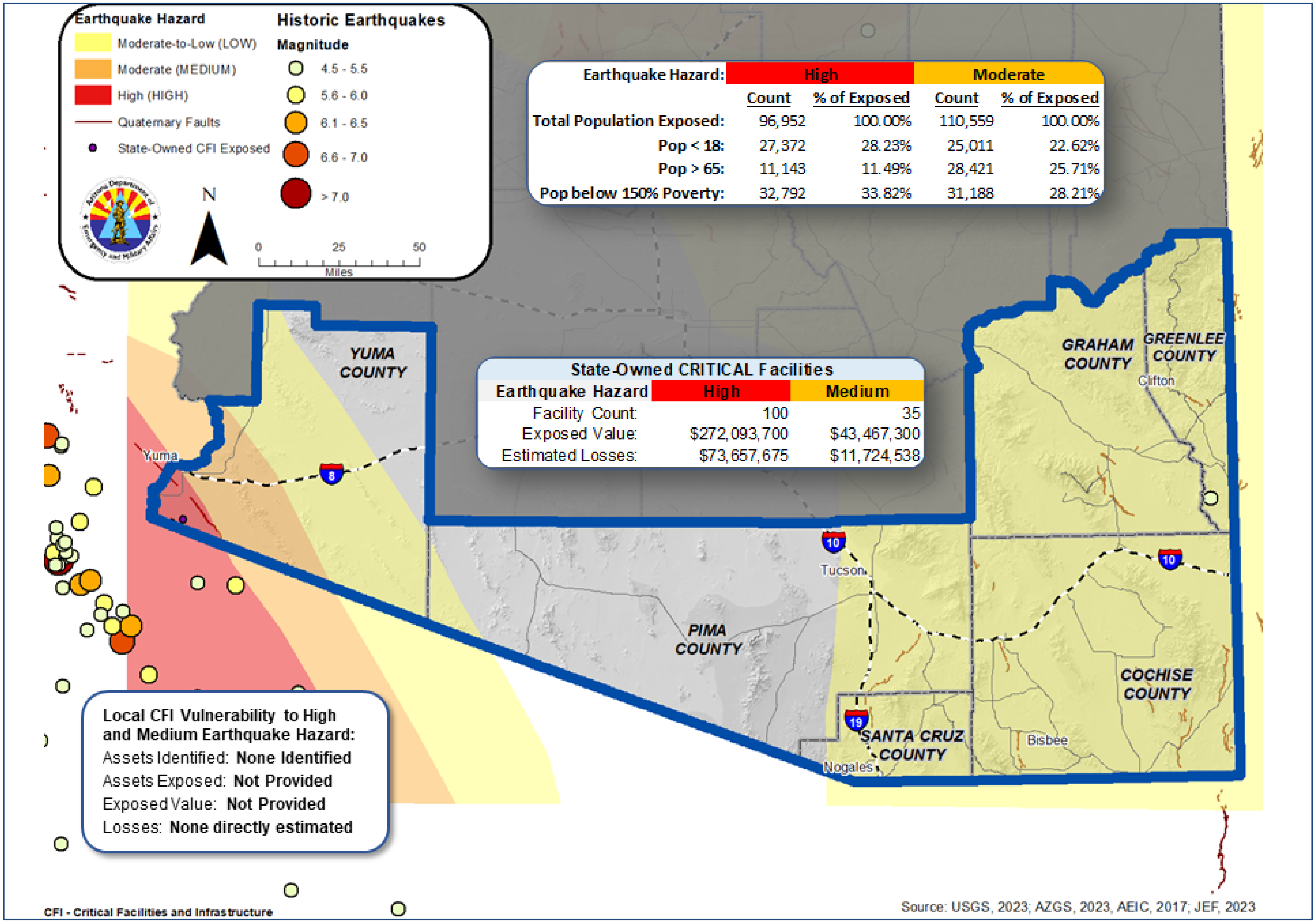
The 2022 estimated total population for the South Region is 1,487,942 people. Approximately 6.60% and 8.07% of the total regional population, or 96,952 and 110,559 persons, are located within the high and moderate (medium) earthquake hazard areas. Other statistics for under 18, over 65, and under 150% of poverty are shown on Map 14.

SVUC Impact Assessment

Earthquake high and moderate (medium) impacts on Central Region SVUC are summarized by CDC SVI themes and percentile rankings in Table 17 and Table 18, respectively. The highest percentages of regional exposure are highlighted using bold text. The strongest majority of exposure is to areas with an index ranking between 0.50 and 0.75, which would suggest a moderate SVUC vulnerability to high earthquake hazards in South Region communities. It is noted that for both hazard classes, a significant portion of the exposure is with "NO DATA" CDC SVI themes. This is due to the large area occupied by the Yuma Proving Grounds, which does not have any population.

Table 17. Earthquake high hazard SVUC exposure for South Region

Region	CDC-SVI Assigned Percentile Rank	Percent of Impacted Area by SVI Percentile Rank Range				
		THEME 1 Socio-Economic Status	THEME 2 Household Characteristics	THEME 3 Racial and Ethnic Minority Status	THEME 4 Housing Type/ Transportation	THEMES (ALL) Overall Ranking
South	NO DATA	28.407%	28.407%	20.198%	28.407%	28.407%
South	0-0.25	0.000%	1.075%	0.000%	5.331%	1.075%
South	0.25-0.50	4.847%	0.322%	0.000%	3.140%	3.355%
South	0.50-0.75	**35.452%**	**31.696%**	12.344%	**43.058%**	**38.443%**
South	0.75-0.90	19.600%	13.964%	29.105%	5.194%	7.839%
South	0.90-1.00	11.695%	24.536%	**38.353%**	14.870%	20.880%



Map 14. Earthquake vulnerability for South Region

Table 18. Earthquake moderate (medium) hazard SVUC exposure for South Region

Region	CDC-SVI Assigned Percentile Rank	Percent of Impacted Area by SVI Percentile Rank Range				
		THEME 1 Socio-Economic Status	THEME 2 Household Characteristics	THEME 3 Racial and Ethnic Minority Status	THEME 4 Housing Type/ Transportation	THEMES (ALL) Overall Ranking
South	NO DATA	59.29%	59.29%	59.29%	59.29%	59.29%
South	0-0.25	1.41%	1.44%	3.20%	0.05%	0.39%
South	0.25-0.50	**23.82%**	4.04%	13.25%	5.51%	4.87%
South	0.50-0.75	4.14%	10.79%	**21.81%**	16.42%	**25.22%**
South	0.75-0.90	10.82%	**22.18%**	2.39%	**18.66%**	8.87%
South	0.90-1.00	0.53%	2.26%	0.06%	0.07%	1.38%

Local Jurisdiction Vulnerability

Cochise County performed a standard event-based HAZUS® analysis assuming a magnitude 6.9 earthquake near the historic epicenter of a 1939 earthquake near Duncan. The general-building related losses were estimated at $3.5 million, with over 70% being attributed to residential structures. The total economic loss was estimated at $3.7 million. Losses to local CFI were not appreciable. Pima County also reported the use of HAZUS® to generate average annualized amounts of approximately $2.3 million in combined residential and commercial losses for the county. No mention is given to local CFI exposure or losses. None of the other South Region counties included earthquakes in their risk assessments.

Specific Areas of Concern

The relatively shallow groundwater table and sandy loam soils that dominate the Yuma and Gila Valley areas adjacent to the Colorado and Gila Rivers pose a significant risk to seismically induced liquefaction zones. Damages to agricultural resources and infrastructure by liquefaction could prove economically catastrophic if a seismic event were to occur during the peak of the growing season. Historic mining and tunneling below Tombstone, Douglas, Nogales, and San Luis pose a seismic risk in that if an event were to occur, it could trigger a collapse of known and unknown subsurface cavities and tunnels in the area.

RESOURCES

Sources

AZ Earthquake Information Center – NAU, https://aeic.nau.edu/

Arizona Geological Survey, https://azgs.arizona.edu/center-natural-hazards/earthquakes

US Geological Survey – Earthquake Hazards Program, https://earthquake.usgs.gov/

US Geological Survey Earthquake Scenario Map (BSSC 2014), http://usgs.maps.arcgis.com/apps/webappviewer/index.html?id=14d2f75c7c4f4619936dac0d14e1e468

References

AZ Central, 2017, *A Brief History of Earthquake Activity in Arizona*, https://www.azcentral.com/story/news/arizona/2014/06/30/arizona-earthquake-timeline/11787839/

Bausch, D.B. and Brumbaugh, D.S.:

- May 23, 1994. Seismic Hazards in Arizona –Arizona Ground Shaking Intensity & 100 yr Acceleration Contour Maps
- June 13, 1994. Phoenix Community Earthquake Hazard Evaluation, Maricopa County, AZ.
- May 23, 1996. Yuma County Earthquake Hazard Evaluation, Yuma County, AZ.
- May 7, 1997. Flagstaff Community Earthquake Hazard Evaluation, Coconino County, AZ.
- June 28, 1997. Earthquake Hazard Evaluation Yavapai County, AZ.
- July 30, 1997. Earthquake Hazard Evaluation Mohave County, AZ.
- August 31, 1997. Earthquake Hazard Evaluation La Paz County, AZ.

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

Brumbaugh, D.S., 1980, Analysis of the Williams, Arizona earthquake of November 4, 1971: Seismological Society of America, Bulletin, v. 70, p. 883-891.

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: AZ Bureau of Geology and Mineral Technology Bulletin 193, 456 p., 1 sheet.

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

FEMA, 2023, National Risk Index, March 2023 (version 1.19.0) Edition. Data accessed at: https://hazards.fema.gov/nri/data-resources.

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

McGarvin, T.G., 1987, *The 1887 Sonoran Earthquake: It Wasn't Our Fault.* Arizona Bureau of Geology and Mineral Technology Field notes, Vol. 17, No. 2, 2 p.

Menges, C.M., and Pearthree, P.A., 1983, *Map of neotectonic (latest Pliocene-Quaternary) deformation in Arizona*: Arizona Bureau of Geology Mineral Technology Open-File Report 83-22, 48 p., scale 1:500,000.

Petersen, M.D., Moschetti, M.P., Powers, P.M., Mueller, C.S., Haller, K.M., Frankel, A.D., Zeng, Yuehua, Rezaeian, Sanaz, Harmsen, S.C., Boyd, O.S., Field, Ned, Chen, Rui, Rukstales, K.S., Luco, Nico, Wheeler, R.L., Williams, R.A., and Olsen, A.H., 2014, *Documentation for the 2014 update of the United States national seismic hazard maps*: US Geological Survey Open-File Report 2014–1091, 243 p.

Pearthree, P.A. and Bausch, D.B. 1999, *Earthquake Hazards in Arizona*. AZGS Map 34.

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.

Pearthree, P.A, 1998, *Quaternary fault data and map for Arizona*. AZGS Open File Report 9824, 122 p.

Rukstales, K.S., and Petersen, M.D., 2019, *Data Release for 2018 Update of the U.S. National Seismic Hazard Model*: U.S. Geological Survey data release, https://doi.org/10.5066/P9WT5OVB.

U.S. Geological Survey and Arizona Geological Survey, Quaternary fault and fold database for the United States, accessed August 2023, at: https://www.usgs.gov/natural-hazards/earthquake-hazards/faults.

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.

Worden, C.B., Gerstenberger, M.C., Rhoades, D.A., and Wald, D.J., 2012, *Probabilistic relationships between ground motion parameters and modified Mercalli intensity in California*, Bulletin of the Seismological Society of America, 102(1), 204-221. https://doi.org/10.1785/0120110156.

EXTREME HEAT

DESCRIPTION

Extreme Heat events are extended periods of time with unusually hot weather conditions that potentially can harm human health. The worst extreme heat events span several days, with one or more near-record or record-breaking temperatures. The significant human risks associated with extreme heat are:

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 the sudden loss of consciousness and is typically associated with people exercising who are not acclimated to warm temperatures. It usually 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/moderately elevated. The prognosis is usually good with fluid treatment and removal from heat.

Heatstroke – Heatstroke is considered a medical emergency and can be 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.

In addition to affecting people, extreme heat places significant stress on plants and animals, leading to reduced agricultural yields and increased mortality rates.

HISTORY

Extreme high temperatures occur in Arizona on a regular basis, but the highest threat typically occurs during the summer months of June to August, when monsoon moisture raises the heat index. Although there have been no federal declarations for extreme heat events, AZ did declare a state of emergency this past summer.Local and national politicians for Arizona, Nevada, and Texas have begun to push for extreme heat events to be added to the list of major disaster-qualifying events. For Arizona, extreme heat is a high risk hazard. Below are some notable events that were either record-breaking or have occurred over the last five years:

- July 2023 – Temperatures in Phoenix Metro area exceeded 110 degress for the entire 31 day month, setting new temperature records Temperatures remained above 115 degress for 17 days, setting another record.   Other records may yet be broken as the summer season draws to a close. The Arizona Governor's declared a Heat State of Emergency on August 11, 2023 (ABC News, 2023; AZ Governor's Office, 2023).

- June 12-20, 2021 – Very hot high temperatures of 106 to 119 degrees, or 8 to 13 degrees above normal, occurred in the lower elevations of southeast Arizona June 12-20 and caused the High Heat Risk category to be reached. New record daily high-temperature records were established at numerous sites on several days during this period. For Tucson International Airport, this nine-day period contributed to the hottest June on record, and the 4th hottest temperature on record of 115 degrees occurred on June 15. Sites that tied or broke all--time hottest temperature records included Ajo with 119 degrees, Sasabe with 113, and Green Valley with 112. The Pima County Medical Examiner confirmed that heat was the primary cause of death for 14 people found in the desert of Pima and Santa Cruz counties during this time period(NCEI, 2023).
- June 15-20, 2021 – A strong upper-level ridge strengthened over the Desert Southwest during the middle part of June with, the center of high pressure becoming focused over the Four Corners region. As a result, temperatures warmed up well above normal, reaching excessive heat conditions. High temperatures climbed at or above 115 degrees each day (6 days) between the 15th-20th, breaking Phoenix's record for consecutive days of 115+ degree temperatures. Temperatures in Phoenix peaked on the 17th at 118 degrees, breaking the record for the date and becoming the hottest temperature for the whole year. According to the Maricopa County Department of Public Health, sixty heat-associated fatalities occurred as a result of this heat wave (NCEI, 2023).
- July 10-19, 2020 – A very strong area of high pressure strengthened over the southwest United States, leading to excessive heat conditions across the region. Temperatures in Phoenix exceeded 110 degreesdaily, with afternoon highs reaching or exceeding 115 degrees on the 11th and the 12th. Record highs were set nearly every day in Phoenix during this time with records broken on the 13th, 14th, 16th, 17th, 18th, and 19th. According to the Maricopa County Department of Public Health, 75 heat-associated fatalities occurred during this event(NCEI, 2023).
- July 23-25, 2018 - Strong high pressure building into the region resulted in excessive heat warning conditions across much of south-central and southwest Arizona. The deadly heatwave resulted in 25 fatalities (23 direct and 2 indirect), according to the Maricopa County Department of Public Health (NCEI, 2023).
- May 6-9, 2018 – Strong high pressure with abundant sunshine and dry air allowed for temperatures to reach excessive heat warning criteria for periods of time from May 6th to the 9th. Temperatures reached 106ºF at Phoenix airport. According to the Maricopa County Department of Public Health, there were three heat-associated fatalities in Maricopa County during this period. As reported to Phoenix, the data are aggregated and represent monthly values for several combined communities (NCEI, 2023).

PROBABILITY/EXTENT

Given the history of past extreme heat events (EHEs), the probability of EHEs occurring somewhere in the state during any given year is very high, and for the lower elevation Sonoran and Mohave Desert areas (generally below 2,500 feet in elevation), a near certainty.

The extreme heat hazard has the potential to be severe due to the number of individuals affected by the hazard, the health impacts that can lead to death, and the increasing number of days of extreme heat each year The National Weather Service (NWS) HeatRisk Protype Index indicates the degree of danger associated with extreme heat. According to the NWS, the HeatRisk index is a color-numeric-based index that provides forecast risk of heat-related impacts to occur over a 24-hour period. HeatRisk considers several factors, including (1) how unusual the heat is for the time of the year, (2) the duration of the heat, including both daytime and nighttime temperatures, and (3) if those temperatures pose an elevated risk of heat-related impacts based on data from the CDC. Figure 8 shows the HeatRisk index with category descriptions.

Category	Risk of Heat-Related Impacts
Green 0	Little to no risk from expected heat.
Yellow 1	Minor - This level of heat affects primarily those individuals extremely sensitive to heat, especially when outdoors without effective cooling and/or adequate hydration.
Orange 2	Moderate - This level of heat affects most individuals sensitive to heat, especially those without effective cooling and/or adequate hydration. Impacts possible in some health systems and in heat-sensitive industries.
Red 3	Major - This level of heat affects anyone without effective cooling and/or adequate hydration. Impacts likely in some health systems, heat-sensitive industries and infrastructure.
Magenta 4	Extreme - This level of rare and/or long-duration extreme heat with little to no overnight relief affects anyone without effective cooling and/or adequate hydration. Impacts likely in most health systems, heat-sensitive industries and infrastructure.

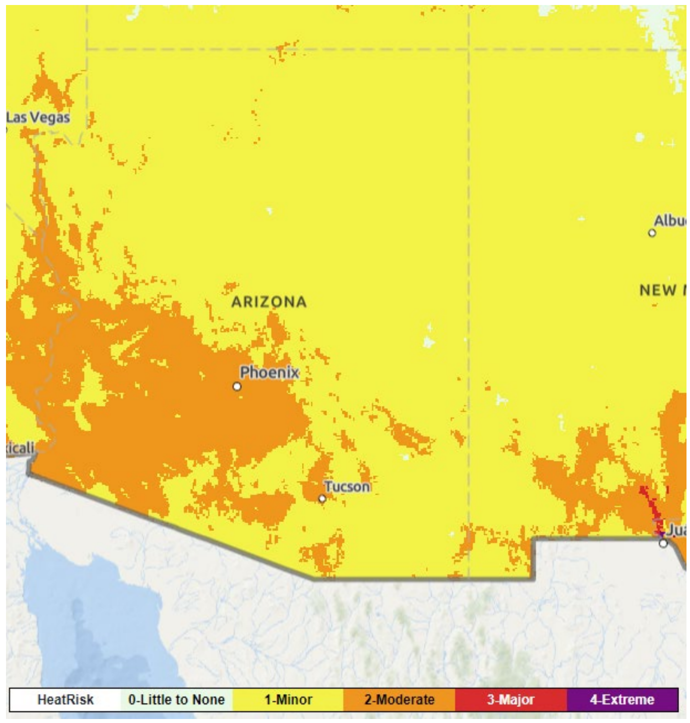


Figure 8. NWS HeatRisk prototype index

WARNING TIME

Warning time for most EHEs can be measured in a couple of days to one week. In a broader, seasonal sense, Arizona residents who live in the lower Sonoran and Mohave Desert areas generally understand that temperatures can exceed 100°F as early as April and will continue hot through September and even October.

During Arizona’s hottest months, the NWS issues three types of heat-related messages, which are described below:

Heat Advisory – Issued when the temperature is forecast to be unusually hot but not life-threatening.

Excessive Heat Watch – Issued when there is moderate (50%) confidence that the "Major" or "Extreme" category HeatRisk may occur. Typically issued 2-7 days in advance and preceding a warning.

Excessive Heat Warning – Issued when there is high confidence (80%) that the "Major" or "Extreme" category HeatRisk will occur. Typically issued at least one day in advance and continuing through the end of the event until HeatRisk drops below the Major category. Major to Extreme HeatRisk is a level of rare and/or long-duration extreme heat with little to no overnight relief that affects anyone without effective cooling and/or adequate hydration. Impacts are likely in most health systems, heat-sensitive industries, and infrastructure.

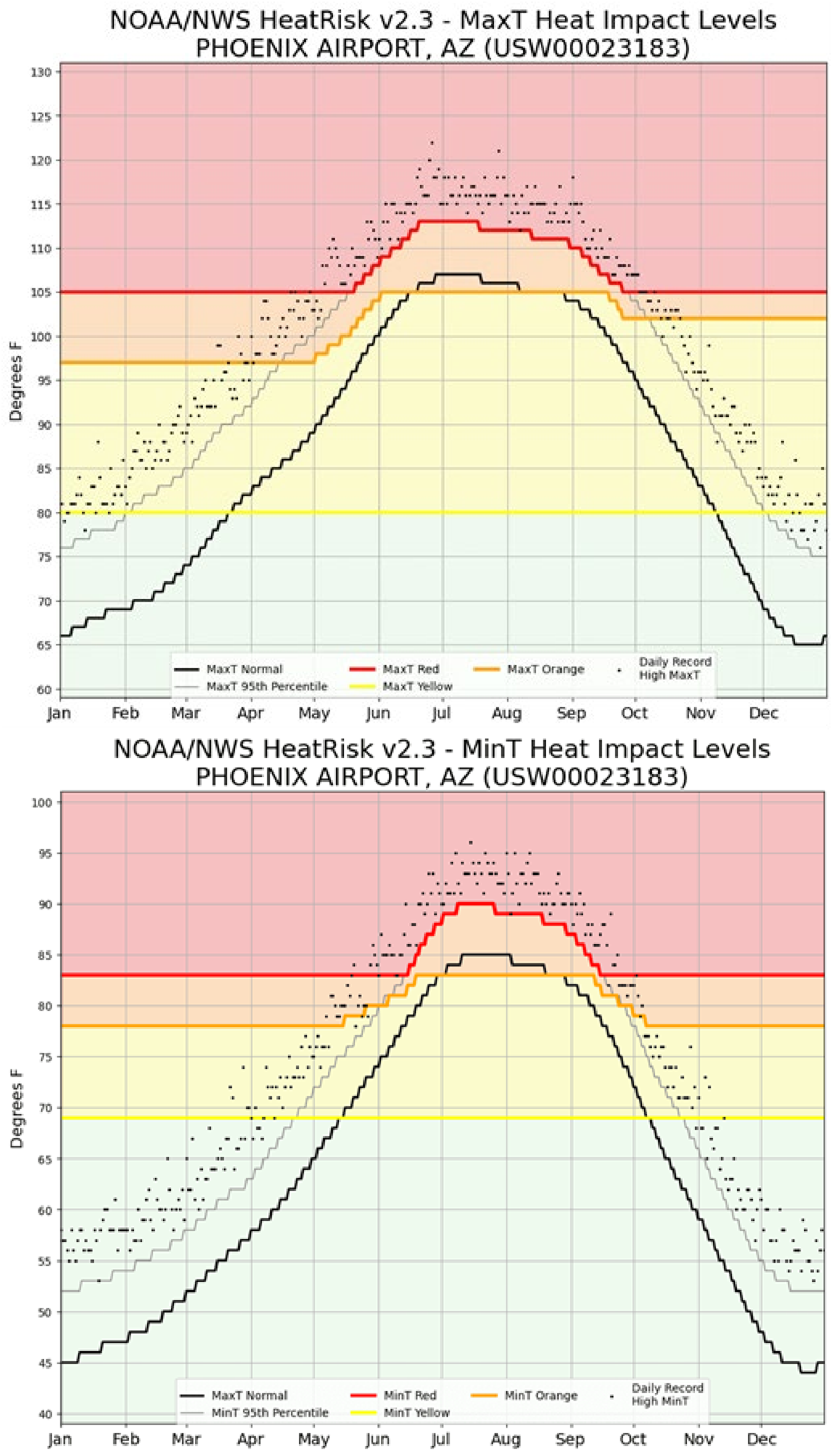


Figure 9. HeatRisk minimum and maximum temperature levels for Phoenix, AZ

FUTURE CONDITIONS

The Arizona Department of Health Services (ADHS) and Arizona State University (ASU) jointly prepared the Arizona Extreme Weather, Climate and Health Profile Report (Chuang et al., 2015), which was the first step in looking at how future extreme heat events and changes in air pollution might affect the health of Arizona's vulnerable populations and suggesting possible ways for adapting to those changes. According to death statistics reported by Chuang et al. (2015), most EHEs occur during July when temperatures are highest, and the state begins to experience the onset of monsoon moisture.

Climate Considerations

In 2022, the NOAA National Centers for Environmental Information's State Climate Summary for Arizona provided an overview of observed temperature, precipitation, and drought data and an analysis of predicted changes over time. The report evaluated the change in temperatures under lower and higher emissions scenarios and defined a range of potential temperature increases under each scenario. The temperature is expected to continue to increase over time under both scenarios, though the increase under the lower emission future scenario is expected to be lower than under the higher emission scenario. Figure 10 presents Arizona's projected increase in near-surface temperature through the year 2100.

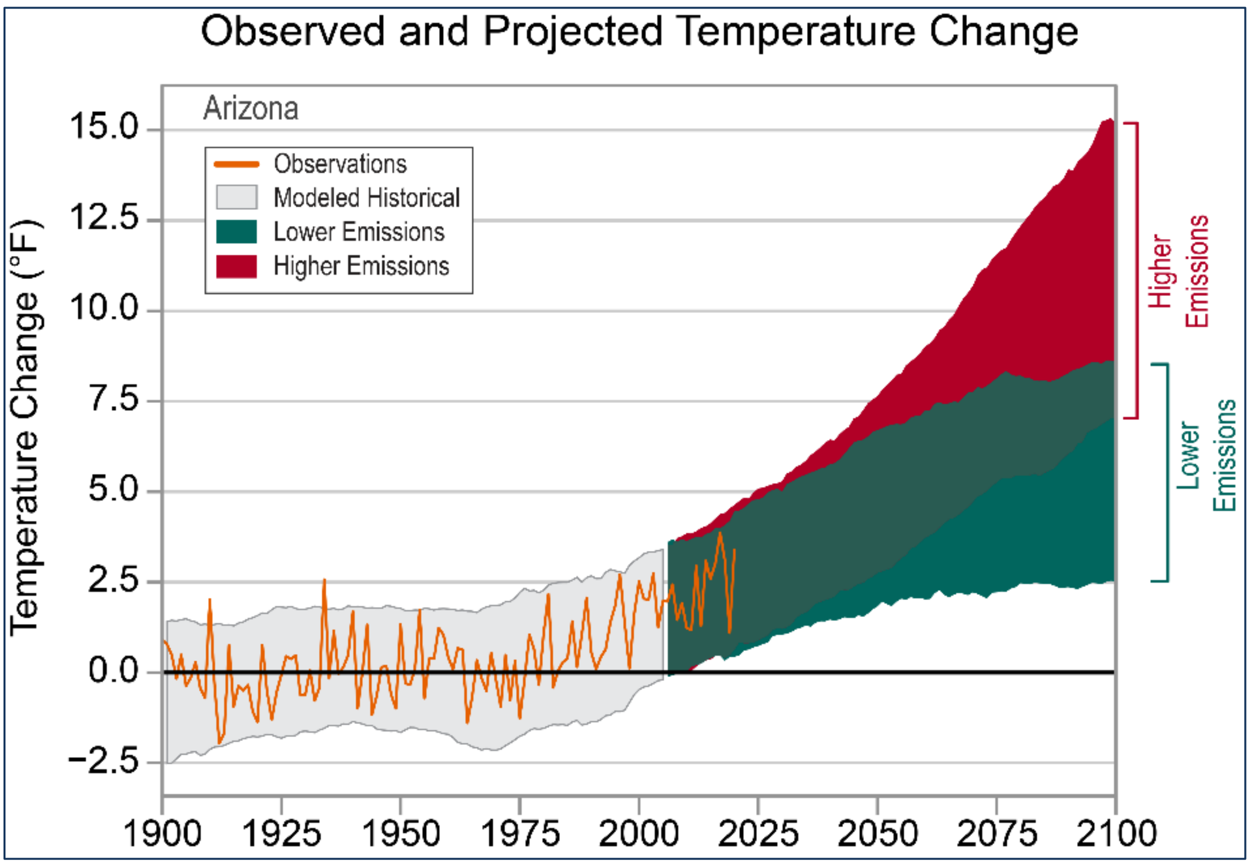


Figure 10. Projected temperature changes in Arizona

Most of the current science and literature generally acknowledge and anticipate a warming trend over the next several decades. The magnitude of temperature increases varies with the assumption of emissions concentrations[19] over the next 50-60 years. Chuang et al. (2015) indicated that the largest temperature changes are likely to occur in Arizona's more rural north and northeastern areas. Map xx graphically depicts the record heat extremes for the state over the 30-year period 1991 to 2020 in context with each of the regions.

Changes in Development

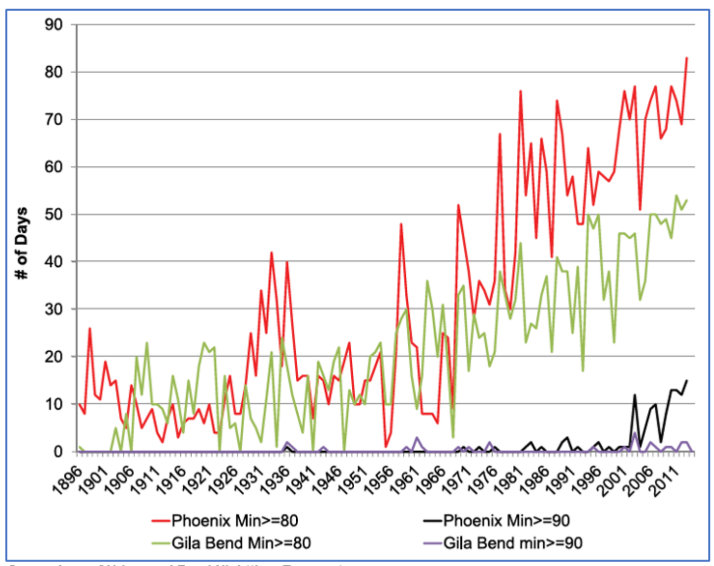
Development-related changes impact extreme heat by increasing the probability and magnitude of the hazard. Expansion of urban footprints and associated heat reflecting and generating mechanisms can all contribute to increases in maximum temperatures if the concentrations are dense enough. Population growth increases the risk of injury or deaths associated with EHEs, especially in urban areas. Extreme Heat hazard-specific changes in vulnerability to state CFI due to changes in development could include increased cooling costs and structure deterioration due to heat exposure.

North Region

Development-related changes for most communities in the North Region are expected to be low based on reports from the local county hazard mitigation plans. The majority of the anticipated growth is expected to expand from the existing cities and towns. The areas with the most significant extreme heat exposure are La Paz and western Mohave Counties.

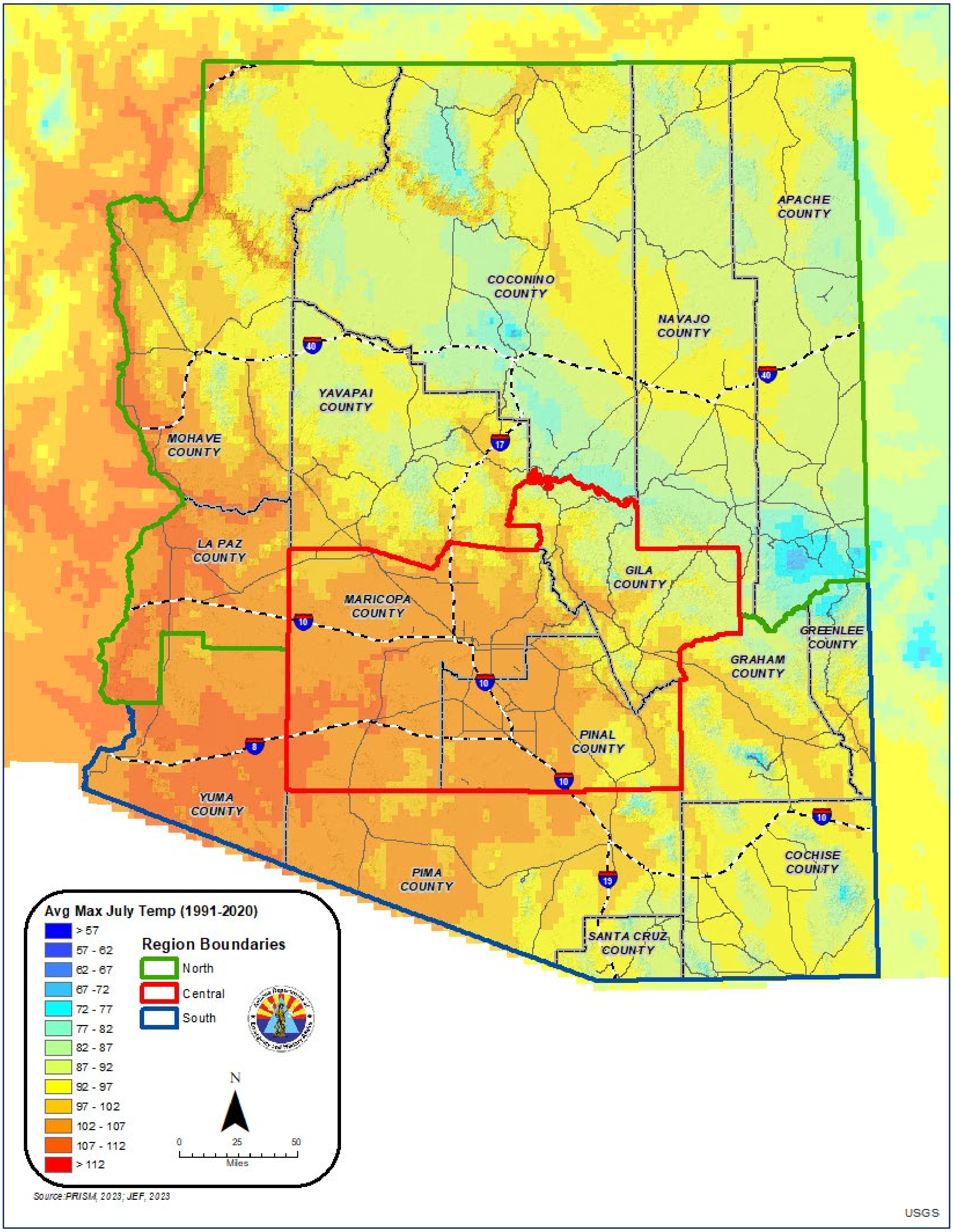
Central Region

Over the past 60 years, the Metropolitan Phoenix area has been among the fastest-growing urban areas in the United States. This expansion of impervious surfaces and other heat-producing/storing mechanisms has resulted in an urban heat island (UHI) of substantial size and intensity. According to Chow, et.al. (2012), from 1948-2000, urbanization increased the nighttime minimum temperature in central Phoenix (Sky Harbor International Airport) by approximately 9°F and the average daily temperature by approximately 5.5°F.



Comparison of Urban and Rural Nighttime Temperatures
Source: Chuang et.al., 2015

[19] The report refers to the modeled scenarios as representative concentration pathways or RCPs.



Map 15. Extreme maximum temperatures for 1991 to 2020 period

Another telling statistic is the number of 100-degree days registered in the Phoenix area. In 1913, Phoenix had 48 days that were over 100°F, and the average now is 109 days. A third impact of the increased UHI footprint is the increase in the number of days in which the minimum nighttime temperatures are above 90°F, which can be detrimental to population sectors without access to air conditioning. Continued growth in these areas will further expand the UHI and its impacts.

South Region

Similar to the Central Region, the Tucson Metropolitan area has grown significantly over the last 50 years, with urban temperatures being about 5.5°F warmer than they were in the last century and noting that 3.5°F of the warming occurred in the previous 30 years. The most significant development anticipated for the South Region is expected to primarily occur in the Tucson Metropolitan Area, which will continue to expand the UHI footprint. Other areas of the South Region are not anticipating significant growth.

VULNERABILITY ASSESSMENT

In many parts of the state, extreme heat occurs as a chronic, rather than episodic, hazard, with dangerously high temperatures persisting throughout the warm season (Harlan et al. 2014). Continual high nighttime lows do not allow the body to recover from the daytime heat if no access to cooling is available. Regardless of SVUC rankings, the worst impacts of EHEs will likely be felt in the lower altitude urban areas, where large numbers of vulnerable people reside, urban heat island effects exist, and air quality is likely to be poor (Revi et al. 2014). Chuang, et.al. (2015) note that human vulnerability to heat involves more than physical exposure to extreme heat events. It also involves individual and population sensitivity to EHEs and adaptive capacity. Sensitivity depends on the underlying characteristics of a population, such as age and ethnicity. Adaptive capacity reflects the capability of a system, population, or individual to cope with changes. The homeless are particularly vulnerable to EHEs during the summer months when the increased humidity and urban heat island effects keep nighttime temperatures above 90°F for prolonged periods. The cumulative effects over several days of continuous 24-hour exposure to this heat, without relief, put these individuals at serious risk of heat stress or worse. Others at significant risk are the low-income populations who do not have air conditioning or, in many cases, do not even have evaporative coolers. The lack of air conditioning means this population, like the homeless, also lacks nighttime relief from the heat, elevating their risk of heat stress or other complications.

According to the Center for Disease Control, extreme heat events are one of the leading causes of weather-related deaths in the United States. Arizona has the largest number of heat-related deaths in the nation (Brown et al., 2013). Figure 11 shows tabulations of heat-related deaths by month during 2012-2022. For that period, a total of 5,198 heat-caused and heat-related deaths occurred in Arizona. Extreme heat-related deaths and illnesses are so prevalent in Arizona because of the consistent and increasing number of days with both high minimum and maximum temperatures. Arizona residents accounted for 3,711 deaths (71.4% of the total), or 371 deaths on average per year in 2012-2022. Non-Arizona residents accounted for the remaining 1,452 deaths (27.9% of the total).

Vulnerability and exposure of the state-owned facilities to EHEs are not significantly damaging in a direct way, but rather on a long-term maintenance basis to fix and repair heat-related damages to HVAC systems, roofs, and other heat-susceptible materials. No damages are estimated for state-owned facilities in this Plan.

Heat-Caused Deaths Summary 2012-2022

		Total	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Month of Occurrence	January	0†	0	0	0	0	0	0	0	*	0	0	*
	February	0	0	0	0	0	0	0	0	0	0	0	*
	March	10†	0	*	0	0	*	*	0	0	0	*	*
	April	30†	*	*	*	*	*	*	*	*	*	*	7
	May	90†	9	9	*	*	*	*	11	*	9	14	25
	June	453	24	30	12	32	52	49	16	20	30	100	88
	July	614	28	39	17	9	51	34	50	53	115	79	139
	August	427	26	14	7	34	26	22	28	53	122	53	42
	September	190†	6	6	*	*	8	9	20	19	26	41	46
	October	40†	*	*	*	*	*	*	*	*	9	8	*
	November	10†	*	*	*	*	*	*	*	0	0	*	*
	December	0†	0	0	0	0	0	*	0	0	*	*	0

Notes: † Sum rounded to nearest tens unit due to non-zero addend less than 6; * Number of deaths related to exposure to excessive natural heat were suppressed due to non-zero count less than 6.

Heat-Related Deaths Summary 2012-2022

		Total	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Month of Occurrence	January	0†	0	0	0	0	0	0	0	*	0	0	*
	February	0†	0	0	0	0	0	0	0	*	0	0	*
	March	10†	0	*	*	*	*	*	0	0	0	*	*
	April	40†	*	*	*	*	*	*	*	*	*	*	10
	May	150†	13	10	*	*	*	9	17	7	21	25	35
	June	719	32	41	20	42	80	83	28	35	46	173	139
	July	1242	43	67	35	27	76	92	97	110	225	154	316
	August	756	52	18	17	48	42	45	68	85	178	115	88
	September	300	11	8	10	7	10	17	35	32	36	67	67
	October	50†	*	*	*	*	*	*	*	6	12	9	*
	November	20†	*	*	*	*	*	*	*	*	0	*	*
	December	10†	*	0	0	0	0	*	0	0	*	*	0

Notes: † Sum rounded to nearest tens unit due to non-zero addend less than 6; * Number of visits related to exposure to excessive natural heat were suppressed due to non-zero count less than 6.

Figure 11. Excessive heat related deaths in Arizona.

North Region

The North Region is considered the least vulnerable to EHEs due to the lower overall temperatures, higher densities of shade-producing vegetation, and reduced population densities. It is noted, however, that the Arizona strip communities along the Colorado River in La Paz and western Mohave Counties (Cibola, Ehrenberg, Parker, Parker Strip, Lake Havasu City, Bullhead City, and Mohave Valley) are actually some of the hottest locations within the state and are routinely the location of state record high temperatures. Approximately 14.4% of the total heat-related deaths reported by ADHS for 2012-2022 are attributed to the North Region, and 77.3% of that attributed to La Paz and Mohave Counties.

State-Owned CFI Exposure and Loss Estimates

All 1,010 state-owned facilities representing $1.2 billion in replacement value are exposed to extreme heat. No losses are estimated.

Vulnerable Population Groups

The entire 2022 estimated population of 801,655 people is considered to be exposed to EHEs, with the Arizona strip communities mentioned above having an elevated risk due to the significantly hotter temperatures. The exposed sub-group populations include 148,243 persons (18.49% of the region total) under 18 years of age, 216,315 persons (26.98% of the region total) older than 65, and 143,746 persons (17.93% of the region total) living at or below poverty level.

SVUC Impact Assessment

Within the North Region, 30.59% of the population falls within the highest social vulnerability index (SVI) percentile rank (0.90-1.0) for racial and ethnic minority status (Theme 3), while the greatest percentage of the population lies within the 0.5 to 0.75 SVI percentile rank for socioeconomic status (34.42%), household characteristics (24.63%), and housing type/transportation (38.82%). The higher-ranked SVUC populations are anticipated to have greater exposure to extreme heat due to lack of resources, such as air conditioning, to mitigate exposure.

Local Jurisdiction Vulnerability

Mohave County is the only North Region county to address extreme heat in its mitigation plan risk assessment. The plan vulnerability section notes several communities, including Lake Havasu City, Kingman, and the Fort Mojave Indian Reservation, which are subject to regular EHEs and have had power outage issues or concerns historically due to the power demand during these events. The plan also notes that as the urban footprint increases, the urban heat island effect will develop, resulting in a steady increase in nighttime low temperatures. Other conclusions of the vulnerability analysis are similar to what is presented in this Plan.

Specific Areas of Concern

According to the Mohave County mitigation plan, elevated demands on power supplies during EHEs in communities like Lake Havasu City, Kingman, and the Fort Mojave Indian

Reservation have resulted in past power failures during a time when air conditioning and other cooling needs are most critical.

Central Region

The Central Region is considered the most vulnerable to EHEs due to the relatively high temperatures, lower densities of shade-producing vegetation, the highest population density, and the significant impacts associated with urban heat island effects in the Phoenix Metropolitan area. Approximately 60.1% of the total heat-related deaths reported by ADHS for 2012 to 2022 are attributed to the Central Region, and 91.7% of that is attributed to Maricopa County.

State-Owned CFI Exposure and Loss Estimates

All 1,741 state-owned facilities representing $4.8 billion in replacement value are exposed to extreme heat. No losses are estimated.

Vulnerable Population Groups

The entire 2022 estimated population of 5,069,600 people are considered to be exposed to EHEs. The exposed sub-group populations include 1,130,454 persons (22.3% of the region total) under 18 years of age, 851,837 (16.8% of the region total) persons older than 65, and 573,046 persons (11.3% of the region total) living at or below poverty level.

SVUC Impact Assessment

Within the Central Region, 33% of the population falls within the 0 to 0.25 percentile rank of the Social Vulnerability Index (SVI) for racial and ethnic minority status (Theme 3), while the greatest percentage of the population lies within the 0.5 to 0.75 SVI percentile rank for socioeconomic status (Theme 1 – 46.43%), household characteristics (Theme 2 – 35.53%), and housing type/transportation (Theme 4 – 36.57%). The higher-ranked SVUC populations are anticipated to have greater exposure to extreme heat due to a lack of resources, such as air conditioning, to mitigate exposure.

Local Jurisdiction Vulnerability

In their mitigation plan risk assessments, Maricopa and Pinal County, within the Central Region, both address extreme heat. The Maricopa County mitigation plan provides an analysis of the vulnerability of communities participating in the plan based on heat vulnerability index data available for the census tracts within the County. This analysis indicates that approximately 25% of Maricopa County residents live in census tracts classified as highly or very highly heat-vulnerable. The Pinal County mitigation plan notes the increased vulnerability of older adults, young children, and people who are sick, overweight, or have an underlying health condition to heat-related illness. The plan also notes that some economic sectors, including the energy and transportation industries, are vulnerable to increasing temperatures. Other conclusions of the vulnerability analyses are similar to what is presented in this Plan.

Specific Areas of Concern

As previously stated, one of the impacts of EHE-caused mortality rates is tied to the urban heat island effects on the corresponding nighttime low temperatures. The combination of potential for future rising temperatures, combined with future growth and un-mitigated expansion of the urban footprint and increased populations, equals increased overall risk to the Phoenix Metropolitan area. Mesa and Phoenix are the two largest cities and also have the largest homeless and poverty populations impacted. Buckeye, Queen Creek, and the adjacent San Tan Valley are the fastest-growing municipal areas and illustrate the expansion of the urban footprint in both the west and east directions.

South Region

The South Region is considered the second-most vulnerable to EHEs due to the relatively high temperatures associated with the highest population centers, lower densities of shade-producing vegetation, the moderately high population density, and the significant impacts associated with urban heat island effects in the Tucson Metropolitan area. Approximately 25.5% of the total heat-related deaths reported by ADHS for 2012-2022 are attributed to the South Region, and 60.7% of those are attributed to Pima County. However, according to a database created by Humane Borders and the Pima County Office of the Medical, it is noted that the majority of contributors to those numbers are related to illegal immigration through the southern Arizona US-Mexico border.

State-Owned CFI Exposure and Loss Estimates

All 1,017 state-owned facilities representing $1.6 billion in replacement value, are exposed to extreme heat. No losses are estimated.

Vulnerable Population Groups

The entire 2022 estimated population of 1,487,942 people is considered to be exposed to EHEs. The exposed sub-group populations include 310,658 persons (20.88% of the region total) under 18 years of age, 313,960 (21.1% of the region total) persons older than 65, and 231,653 persons (15.57% of the region total) living at or below the poverty level.

SVUC Impact Assessment

Within the South Region, 29.48% of the population falls within the 0.75 to 0.90 percentile rank of the Social Vulnerability Index (SVI) for household characteristics (Theme 2), and 27.38% fall within the same rank for housing type/transportation (Theme 4), while 36.65% of the population lies within the 0.25 to 0.50 SVI percentile rank for socioeconomic status (Theme 1) and 38.83 fall within the 0.50 to 0.75 percentile rank for racial and ethnic minority status (Theme 3). The higher-ranked SVUC populations are anticipated to have greater exposure to extreme heat due to a lack of resources, such as air conditioning, to mitigate exposure.

Local Jurisdiction Vulnerability

Pima County and Yuma County are the only South Region counties to address extreme heat in their mitigation plan risk assessments. The Pima County plan notes the increasing trend in temperatures over time. The plan also notes that cardiovascular disease and prescription drug use increase susceptibility to negative outcomes for extreme heat-related illness and the risk of greater demand for power resources. Other conclusions of the vulnerability analysis are similar to what is presented in this Plan. The Yuma County plan notes the populations at increased risk throughout the County, including the elderly, homeless, residents living in mobile homes and older structures, and first responders who provide emergency services during extreme heat events. The plan also notes that members of the Cocopah Indian Tribe who rely on temperature-sensitive medication, such as insulin, are particularly vulnerable to extreme heat events.

Specific Areas of Concern

As noted above, one of the impacts of EHE-caused mortality rates is tied to the urban heat island effects on the corresponding nighttime low temperatures. The combination of potential for future rising temperatures, combined with future growth and un-mitigated expansion of the urban footprint and increased populations, equals increased overall risk to the Tucson Metropolitan area..

RESOURCES

Sources

AZ Dept of Health Services, http://www.azdhs.gov/preparedness/epidemiology-disease-control/extreme-weather/index.php#heat-illness

ASU – State Climate Office, https://azclimate.asu.edu/

NWS – Phoenix Forecast Office, https://www.weather.gov/psr/

NWS – Tucson Forecast Office, http://w2.weather.gov/climate/local_data.php?wfo=twc

References

Brown, E. H., A. C. Comrie, D. M. Drechsler, C. M. Baker, R. Basu, T. Brown, A. Gershunov, A. M. Kilpatrick, W. K. Reisen and D. M. Ruddell, 2013, *Human Health. Assessment of Climate Change in the Southwest United States: A Report Prepared for the National Climate Assessment*. G. Garfin, A. Jardine, R. Merideth, M. Black and S. LeRoy. Washington, DC, Island Press.

Chow, Winston T. L., Dean Brennan, Anthony J. Brazel, 2012, *Urban Heat Island Research in Phoenix, Arizona: Theoretical Contributions and Policy Applications*. Bull. Amer. Meteor. Soc., 93, 517–530.

Chuang, W-C., A. Karner, N. Selover, D. Hondula, N.Chhetri, A. Middel, M. Roach and B.Dufour, 2015, *Arizona Extreme Weather, Climate and Health Profile Report*. A report prepared for Arizona Department of Health Services and the United States Centers for Disease Control and Prevention Climate-Ready States and Cities Initiative.

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

Frankson, R., K.E. Kunkel, L.E. Stevens, D.R. Easterling, T. Brown, N. Selover, and E. Saffell, 2022: Arizona State Climate Summary 2022. NOAA Technical Report NESDIS 150-AZ. NOAA/NESDIS, Silver Spring, MD, 5 pp.

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.

Harlan, S. L., G. Chowell, S. Yang, D. B. Petitti, E. J. Morales Butler, B. L. Ruddell and D. M. Ruddell, 2014, *Heat-Related Deaths in Hot Cities: Estimates of Human Tolerance to High Temperature Thresholds*. International Journal of Environmental Research and Public Health 11(3): 3304-3326.

Revi, A., D. E. Satterthwaite, F. Aragón-Durand, J. Corfee-Morlot, R. B. R. Kiunsi, M. Pelling, D. C. Roberts and W. Solecki, 2014, *Urban areas. Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects*. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. C. B. Field, V. R. Barros, D. J. Dokkenet al. Cambridge, United Kingdom and New York, NY, USA, Cambridge University Press.

Sagna, M.L., Gupta, S., Torres, C., 2017, *Mortality and Morbidity from Exposure to Excessive Natural Heat in Arizona, 2005-2015*. A report prepared by the AZ Dept of Health Services, Bureau of Public Health Statistics, Population Health and Vital Statistics Section. 36 p, http://www.azdhs.gov/preparedness/epidemiology-disease-control/extreme-weather/index.php#heat-illness

WestMap Climate Analysis & Mapping Toolbox, 2017, https://cefa.dri.edu/Westmap/Westmap_home.php

Maricopa County Department of Public Health, Division of Disease Control, Office of Epidemiology and Data Services, 2016, *Heat-Associated Deaths in Maricopa County, AZ, Final Report for 2016*, http://www.maricopa.gov/ArchiveCenter/ViewFile/Item/3084

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

FISSURE

DESCRIPTION

Earth fissures are linear cracks, seams, or separations in the ground that extend from the groundwater table and are caused by tensional forces related to differential land subsidence. In many cases, fissures form as a direct result of subsidence caused by groundwater depletion. The surface expression of fissures can range from less than a yard to several miles long and from less than an inch to tens of feet wide. The longest fissure zone in Arizona is located in Pinal County, near Picacho, and is over eight miles long. As illustrated below, earth fissures occur at the edges of alluvium basins - usually parallel to mountain fronts or above local bedrock subsurface pinnacles. Earth fissures generally tend to cut across natural drainage patterns, but not always. Fissures can alter flood patterns, break buried pipes and lines, cause infrastructure to collapse, provide a direct conduit to the groundwater table for contaminants, and even pose a life safety hazard for both humans and animals.

Earth Fissure in Apache Junction
(Photo date 1/18/2008. Photo by Todd Shipman / Meagan Shoots)
Source: AZGS Website at:
http://www.azgs.az.gov/efimagesandvideo.shtml

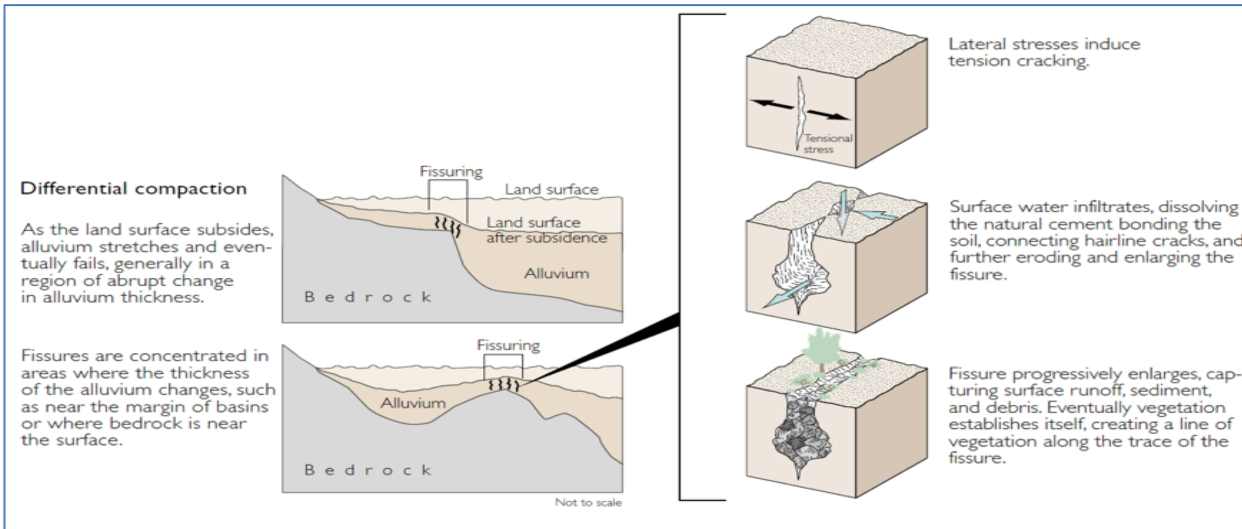


Illustration of Fissure Development Options
Source: USGS Circular 1182 (Galloway, et.al., 1999)

Figure 12. Fissure formation

HISTORY

There are no state or federal disaster declarations for fissure occurrences in Arizona. Fissures, however, have been occurring in Arizona at least since 1927, when the first one was found near Eloy. The number of fissures has increased dramatically since the 1950s because of groundwater depletion, first because of agriculture and later due to exponential population growth. The risk posed by fissures is also increased as the population expands into the peripheral basin edges and mountain fronts. In 2006, Arizona enacted legislation to target the identification and public disclosure of earth fissures by tasking the AZGS to map fissures. The implied intent of this action was to mitigate the potential hazard by encouraging avoidance. Several fissure case histories documented by AZGS and others are outlined below.

San Tan Mountains, Maricopa, and Pinal Counties

- Foothills: The fissure is undermining at least one home and crossing several roads; dogs were trapped in flash floods flowing through the fissure in 2007
- Y-crack: Fissure crosses Hunt Hwy and San Tan Boulevard, east of Sossaman Road; present at least by 1969; catastrophically re-opened from 195th Street and Happy Road to San Tan in 2005 and again in 2007, damaging roads, corrals, fences, driveways, stranding and trapping vehicles, and killing a horse.

Apache Junction/East Mesa, Maricopa County

- Baseline & Meridian: The Fissure crosses diagonally under the intersection; the fissure zone is over one mile long.
- Ironwood and Guadalupe: Industrial facilities are built on top of several fissures in the area; mapped fissures stop immediately east of the subdivision; however, AZGS suspects that the fissure may extend under some existing homes[20]; fissures crossing power lines.
- Houston Avenue: Industrial facilities are built on top of several fissures in the area; mapped fissures stop immediately east of the subdivision; however, AZGS suspects that the fissure may extend under some existing homes: https://azgs.arizona.edu/video/earth-fissure-undermines-houston-ave-apache-junction?page=1

Mesa, Maricopa County

- Loop 202 (Red Mountain Freeway): Fissure present at least since the 1970s; attempted mitigation during construction cost $200,000.
- Sossaman Road and University Drive: The Fissure runs diagonally through a subdivision along the entrance; the fissure was known in 1973 and subsequently backfilled.

Picacho, Pinal County

- Picacho Peak: A new 1.8-mile-long fissure identified in 2017 that is ten miles southwest of Picacho Peak State Park. The fissure is up to ten feet wide and 30 feet deep in portions.
- I-10 at MP 215.4: Arizona Department of Transportation (ADOT) has trenched and installed geotextile liner and engineered fill across fissure trace beneath frontage road on

[20] Personal communication from Joe Cook of AZGS.

both sides of the interstate in an attempt to mitigate collapse along fissure beneath the freeway.

- Picacho Pump Station: In 1984, a fissure crossed the access road and ran nearly to the canal.

Wintersburg, Maricopa County

- Palo Verde NP: The Fissure runs perpendicular to power transmission lines near Palo Verde Nuclear Generating Station, making one road impassable.

Scottsdale, Maricopa County

- CAP Canal: Fissure paralleling the canal opened within a few feet of the lining on the east side in 2003.
- 40th St and Cholla: Discovered in the 1980s.

Flood retarding structures, Maricopa County

- McMicken Dam, White Tank Mountains: The Dam had to be removed and replaced; it cost several million dollars.
- Powerline FRS, Apache Junction: Fissure discovered within 1200 feet of the Powerline FRS embankment. Flood Control District of Maricopa County constructed an interim measure structure to keep water away from fissure and will ultimately remove Powerline FRS completely.

Avra Valley, Pima County

- CAP Canal: A Fissure was discovered in 1988 that intersected and damaged the canal just before it started conveying water. The canal section had been strengthened with reinforcing steel mats (Sandoval and Bartlett, 1991), which minimized damage to only a crack that was repaired and has not sustained further damage (Slaff, 1991).

Cochise County Areas

- Nickels Road: In 1984, a fissure opened down one side of the road near where it crosses power transmission lines.
- Van Ness Road: Giant desiccation cracks that were initially thought to be fissures opened up in 2011 down the middle of the road, causing difficulty for local residents who may become trapped in their homes. Emergency vehicles were unable to access the area.
- Parker Ranch Rd (SE of Willcox Playa): Heavy damage to the road in several places due to a new earth fissure formation in July 2010. Many new fissures formed in the 2010 monsoon, but the main impact was where fissures collapsed beneath the road. Fissures were reactivated in the same locations in the summer of 2021, resulting in further road damage in 3 places.

Sign at Parker Ranch Rd (credit Brian Conway, ADWR)

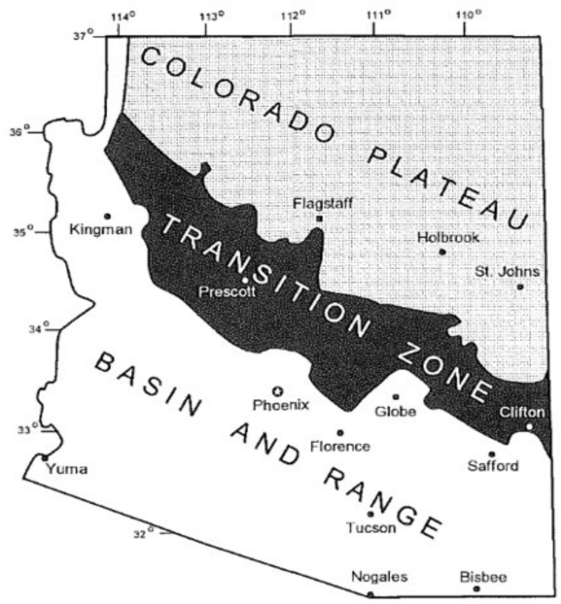
- West Dragoon Road: Damage to roadway east of Cochise Stronghold Road. Repeated damage to the intersection with Cochise Stronghold Road with a fissure passing beneath the intersection and ongoing subsidence requiring annual inspection and repair. https://repository.arizona.edu/handle/10150/667571
- Highway 191: Damage to the highway between MP 53-54 due to the collapse of underlying cracks. Cracks may be hybrid giant desiccation cracks (GDCs)/earth fissures,

but impoundment of water alongside the highway leads to saturation of soil cracks and collapse.

- I-10 Near East Bowie: Two fissures have been identified to pass beneath the interstate at approximately MP 370.6 - 370.9. Additional fissures exist on both sides of I-10 MP 375-376.

PROBABILITY/EXTENT

The probability of earth fissures occurring somewhere in the state is 100%, but the probability of a fissure leading to a disaster declaration or severe statewide damage is low. The locations of increased risk for potential fissures may be highlighted in specific areas if enough information about the subsurface geology and groundwater levels is available. As long as subsidence continues (even if the groundwater levels should rise and stabilize), fissures will continue to occur. The magnitude of the fissures varies with the depth of groundwater, type of surficial material present, amount of groundwater removed, basin depth, the volume of intercepted runoff from precipitation, and human intervention. Large fissures that intersect critical infrastructure can result in severe impacts and damages.



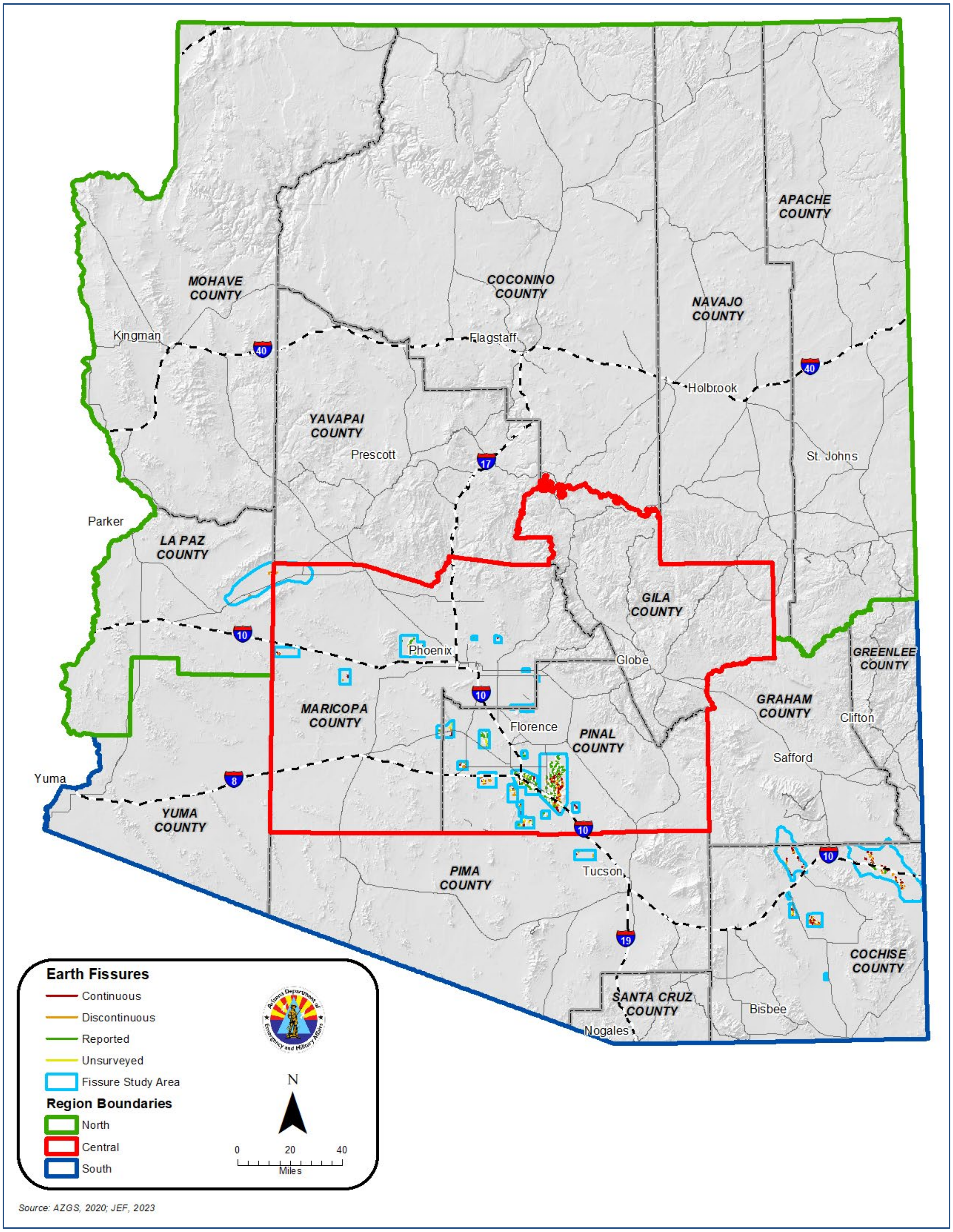
Map of Arizona Physiographic Areas
Source: AZGS (Slath, 1993))

The Basin and Range Province that occupies the southern third of Arizona is the primary area susceptible to earth fissures. This area encompasses most of the Central and southern regions, with four counties particularly prone to earth fissures: Cochise, Maricopa, Pima, and Pinal Counties.

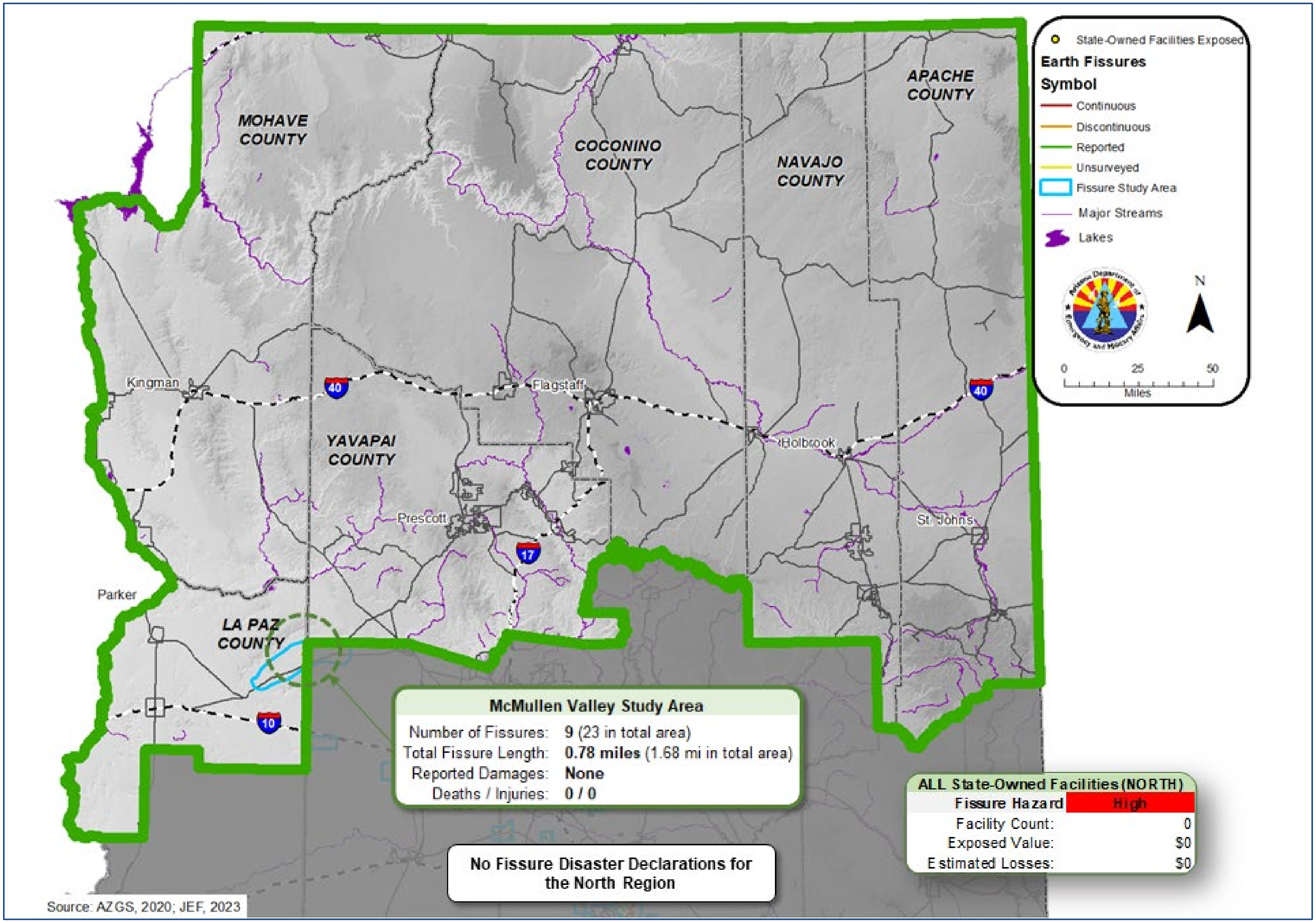
AZGS has identified and mapped numerous fissures that are generally aggregated by study areas primarily located within the Central and Southern regions. A statewide depiction of the fissures and study areas is shown in Map 16. More detailed depictions of the mapped fissures are shown in Map 17, Map 18, and Map 19 for the North, Central and South regions, respectively. Further details of all the study areas can be accessed online at the AZGS website listed in the Resources section.

WARNING TIME

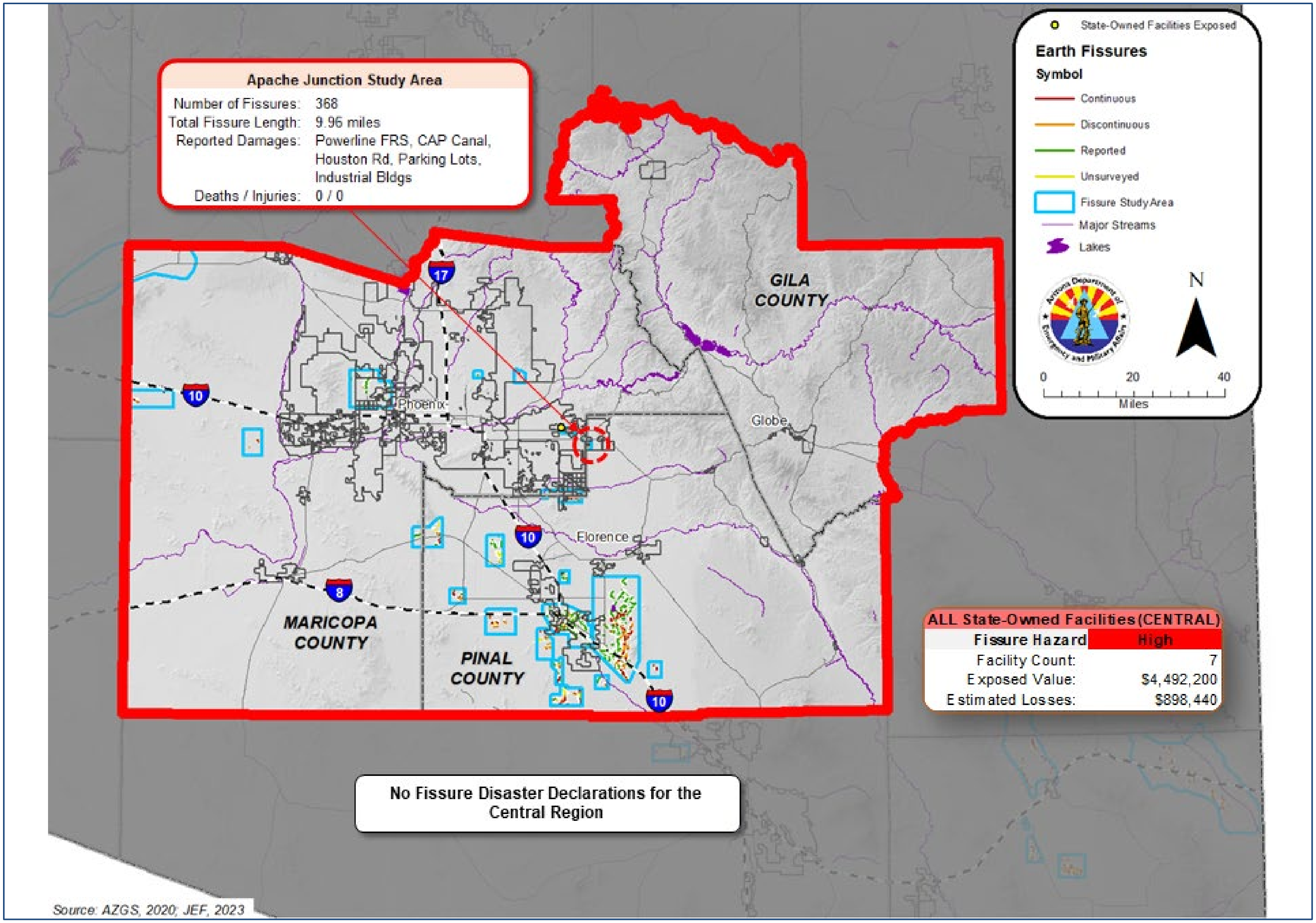
While the process of land subsidence and subsequent fissure formation is gradual and develops over long periods of time, there is little to no warning time for a new fissure to become visible or for an existing fissure to be activated and grow and expand. Often, the significant expansion of fissures is usually tied to a flood-producing precipitation event and, therefore, tied to the warning time of those events. Alternately, the presence of previously identified fissures in an area serves as an implied warning of future new fissures or extensions/expansions of existing ones.



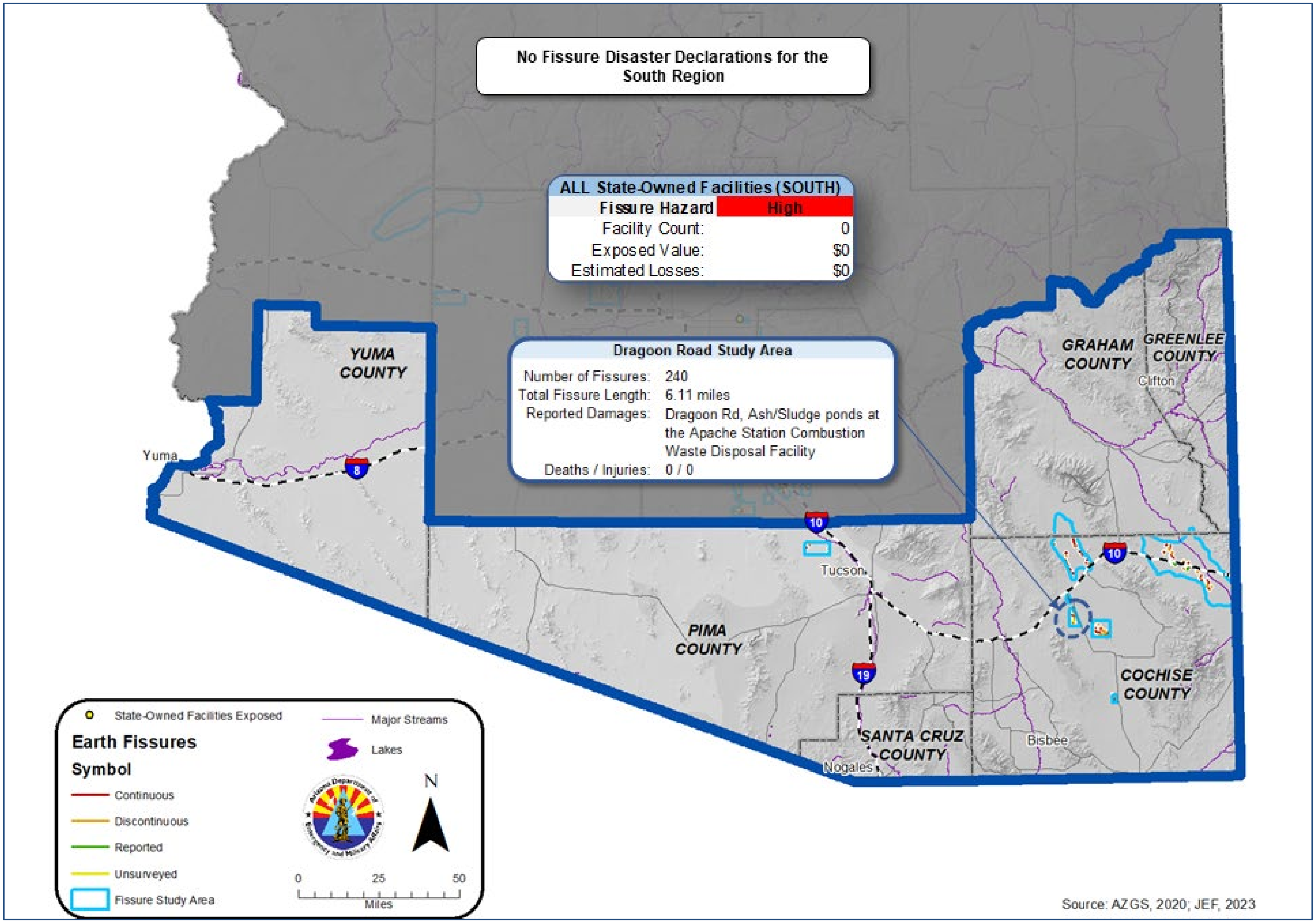
Map 16. Fissure study areas statewide



Map 17. Fissure hazard for the North region



Map 18. Fissure hazard for the Central region



Map 19. Fissure hazard for the Soutth region

FUTURE CONDITIONS

Climate Considerations

Since a significant number of fissures impacting Arizona are primarily the result of subsidence caused by groundwater depletion, climate change factors that influence the increased withdrawal of groundwater and decreased natural recharge due to drought will directly impact the fissure risk. As noted in other sections of this Plan, the projected long-term worsening or intensifying of drought periods through warming trends and precipitation influences may also increase the number and location of fissures in the zones of their development. The Arizona Land Subsidence Group (2007) states: "*The problems encountered with subsidence and earth fissures in Arizona will increase as groundwater continues to be withdrawn at unsustainable levels. More damage to structures and infrastructure can be expected with ever-increasing economic losses, and, more importantly, a burgeoning threat to human health and safety, too.*"

Changes in Development

Development continues to grow in areas that are subjected to the risks of fissure formation as old agricultural lands continue to be converted to residential housing units, which can increase the probability of an event that intersects humans or structures. Increased water demand from new developments and limited surface-water supplies induce increased groundwater pumping that exacerbates fissure formation conditions. Fissure hazard-specific changes in vulnerability to state CFI due to changes in development could include increased or decreased vulnerability depending on design and engineering of fissure treatments in the vicinity of state CFI. Improper treatment of drainage could result in rapidly expanding fissure openings. Alternately, proper design of drainage improvements may have the effect of decreasing vulnerability.

North Region

Except for a small portion of La Paz County, most of the North Region has very low to no risk from fissures. The mapped area in La Paz County is not anticipated to develop any time soon. Development changes in other areas of the North Region are not expected to be impacted by fissure risk.

Central Region

Development of the Phoenix Metropolitan perimeter communities (both the west and east valleys) and San Tan Valley are expected to continue and will likely intersect with areas of known fissure hazards. Development expansion in the Casa Grande, Eloy, and Picacho areas is expected to be limited but may intersect areas of significant fissure activity.

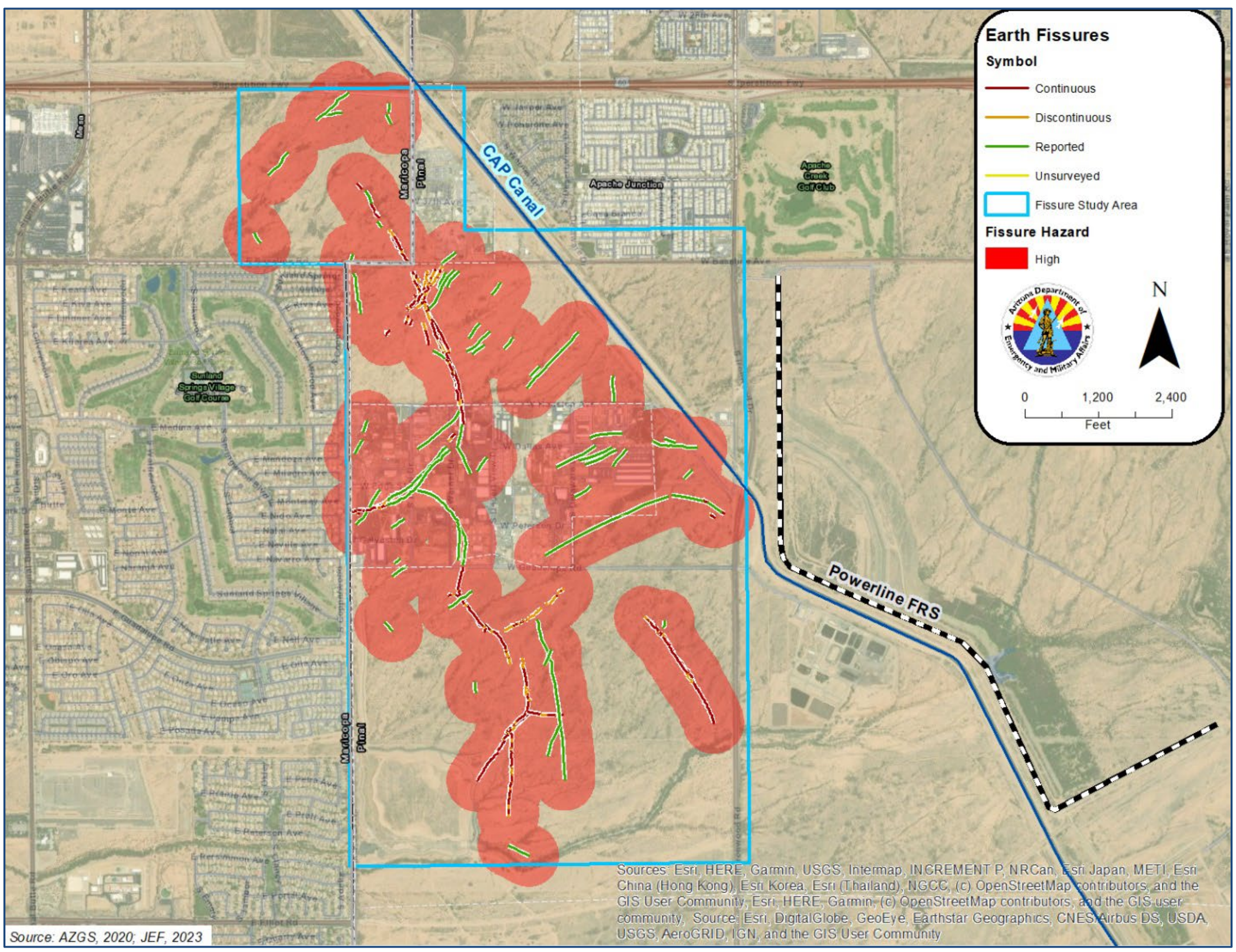
South Region

The primary areas of identified fissure activity are located in the Avra Valley area near Marana in Pima County and northern Cochise County surrounding Willcox. Marana expects moderate growth over the next five years but is not expected to push into the fissure areas. Very limited growth of the Willcox area is anticipated but may intersect with the identified fissure zones.

VULNERABILITY ASSESSMENT

For the purpose of this vulnerability assessment, the Planning Team chose to change the assessment for this update and only estimate a high fissure hazard area by creating polygons that represent a 500-foot buffer along all of the AZGS mapped fissure lineaments. As an example, Map 20 illustrates the results of the buffering process for fissures identified in the Apache Junction Study Area. It is recognized that limitations to the accuracy in buffering in this manner may not best represent the way fissures normally extend or activate. For planning purposes, however, the buffered areas are an adequate tool for estimating the risk.

The potential exposure to the identified fissure high-hazard zones was estimated using GIS tools to intersect the human and state-owned critical facilities and infrastructure (CFI) data with the fissure hazard limits. No standard loss-to-exposure ratios for structures exposed or impacted by fissures are available. Instead, the Planning Team chose to estimate losses to state-owned facilities using a subjective loss-to-exposure ratio of 20% of the replacement value for structures located in the high-hazard zones. Exposure estimates of the various population sectors to fissure high-hazard areas are also made and summarized by region below.



Map 20. Fissure hazard areas, Apache Junction Study Area

Only four counties (Cochise, Graham, Maricopa, and Pinal) included fissures as a significant hazard in their local county risk assessments.

North Region

The North Region, depicted in Map 21, is the least vulnerable region of the state, primarily due to the lack of identified fissures and assets at risk.

State-Owned CFI Exposure and Loss Estimates

None of the state-owned CFI are located within a high-hazard area, and no losses are estimated. The fissures identified in eastern La Paz County are remote and not anticipated as posing a threat to Hwy 60, which is the nearest ADOT-maintained road.

Vulnerable Population Groups

None of the 2022 estimated total North Region population of 801,655 people are exposed to a high fissure hazard. This extends to all of the sub-population groups under 18 years of age, older than 65, and less than 150% poverty level.

SVUC Impact Assessment

There are no significant fissure impacts to North Region SVUC.

Local Jurisdiction Vulnerability

None of the local jurisdictions in the North Region included fissures in their risk assessments. Accordingly, there are no estimated quantitative fissure-related losses for locally identified critical and non-critical facilities.

Specific Areas of Concern

There are currently no special areas of concern for the North Region. Fissure development in McMullen Study Area will continue to be monitored by the AZGS, but the area is unpopulated and not anticipated to threaten any of the nearest state-owned or maintained facilities within this Plan cycle.

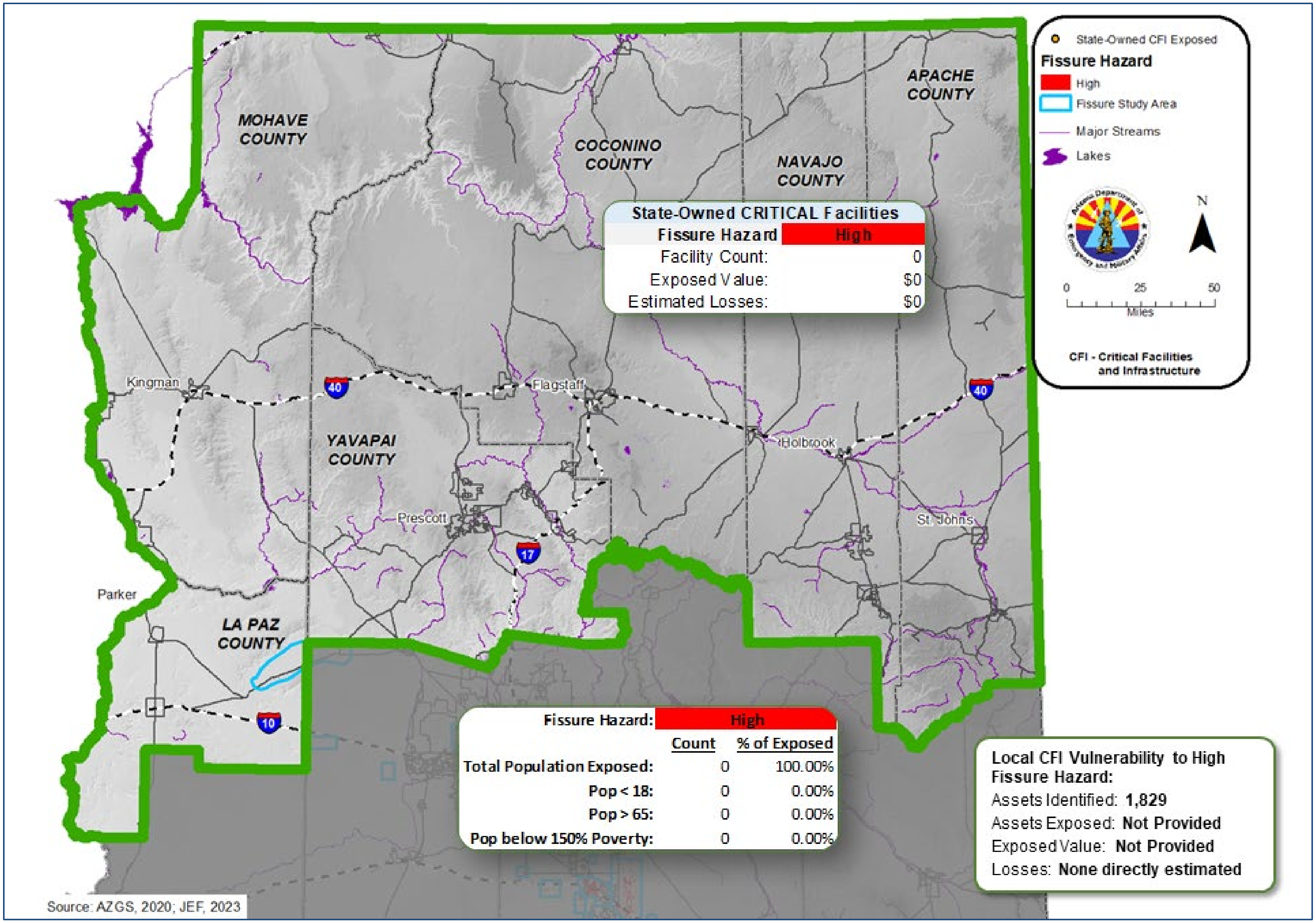
Central Region

The Central Region, depicted in Map 22, is the most vulnerable region in the state, largely due to the number and density of identified active fissure areas, significant population and infrastructure within some areas, and exposure of population and state-owned facilities.

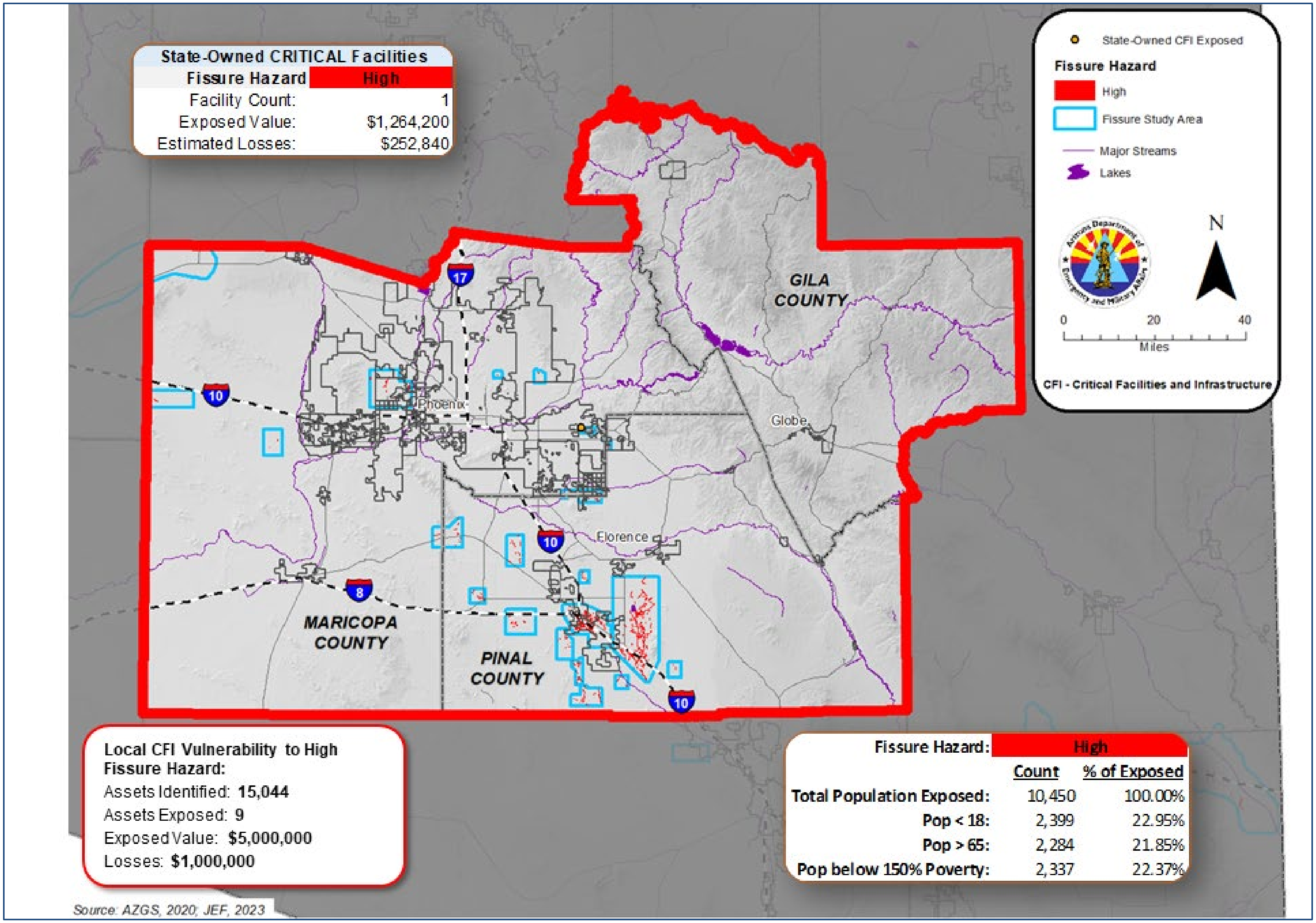
State-Owned CFI Exposure and Loss Estimates

A total of one state-owned CFI, or 100% of the statewide exposure, is located within a high-hazard area. The exposed facility represents a total replacement value of $1.26 million, with an estimated $252,840 in potential losses.

Additional state-owned facilities vulnerable to fissures are the ADOT-operated and maintained freeways, highways, and state routes that pass through known fissure hazard areas. For example, the reaches of I-10 and I-8 passing through the Picacho Peak and Friendly Corner and Toltec Buttes Study Areas have historically been impacted by fissures



Map 21. Fissure vulnerability for the North region



Map 22. Fissure vulnerability for the Central region

that pass under the freeways (Slaff, 1993 and Pearthree et. al., 2021). Future damages are dependent on the activation of the fissures (existing or new) and, based on past history, could be tens to hundreds of thousands of dollars. To date, only short-term mitigation has been possible, and additional repair and mitigation expenses are anticipated to continue into the future.

Vulnerable Population Groups

The 2022 estimated total population for the Central Region is 5,069,600 people. Approximately 0.21 % of the total population, or 10,450 persons, are located within the fissure high-hazard areas.

SVUC Impact Assessment

Fissure impacts on Central Region SVUC are summarized by CDC SVI themes and percentile rankings in Table 19. The highest percentages of regional exposure are highlighted using bold text. The strongest majority of exposure is generally centered around the 0.50 index, between 0.25-0.75, which would suggest a moderate SVUC vulnerability in Central Region communities.

Table 19. Fissure high hazard SVUC exposure for Central Region

Region	CDC-SVI Assigned Percentile Rank	Percent of Impacted Area by SVI Percentile Rank Range				
		THEME 1 Socio-Economic Status	THEME 2 Household Characteristics	THEME 3 Racial and Ethnic Minority Status	THEME 4 Housing Type/ Transportation	THEMES (ALL) Overall Ranking
Central	NO DATA	0.488%	0.488%	0.373%	0.585%	0.585%
Central	0-0.25	15.990%	29.337%	10.802%	16.248%	16.737%
Central	0.25-0.50	21.127%	13.289%	**24.306%**	**27.352%**	21.809%
Central	0.50-0.75	**31.383%**	**31.871%**	20.106%	32.750%	**36.716%**
Central	0.75-0.90	24.950%	20.844%	23.499%	6.920%	11.970%
Central	0.90-1.00	6.061%	4.151%	20.914%	13.154%	12.183%

Local Jurisdiction Vulnerability

Maricopa and Pinal Counties included fissures in their risk assessments and used a similar buffering approach to define fissure hazard zones. Between the two plans, a total of nine assets with a total replacement value of $5 million have been identified as located within a high-hazard area. A total loss to local CFI was estimated at $1 million.

Specific Areas of Concern

When activated, fissures can open rapidly and even suddenly depending on their formation, threatening life and property. In the Chandler Heights Study Area, a sudden collapse of a cavity formed on a fissure caused the death of a horse. In the same area, a motorist drove into a crevice formed overnight along an activated fissure, causing damage and injury. Extra attention to developments and transportation corridors proposed for areas with known fissure zones is critical to effective mitigation. Also critical is mitigating floodwaters from entering fissures as much as possible, as flooding is one of the key activators.

South Region

The South Region, depicted in Map 23, is the second-most vulnerable region in the state, largely due to the scattered presence of identified fissures in Cochise, Graham, and Pima Counties and a growing history of damages. Most of the fissure hazard areas are in remote rural or undeveloped areas outside of the region's population centers.

State-Owned CFI Exposure and Loss Estimates

None of the state-owned CFI are located within a high-hazard area, and no losses are estimated. A few of the Cochise County fissures are located near I-10 and Hwy 191 and may, upon activation, cause damage to those road segments.

Vulnerable Population Groups

The 2022 estimated total population for the South Region is 1,487,942 people. Less than 0.01 % of the total population, or 127 persons, are located within the fissure high-hazard areas. Of those, 27 persons are under the age of 18, 27 are over the age of 65, and 27 are living at or below 150% of the poverty level.

SVUC Impact Assessment

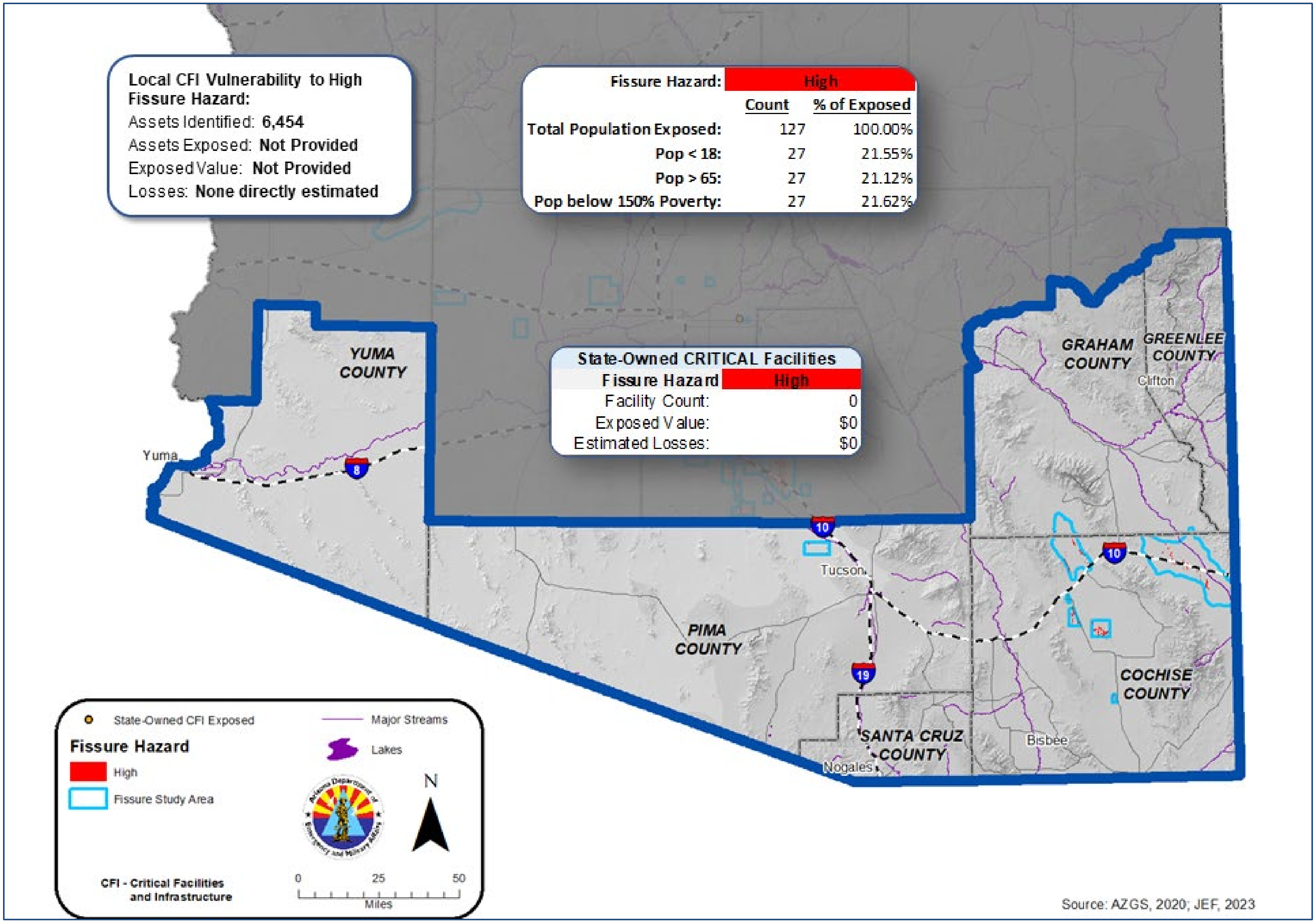
Fissure impacts on South Region SVUC are summarized by CDC SVI themes and percentile rankings in Table 20. The highest percentages of regional exposure are highlighted using bold text. The strongest majority of exposure is to areas with index ranking centered around 0.75 between 0.50 and 0.90, suggesting a moderately high SVUC vulnerability in South Region communities.

Table 20. Fissure high hazard SVUC exposure for South Region

Region	CDC-SVI Assigned Percentile Rank	Percent of Impacted Area by SVI Percentile Rank Range				
		THEME 1 Socio-Economic Status	THEME 2 Household Characteristics	THEME 3 Racial and Ethnic Minority Status	THEME 4 Housing Type/ Transportation	THEMES (ALL) Overall Ranking
South	NO DATA	0.000%	0.000%	0.000%	0.000%	0.000%
South	0-0.25	0.000%	1.072%	0.774%	3.251%	0.000%
South	0.25-0.50	37.770%	1.975%	15.951%	2.935%	5.191%
South	0.50-0.75	13.868%	37.155%	**60.544%**	**46.231%**	**63.429%**
South	0.75-0.90	**41.915%**	**42.034%**	6.780%	38.312%	15.488%
South	0.90-1.00	6.447%	17.763%	15.951%	9.065%	15.892%

Local Jurisdiction Vulnerability

Cochise and Graham Counties included fissures in their risk assessments. No mention by either county is made relative to local CFI exposure or losses. The Cochise County plan noted that



Map 23. Fissure vulnerability for the Soutth region

fissures impacted a total of 287 parcels of land in the unincorporated county. None of the other South Region counties included fissures in their risk assessments.

Specific Areas of Concern

Similar to the Central Region, monitoring of development in or near areas of known fissure activity is crucial to effective mitigation. In recent years, AZGS officials have noted fissures near I-10 near Bowie that will require monitoring and possible mitigation should they activate. Most of the areas in the South Region are remote, but expansion of growth around the area south of Willcox may increase exposure in those areas.

RESOURCES

Sources

AZ Geological Survey in partnership with the AZ Dept of Emergency and Military Affairs, Hazards Viewer, Natural Hazards in Arizona (arcgis.com)

AZ Geologic Survey, Arizona's Earth Fissure Center, https://azgs.arizona.edu/center-natural-hazards/earth-fissures-subsidence-karst-arizona

References

Allison, M.L., T.C. Shipman, 2007a, *Earth Fissure Mapping Program, 2006 Progress Report*. AZGS Open File Report OFR 07-01, Tucson, AZ.

Allison, M.L., T.C. Shipman, 2007, *The Role of AZGS in Mapping Earth Fissures in AZ.* Arizona Geology, Vol. 36, No. 4/ Vol. 37 No. 1, Winter/Spring 2007, AZGS, Tucson, AZ.

Arizona Land Subsidence Group, 2007, Land Subsidence and Earth Fissures in Arizona, Research and Information Needs for Effective Risk Management., AZGS Contributed Report CR-07-C. http://hdl.handle.net/10150/629244

Galloway, D., D.R. Jones, S.E. Ingebritsen, 1999, *Land Subsidence in the United States.* US Geological Survey Circular 1182. ISBN 0-607-92696-1.

Gelt, J., 1992, *Land Subsidence, Earth fissures change Arizona's Landscape*. University of Arizona's Water Resources Research Center, Arroyo, Vol. 6, No. 2.

Pearthree, P. A., Ben-Horin, J.Y., 2021, *Arizona Geology Newsletter v.42 no.3 - Winter 2021*. http://hdl.handle.net/10150/667571

Sandoval, J.P., S.R. Bartlett, 1991, *Land subsidence and earth fissuring on the Central Arizona Project, Arizona*: International Symposium on Land Subsidence, 4th, Houston, 1991, Proceedings: International Association of Hydrological Sciences Publication 200, p. 249-260.

Slaff, Steven, 1991, Earth -Fissure Activity Near Brady and Picacho Pumping Plants, Tucson Aqueduct, Central Arizona Project, Pinal County, Arizona. AZ Geological Survey Open-File Report 91-1, prepared for the US Bureau of Reclamation.

Slaff, Steven, 1993, *Land Subsidence and Earth Fissures in Arizona*. AZ Geological Survey, Down-to-Earth Series 3.

FLOODING

DESCRIPTION

Flooding is the most common and most expensive hazard in Arizona. Since February 1966, the state has experienced 141 flooding incidents of sufficient magnitude to prompt a Presidential or Gubernatorial disaster declaration, which is more than any other hazard category to date. Total allocations from the Governor's Emergency Fund over that period exceeded $200 million. Total federal expenditures exceeded $1.22 billion.

Precipitation Event Types

There are three (3) seasonal atmospheric conditions that tend to trigger significant flood events in Arizona:

Tropical Storm Remnants

Historically, the most regionally severe flooding occurs when remnants of hurricanes and tropical storms enter the state. These events infrequently occur (i.e., approximately every ten years), mostly in early autumn, and can bring several days of prolonged, intense precipitation events covering large regions that can cause severe flooding. In general, the flood hazard imposed by tropical storm remnants tends to degrade with northern movement through the state. The Southern Region and lower Central Region are usually impacted the most.

Winter Rains

Winter brings the threat of low-intensity, long-duration rains that cover large areas and cause extensive flooding and erosion, particularly when combined with snowmelt that increases runoff after rain falls on significant snowpack. The El Nino climate phenomenon can influence winter storms and cause severe flooding. Winter rains tend to impact the Northern Region's northernmost portions of Central and Southern Regions..

Summer Monsoons

Monsoon winds bring humid subtropical air into the state in mid to late summer. Solar heating triggers afternoon thunderstorms that can be devastating. Flash flooding may occur as a result of local, intense rainfall in a short period (usually six hours). Many Arizona communities get half of their annual rainfall during the summer monsoon from June 15 to September 30. Summer monsoons impact areas statewide but tend to be strongest in the Central and Southern Regions.

Palm trees wave in the wind while lightning strikes behind them during a monsoon storm in Mesa on July 29, 2016. (Photo: Michael Chow/The Republic)

Flood Types

Flooding can occur in several different ways and is generally characterized into the following types:

Riverine

The most common type of flooding occurs along well defined watercourses such as rivers or desert washes. Many of the watercourses within the state are ephemeral and typically remain dry until significant rain causes flooding.

Shallow Sheet Flow

Flooding that occurs in areas that are fairly flat with no definable washes or low-flow areas of significance. The flooding occurs as a shallow sheet of water that can be several feet deep. Depending on the slope of the land, there can also be ponding, and the sheet flow can be slow or move fast enough to cause erosion.

Distributary flow

Flooding in relatively flat areas where the watercourse divides and braids into smaller continuous or discontinuous channels or branches that are subject to either further erosion and expansion, or plugging with debris and sediment. Flow may also include sheet flooding of areas between channels depending on the magnitude of storm and watercourse slopes. For further discussion of distributary flow characteristics, see Hjalmarson and Kenna (1991).

Alluvial fans

In the arid southwest, active alluvial fans can develop at locations where steep mountain washes abruptly transition to flatter alluvial piedmonts located at the base of the mountain. During flood events, the steep washes carry heavy sediment loads that deposit in a fan-shape, with one or more primary flow paths of concentrated flooding that can change location across the fan face with any given flood event. The point of slope change at the upper-most portion of the fan is known as the fan apex. It is noted that alluvial fans and distributary flow areas are similar; however, alluvial fans are significantly more active and volatile in moving the primary channel(s) and creating new flow paths.

Post-Fire Flooding

Normally, vegetation absorbs and attenuates the impact of rainfall, which reduces runoff. Wildfires leave the watershed charred barren and can physically alter the ground’s ability to absorb water, creating conditions ripe for flash flooding and debris-mud flows. Significantly elevated flood risk remains until vegetation is restored and can last for 5-10 years after a wildfire. Flooding immediately after a wildfire is often significantly more severe, as debris and ash left from the fire can combine with eroded soil and sediment to form debris and mud flows, rendering drainage infrastructure such as culverts, storm drains, and even channels useless. The combined increase of floodwaters and debris-mud flows can cause significant damage to areas downstream of the burned watershed.

HISTORY

The following are a few recent examples of significantly large flood events that occurred in the state over the last 10 years:

- July 31, 2022 - Heavy rain of 1.5-2.5 inches fell in less than 1 hour over the Finger Rock Canyon watershed, with 2.29 inches recorded in 30 minutes at the Mt. Kimball gauge near the headwaters, which was in the severe burn area of the 2020 Bighorn Fire burn scar. Finger Rock Wash rose over 14 feet at a downstream gauge at the mouth of the canyon. Residents of seven homes and 12 people from an 8th structure used as an assisted living facility were evacuated due to as much as 3 feet of water inside the structures. Most of the homes will be purchased and demolished. Several of the roads in the area were washed out, and the wash structure itself was damaged. Damages were estimated at $3 million (NCDC, 2023).
- August 14, 2021 - The town of Gila Bend suffered catastrophic flash flooding after 2 to 4 inches of rain fell over a large portion of Sand Tank and Bender Wash watersheds in a 1-2 hour period. A breach of the canal in town due to erosion added to the flash flooding. Significant flow through the washes impacted numerous homes and businesses, and there were 2 fatalities. Damages were estimated at $25 million, and a state declaration of emergency was declared by Governor Ducey effective August 13, 2021 (NCDC, 2023).

Flood photos posted by Arizona Rangers – Tucson Co./Facebook

- February 14, 2019 - A winter storm over a broad swath of Arizona brought moderate to heavy precipitation over 12 to 18 hours, with rising snow levels in upper elevations. Wet Beaver Creek near Rimrock and at Montezuma Castle rose 7 and 15 feet in 2-hours. Yavapai County officials estimated 25 homes were damaged as a result of the flooding, and some were declared unsafe. Multiple rescues were performed in the Montezuma and Rimrock areas. Damages were estimated to exceed $1 million (NCDC, 2023).
- July 10, 2018 - Thunderstorms produced 2 to 3 inches of rain on both sides of I-10 from Cortaro to Twin Peaks, causing flash flooding that closed numerous roads and intersections. First responders performed at least eight swift water rescues of motorists. A restaurant and animal shelter were flooded, and railroad track flooding derailed over two dozen Union Pacific railroad cars north of Twin Peaks Road, causing extensive damage and closing the access road to Interstate 10 for several days. Damages were estimated to exceed $4 million (NCDC, 2023).

- July 19, 2017 – Thunderstorms produced heavy rain over the Goodwin Fire scar that produced flash floods on Big Big Bug Creek, Grapevine Creek, and ultimately Agua Fria River, damaging homes and infrastructure in Mayer and Spring Valley in Yavapai County. A total of 120 homes were impacted, with 40 being either destroyed or receiving major damage. Losses were estimated at over $7 million. Fortunately, no injuries or deaths were reported (NCDC, 2023).

Big Bug Creek Flooding in Mayer (NWS, 2023)

- July 15, 2017 – Ten family members died after a flash flood swept them downstream. While swimming in the Cold Springs swimming hole, rain fell eight miles upstream of them along the Ellison Creek watershed. This area is within the burn scar of the 7,198-acre Highline fire from June of 2017. The flash flood sent a six-foot-high and 40-foot-wide wall of water laden with debris, tumbling downstream (NCDC, 2023)..
- October 8, 2016 – Safford in Graham County experienced two inches of rain and six inches of hail. This caused damage to homes and cars and a collapse of 12th Avenue. The state declared a disaster on October 19th (NCDC, 2023).
- September 14, 2015 – Flash floods in the community of Hilldale, Utah and Colorado City, in Mohave County, caused the deaths of 12 people who were swept away in their vehicles. The flooding spilled into an overbank area of the main watercourse and flanked the unsuspecting parked vehicles, carrying them downstream (NCDC, 2023).
- September 8, 2014 – Remnants of hurricane Norbert produced storms with rainfall more than two inches per hour. Major flooding caused damage in La Paz, Maricopa, Mohave, and Pinal Counties. Over 125 homes in Mesa near Val Vista and US 60 were in danger of flooding. A fatality was reported in the Oracle Road area after a 76-year-old woman was swept away when her car was caught in the flood waters. $2,608,829 from the Governor's Emergency Fund was utilized to help with over 150 disaster recovery projects (NCDC, 2023; FCDMC, 2023).

Interstate 10 flooding, September 2014. AZ Republic.

NATIONAL FLOOD INSURANCE PROGRAM (NFIP)

As of July 31, 2023, 23,175 homeowners in Arizona held flood insurance policies through the NFIP program. It is important to note that flood insurance is mandatory for a building constructed in a federal floodplain with a federally backed mortgage. During the period of January 1, 1978, through July 31, 2023, there were 4,619 losses and over $59.9 million in payments reported for Arizona's NFIP communities. Since 2018, there have been 348 loss claims for a total of over $11.3 million paid[1].

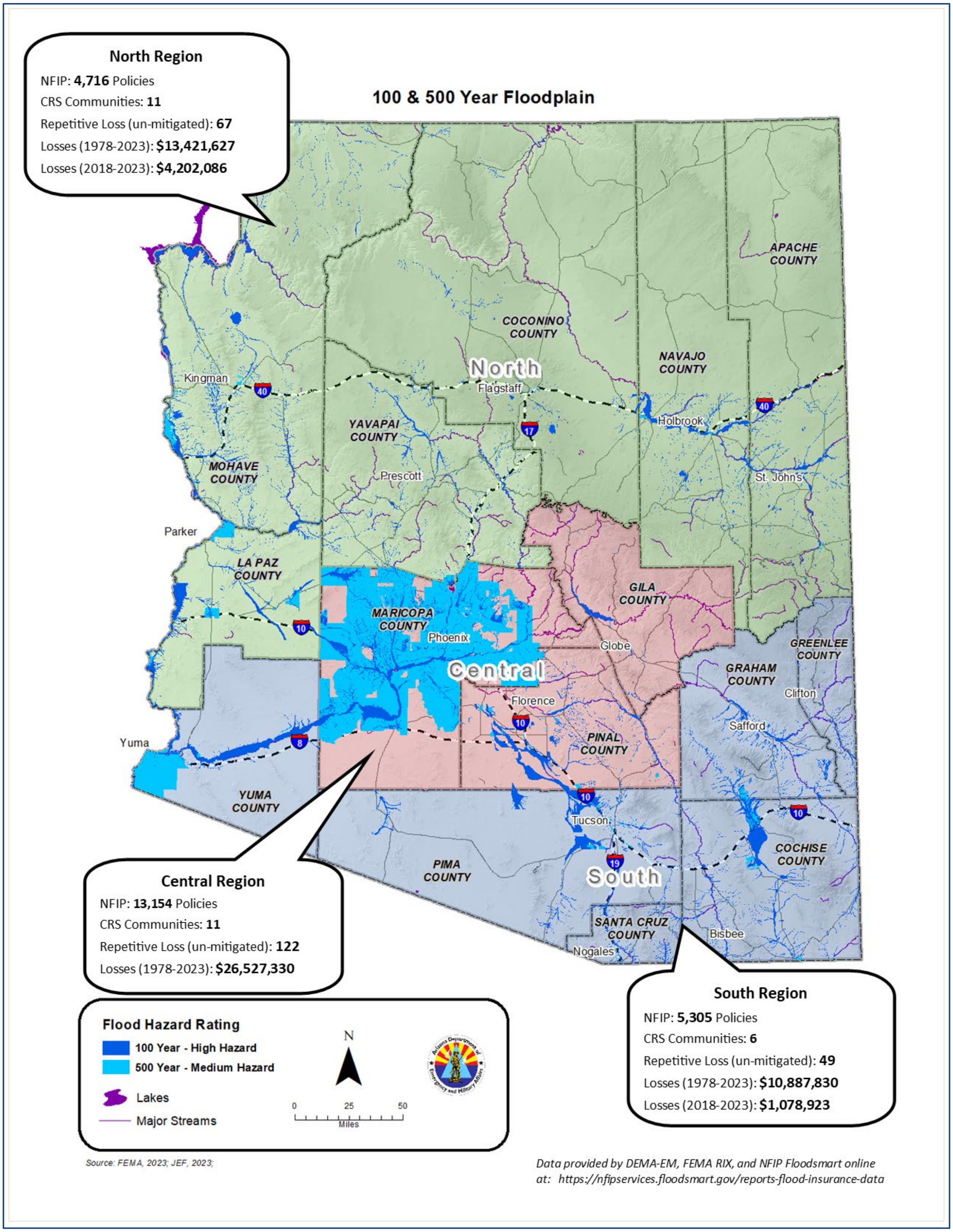
As of the 2018 Plan, FEMA records indicated there were one Severe Repetitive Loss (SRL) and nine Repetitive Loss (RL) properties identified in Arizona. Access to updated information was not available to the Planning Team for this update, so the 2018 Plan numbers will be the latest available. There are multiple sources with varying standards for what constitutes SRL and RL properties. This Plan acknowledges the FEMA-identified SRL and RL properties in accordance with the Flood Mitigation Assistance (FMA) grant requirements.

ADWR's floodplain management program is partially funded by FEMA's Community Assistance Program (CAP). One of the main objectives of the CAP is to ensure that jurisdictions adopt and enforce floodplain management regulations in accordance with the requirements of the NFIP and the Arizona Revised Statutes (ARS). Through this program, Community Assistance Visits (CAVs) are made to the state's NFIP participating communities. It is the goal of ADWR to visit communities periodically to provide updates on state and federal floodplain management program changes, provide technical and programmatic assistance, and verify that development in flood-prone areas is compliant with local floodplain management regulations. The Community Rating System (CRS) is a voluntary incentive program that recognizes and encourages a community's floodplain management activities that exceed the minimum NFIP requirements. Flood insurance premium rates are discounted to reflect the reduced flood risk resulting from community measures that meet the goals of the CRS program..

Map 24 details the number of NFIP policies, loss claims made by flood insurance policyholders, repetitive and severe repetitive loss properties, and the number of CRS communities for each of the DEMA/EM field operations regions.

PROBABILITY/EXTENT

The probability of floods occurring in Arizona is very high. The extent of the flood hazard can vary greatly and is influenced by many factors including the volume and intensity of precipitation, geography, and land-use characteristics. One of the most widely adopted design and regulatory standards for flooding in Arizona is an event of a certain magnitude that has a 1% probability of



Map 24. NFIP statistics statewide

being equaled for exceeded in any given year, or the 1% annual chance of exceedance (ACE) flood. The 1% ACE flood is the standard formally adopted by FEMA for regulatory use and is often referred to with the recurrence interval moniker of "100-year flood." The reality is that a community could experience multiple 1% ACE flood events (100-year floods) in any given year.

For this Plan, the inundation limits of the 1% ACE flood is designated as the 'high' risk area, and the 0.2% ACE flood inundation limits are designated as 'medium'risk. The geospatial limits for the high and medium flood hazard areas are derived from FEMA's most current National Flood Hazard Layer data[21], and are presented by region on the profile and vulnerability maps in this section.

Another measure of the likelihood of a damaging flood occurring in the state based on historic incidents can be made using the average number of flood related disasters declared by the state per year. Records dating back to 1966 indicate that there have been a total of 104 state declared disasters related to flooding, with the last state declaration occurring in March 2023. This equates to a statewide average of 1.8 flood related declarations per year.

WARNING TIME

Warning time for flood-related events is composed of the time needed to assess and issue a meteorological warning for a probable precipitation event and the time from initiation of precipitation to the time that peak flooding occurs. For Arizona, those times will vary depending on the type of precipitation event and the size of the watercourse and tributary watershed.

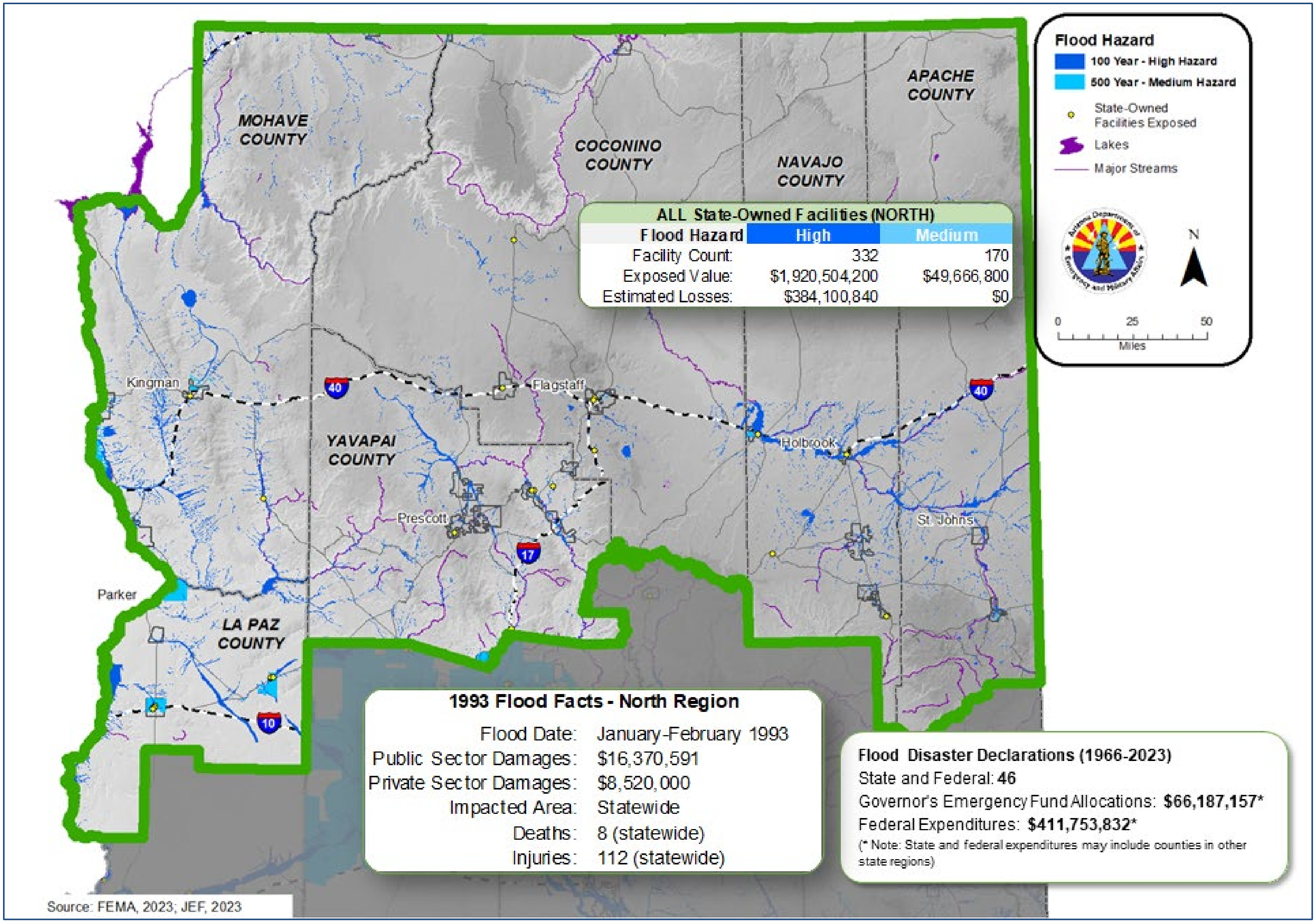
Summer Monsoons

Typical monsoon thunderstorms develop rapidly and are relatively small in areal extent with short duration, high-intensity bursts of rainfall that result in swiftly moving flash floods. The full warning times for monsoon events are usually less than a couple of hours, and flood peak arrival times can be measured in minutes for small watersheds. Many of the fatalities associated with flood events within the state are due to thunderstorms that caused flash floods that caught people unaware.

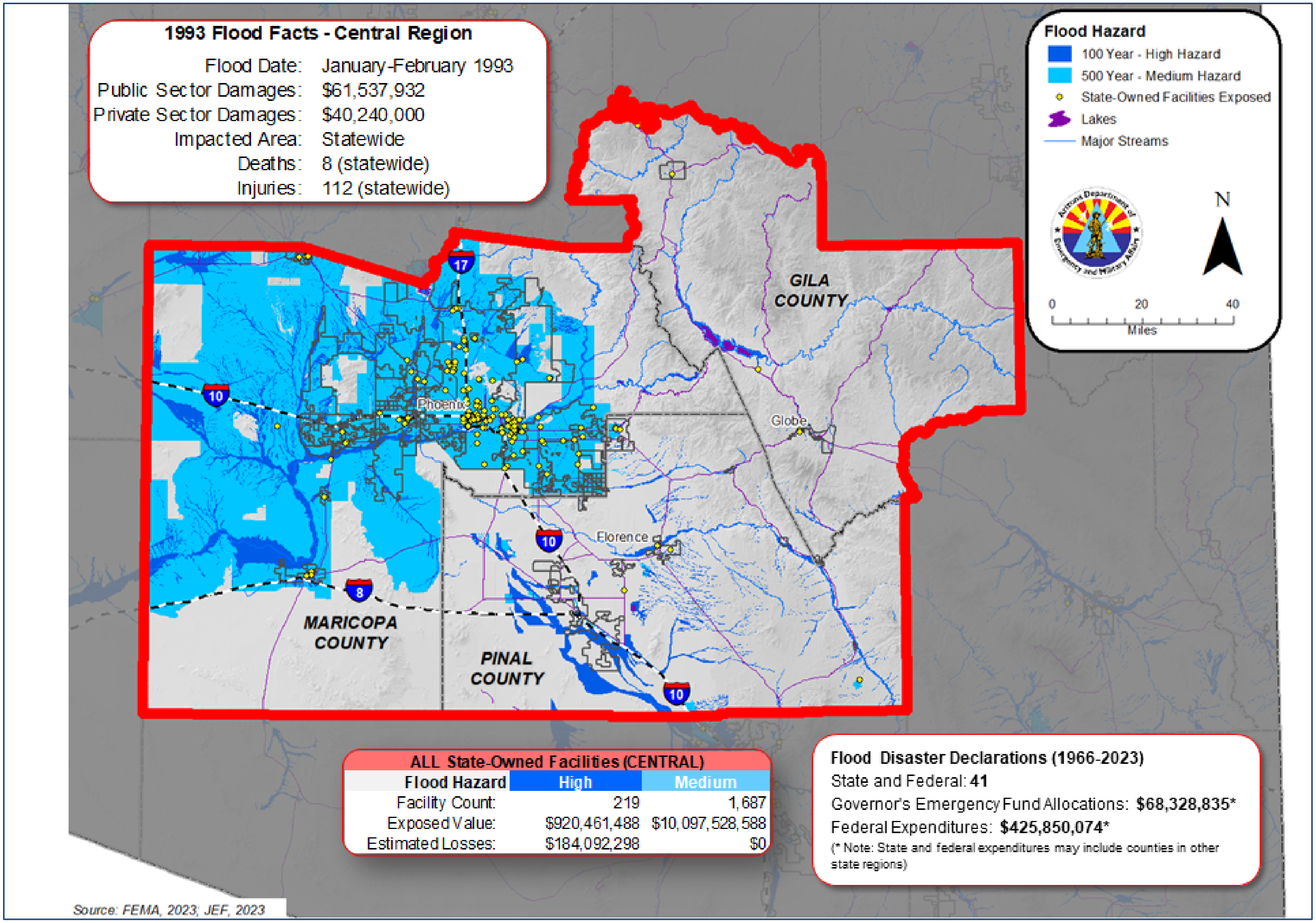
Tropical Storm Remnants

Tropical storms moving into Arizona typically have more advanced meteorological notice and tracking. Rainfall areal extents and durations are typically larger and longer than monsoon storms, but intensities can still generate fairly rapid peak flows. Full warning times for tropical storm remnants are usually greater than six hours, with flood peak arrival times in a couple of hours, depending on the watercourse and watershed size.

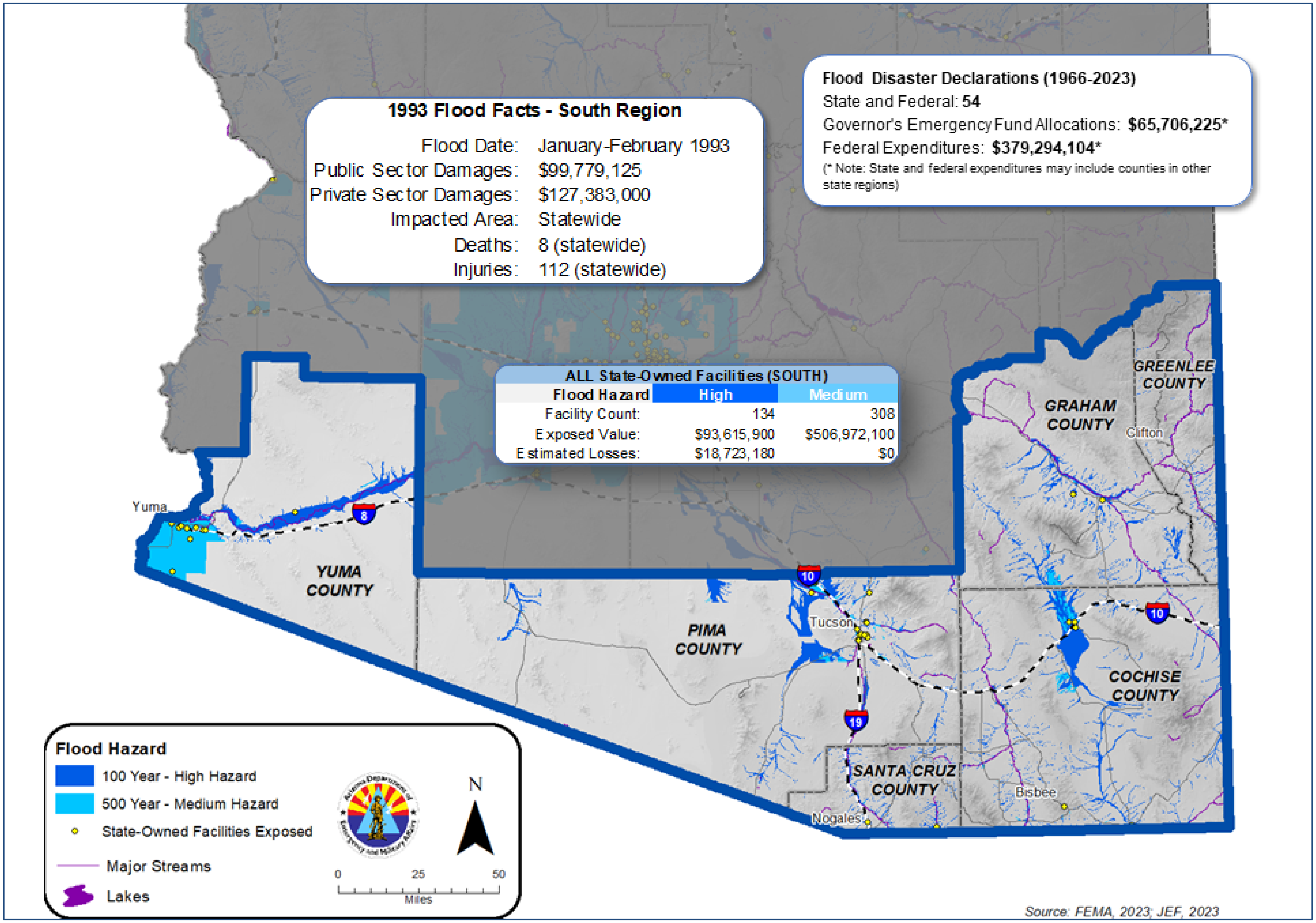
[21] Accessed July 2023 via FEMA's Map Service Center at: [FEMA Flood Map Service Center | Welcome!]



Map 25. Flood hazard for the North region



Map 26. Flood hazard for the Central region



Map 27. Flood hazard for the Soutth region

Winter Rains

General winter storms have a longer duration, low-intensity rainfall that covers large areas of the state and produces runoff that gradually accumulates to peak flood stages. Winter storms moving into Arizona typically have more advanced meteorological notice and tracking. Full warning times generally exceed 12 hours, with flood peak arrival times in several hours.

FUTURE CONDITIONS

Climate Considerations

The 4th Edition of the National Climate Assessment (NCA) report (Gonzales et al., 2018) is relatively silent on non-coastal flood-related impacts except as they are indirectly influenced by deepening drought, increased wildfire potential, etc.

Prior work in the 3rd Edition (Garfin et al., 2014) notes that one of the anticipated impacts of climate change for the Southwest is a shift in rain patterns with more intense winter rains, less snow, and less frequent but more intense monsoon-related thunderstorms. A reduction in average annual precipitation and streamflow volumes. For Northern Region communities, the impacts could result in more severe winter season flooding.

A second study by Luong (Luong et al., 2015) notes that monsoon thunderstorms in the Central and Southern Regions of the state have become more intense over a recent 20-year period (1991-2010) when compared to events recorded in the past (1950-1970). The study concludes that the trend will likely continue as the temperatures rise and provide more moisture storage capacity in the lower atmosphere. The increased intensities may result in increased flood levels.

Statewide, the overall flooding conditions could also be exacerbated by watersheds with reduced vegetation due to increases in drought or wildfire conditions.

Changes in Development

Anticipated flooding impacts due to future development and land-use planning changes for each region are generally obtained from the county hazard mitigation plans. All 15 counties and the incorporated communities generally require adherence to modern building codes and actively regulate their respective floodplains for new developments or substantial re-development to modern floodplain ordinances. The majority of flood-prone properties pre-date the state and counties' entry into the NFIP program and will continue to be areas of focus and attention. Development and population growth into known and unknown floodplains can increase the future probability of an event. Post-wildfire flooding events arguably pose the greatest flood risk to many communities in the state, especially those situated along the wildland-urban interface areas, which often tend to also be the higher growth areas.

State-owned facilities primarily impacted by future changes in development generally include the freeways and highways and their supporting culverts and bridges. Unless otherwise noted, reference to a county also includes the incorporated communities within that county.

North Region

Coconino, Mohave, and Yavapai Counties have well-established flood control districts with strong modeling, mapping, planning, and construction programs and regulatory floodplain ordinances to better inform the public of flood risks and reduce risk in flood-prone areas. Apache, Navajo, and La Paz Counties also regulate adopted floodplain ordinances as a normal part of development review. Areas of anticipated growth that may extend into flood hazard areas are identified in the Flagstaff and Tusayan (Coconino), Prescott Valley and Chino Valley (Yavapai), Kingman, Bullhead City, and Lake Havasu City (Mohave), plus several populated areas within the unincorporated areas of Coconino, Mohave, and Yavapai Counties.

Central Region

All Central Region counties have well-established flood control districts with varying modeling, mapping, planning and construction programs, and regulatory floodplain ordinances to better inform the public of flood risks and reduce risk in flood-prone areas. Growth along the urban fringes of currently populated areas within Maricopa and Pinal Counties will continue to be managed to the current floodplain ordinance and permitting requirements. Growth in Gila County is still most active in and around the Payson area, but the greater flood risk challenges occur in unincorporated communities.

South Region

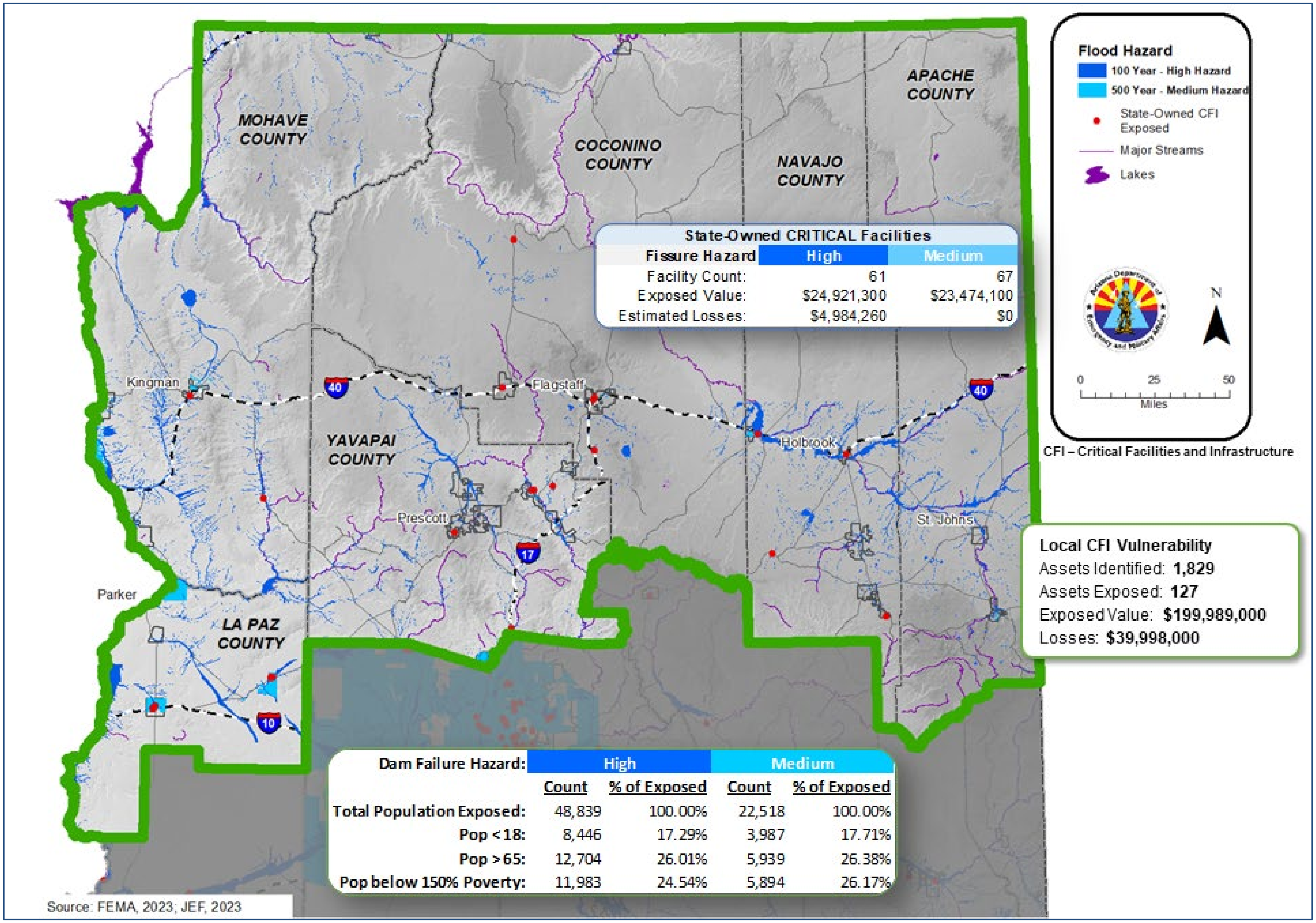
All South Region counties have well-established flood control districts with strong modeling, mapping, planning and construction programs, and regulatory floodplain ordinances, and they work closely with their incorporated communities to better inform the public of flood risks in their area and reduce risk in flood-prone areas. Future growth into flood-prone areas within Cochise, Graham, Greenlee, Santa Cruz, and Yuma Counties is not anticipated to be significant.

VULNERABILITY ASSESSMENT

The estimation of potential exposure to the identified high and medium flood hazards was accomplished by using GIS tools to intersect the human and state-owned critical facilities and infrastructure (CFI) data with the flood hazard limits as depicted on the profile maps that follow. The loss calculations assume that no structure will be flooded to a depth of greater than two feet on average and, per the FEMA tables, are subject to a loss-to-exposure ratio of 0.20 (or 20% damaged) for high-hazard areas. The loss estimates presented are based on a single event and assume that the entire region is flooded to the depicted hazard at the same time. No losses are estimated for assets located in the medium flood hazard areas.

North Region

The North Region vulnerability, depicted on Map 28, is the least vulnerable to flood hazards when considering the number of historic declarations and exposure estimates. It is noted, however, that the North Region has the most RL ans SRL properties.



Map 28. Flood vulnerability for the Nortth region

State-Owned CFI Exposure and Loss Estimates

A total of 61 state-owned CFI, or 18.4% of the statewide exposure, are located within a high-hazard area. The exposed facilities represent a total exposed replacement value of $24.9 million, with an estimated $5.0 million in potential losses. For the medium flood hazard, a total of 67 state-owned CFI, or 5.4% of the statewide exposure, are exposed and represent a total replacement value of $23.5 million. No losses are estimated for facilities exposed to a medium flood hazard.

Additional state-owned facilities vulnerable to flood hazards are the AZ Dept of Transportation (ADOT) operated and maintained freeways, highways, and state routes. The majority of ADOT roadway corridors in rural areas are designed to handle at least a 2% annual flood (50-year), which means a 1% ACE flood may overtop or exceed the constructed drainage facilities. There are numerous drainage facilities (bridges, culverts, and channels) constructed with the ADOT roadways. Typical impacts might include erosion of roadway embankments and pavements, culvert failures, and potential bridge failures.

Vulnerable Population Groups

The 2022 estimated total population for the North Region is 801,655 people. Approximately 6.09% and 2.81% of the total population, or 48,839 and 22,518 persons, are exposed to high and medium flood hazards. Exposure statistics for the sub-population groups under 18 years of age, older than 65, and less than 150% poverty level are indicated on Map 28.

SVUC Impact Assessment

CDC SVI themes and percentile rankings summarize high flood hazard impacts on North Region SVUC in Table 21. The highest percentages of regional exposure are highlighted using bold text. The results indicate that the SVUC exposure is moderate for the region, with the majority of impacts centering on 0.50 to 0.75 rank for North Region communities and populations.

Table 21. High flood hazard SVUC exposure for North Region

Region	CDC-SVI Assigned Percentile Rank	Percent of Impacted Area by SVI Percentile Rank Range				
		THEME 1 Socio-Economic Status	THEME 2 Household Characteristics	THEME 3 Racial and Ethnic Minority Status	THEME 4 Housing Type/ Transportation	THEMES (ALL) Overall Ranking
North	NO DATA	0.05%	0.05%	0.00%	0.07%	0.07%
North	0-0.25	9.77%	14.99%	**43.92%**	7.08%	7.46%
North	0.25-0.50	24.73%	22.49%	21.91%	31.04%	33.50%
North	0.50-0.75	**52.60%**	**29.61%**	25.33%	**43.44%**	**33.70%**
North	0.75-0.90	9.36%	17.73%	7.05%	7.02%	19.95%
North	0.90-1.00	3.49%	15.12%	1.79%	11.34%	5.32%

Local Jurisdiction Vulnerability

Local hazard mitigation plans for the North Region identified a total of 1,829 assets with a total replacement value of $2.0 million. Total potential losses to local CFI were estimated at $40 million.

Specific Areas of Concern

Existing development statewide that was built before the floodplain standards were enacted remains vulnerable to regular flooding. Flood regulations and elevation requirements have typically only been applied to new structures built after the mid-1980s. Historic cities and towns in Arizona were often built near rivers or other regional watercourses within areas that face periodic flooding. Several small towns in the North region face elevated flood risk due to their location near rivers or major washes. The Town of Wenden in La Paz County is located adjacent to Centennial Wash, is located in an active subsidence zone, and has experienced two major floods in the years 2000 and 2010. Winslow and Holbrook are communities in Navajo County that face elevated flood risk due to their proximity to the Little Colorado River and their reliance upon aging levees and associated infrastructure that is very expensive to fix. The Rio de-Flag, running through the middle of Flagstaff, is a constant source of flooding, with significant damages in 2014, 2010, and 2004. In Mohave County, a significant number of road crossings are susceptible to flooding and closure during flood events.

One area of particular concern to many of the North Region communities is the possibility of significant post-wildfire flooding. AZGS and DEMA/EM have partnered with FEMA to secure grant funding to perform advanced post-wildfire debris flow and flood risk planning and risk assessments for several watersheds with significant populations or development in place. In some communities, risk assessments are used to develop action plans and formulate pre-disaster mitigation and response strategies.

Another challenge to a large geographic area of the North Region is flood risk management on tribal lands. Since tribes have sovereignty, much of the state’s efforts are cooperative.

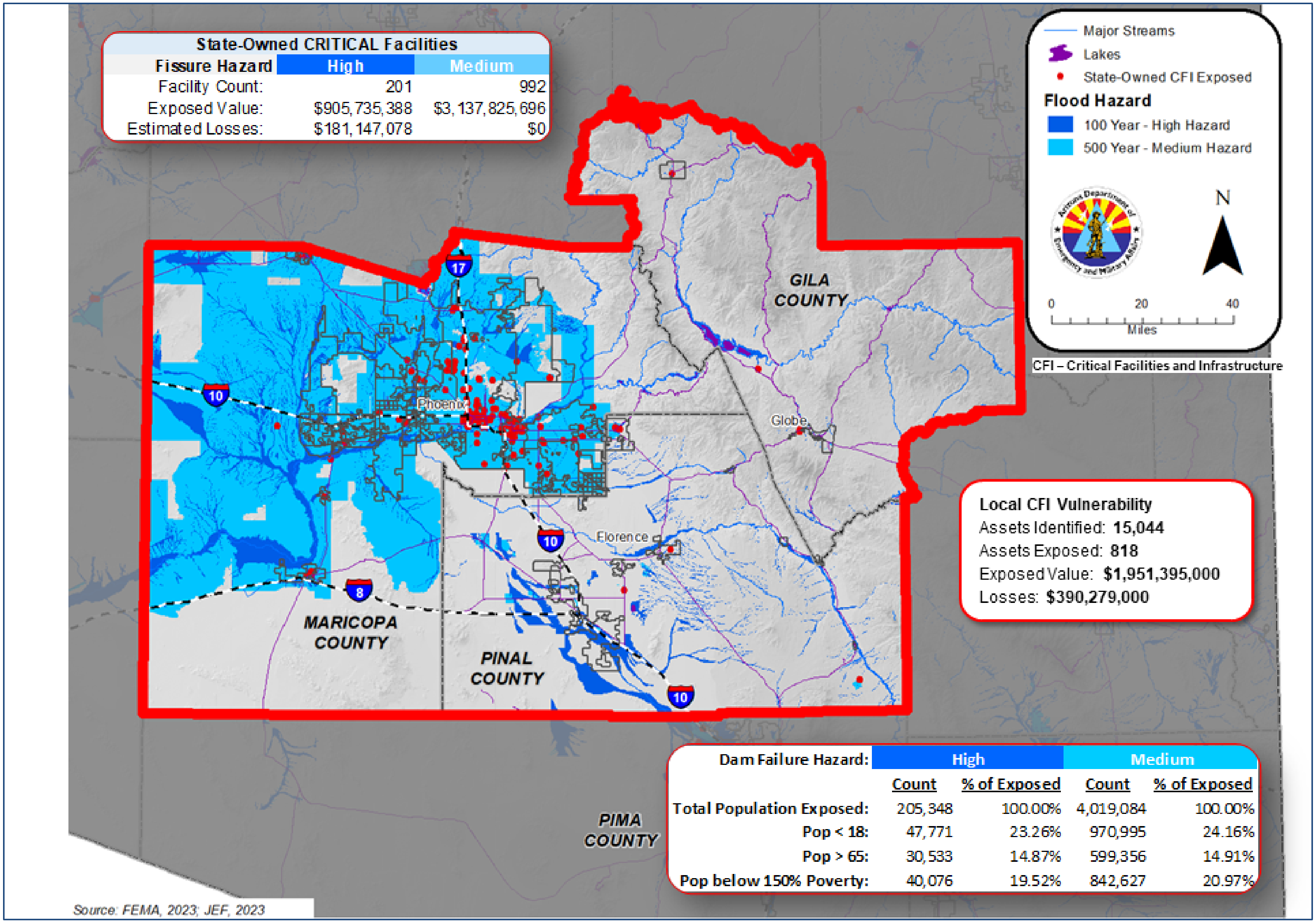
Many of the tribal population areas are remote and easily isolated by regular flood events. Cultural and economic limitations make flood risk reduction measures difficult and leave significant tribal populations at risk.

Central Region

Among the three state regions, the Central Region, shown in Map 29, has the most significant vulnerability to flood hazards when considering the number of historic declarations, exposure estimates, and RL/SRL properties. Alternately, the Central Region arguably has the greatest amount of resources for active flood mapping, modeling, and mitigation.

State-Owned CFI Exposure and Loss Estimates

A total of 201 state-owned CFI, or 60.7% of the statewide exposure, are located within a high-hazard flood area. The exposed facilities represent a total exposed replacement value of $905.7 million, with an estimated $181.1 million in potential losses. For the medium



Map 29. Flood vulnerability for the Central region

flood hazard, a total of 992 state-owned CFI, or 79.9% of the statewide exposure, are exposed and represent a total replacement value of $3.14 billion. No losses are estimated for facilities exposed to a medium flood hazard.

Roadways and infrastructure within the metropolitan Phoenix area are designed to meet local drainage requirements and, therefore, are protected to a 1% ACE flood level. Risks still remain, as was demonstrated in the 2014 flooding events. There are numerous drainage facilities (bridges, culverts, and channels) constructed with the ADOT roadways. Estimation of losses is difficult, but historic losses give some indication of the potential for future losses. During the 1993 flood, the Federal Highway Administration provided over $28.3 million in financial assistance to fix damaged roads in the Central Region (USACE, 1994). Therefore, losses exceeding $29 million are feasible.

Vulnerable Population Groups

The 2022 estimated total population for the Central Region is 5,069,600 people. Approximately 4.05% and 79.28% of the total population, or 205,348 and 4,019,084 persons, are exposed to high and medium flood hazards. Exposure statistics for the sub-population groups under 18 years of age, older than 65, and less than 150% poverty level are indicated on Map 29.

SVUC Impact Assessment

CDC SVI themes and percentile rankings summarize high-hazard flood impacts on Central Region SVUC in Table 22. The highest percentages of regional exposure are highlighted using bold text. The strongest majority of exposure is generally centered around the 0.50 index and within a range between 0.25-0.75, which would suggest a moderate SVUC vulnerability in Central Region communities.

Table 22. Flood high hazard SVUC exposure for Central Region

Region	CDC-SVI Assigned Percentile Rank	Percent of Impacted Area by SVI Percentile Rank Range				
		THEME 1 Socio-Economic Status	THEME 2 Household Characteristics	THEME 3 Racial and Ethnic Minority Status	THEME 4 Housing Type/ Transportation	THEMES (ALL) Overall Ranking
Central	NO DATA	0.09%	0.09%	0.04%	0.09%	0.09%
Central	0-0.25	11.27%	19.39%	25.02%	11.05%	10.94%
Central	0.25-0.50	20.61%	13.68%	**27.93%**	37.33%	19.52%
Central	0.50-0.75	**54.99%**	**43.32%**	27.85%	**38.54%**	**50.77%**
Central	0.75-0.90	11.50%	14.89%	18.04%	3.68%	8.16%
Central	0.90-1.00	1.54%	8.64%	1.12%	9.17%	10.52%

Local Jurisdiction Vulnerability

Local hazard mitigation plans for the Central Region identified 818 assets with a total replacement value of $1.95 billion. Total potential losses to local CFI were estimated at $390 million.

Specific Areas of Concern

Existing development that was built before the floodplain standards were enacted remains vulnerable to regular flooding. This was recently observed with the 2021 flooding in Gila Bend. Older locations of the Phoenix Metropolitan area experience local flooding due to the lack of adequate drainage facilities, especially in areas adjacent to canal systems crossing through the valley. In the western portion of Pinal County, the City of Maricopa and surrounding communities face a flood risk from several regional watercourses that comprise the Lower Santa Cruz River system. Several areas downstream of recent wildfires within Gila County (Globe, Miami, Gisela, Tonto Creek, etc.) are now facing elevated flood risk while the burn scar areas begin to recover.

South Region

Among the three state regions, the South Region, shown in Map 30, is the second most vulnerable to flood hazards. The Tucson Metropolitan area of Pima County has significant resources for active flood mapping, modeling, and mitigation in those areas. The more rural areas, however, are not as equipped and financially backed. Of the three state regions, the South Region has the least amount of RL/SRL properties but is considered to be the second most vulnerable region.

State-Owned CFI Exposure and Loss Estimates

A total of 69 state-owned CFI, or 20.8% of the statewide exposure, are located within a high-hazard area. The exposed facilities represent a total exposed replacement value of $66.1 million, with an estimated $13.2 million in potential losses. For the medium flood hazard, a total of 182 state-owned CFI, or 14.7% of the statewide exposure, are exposed and represent a total replacement value of $352.8 million. No losses are estimated for facilities exposed to a medium flood hazard.

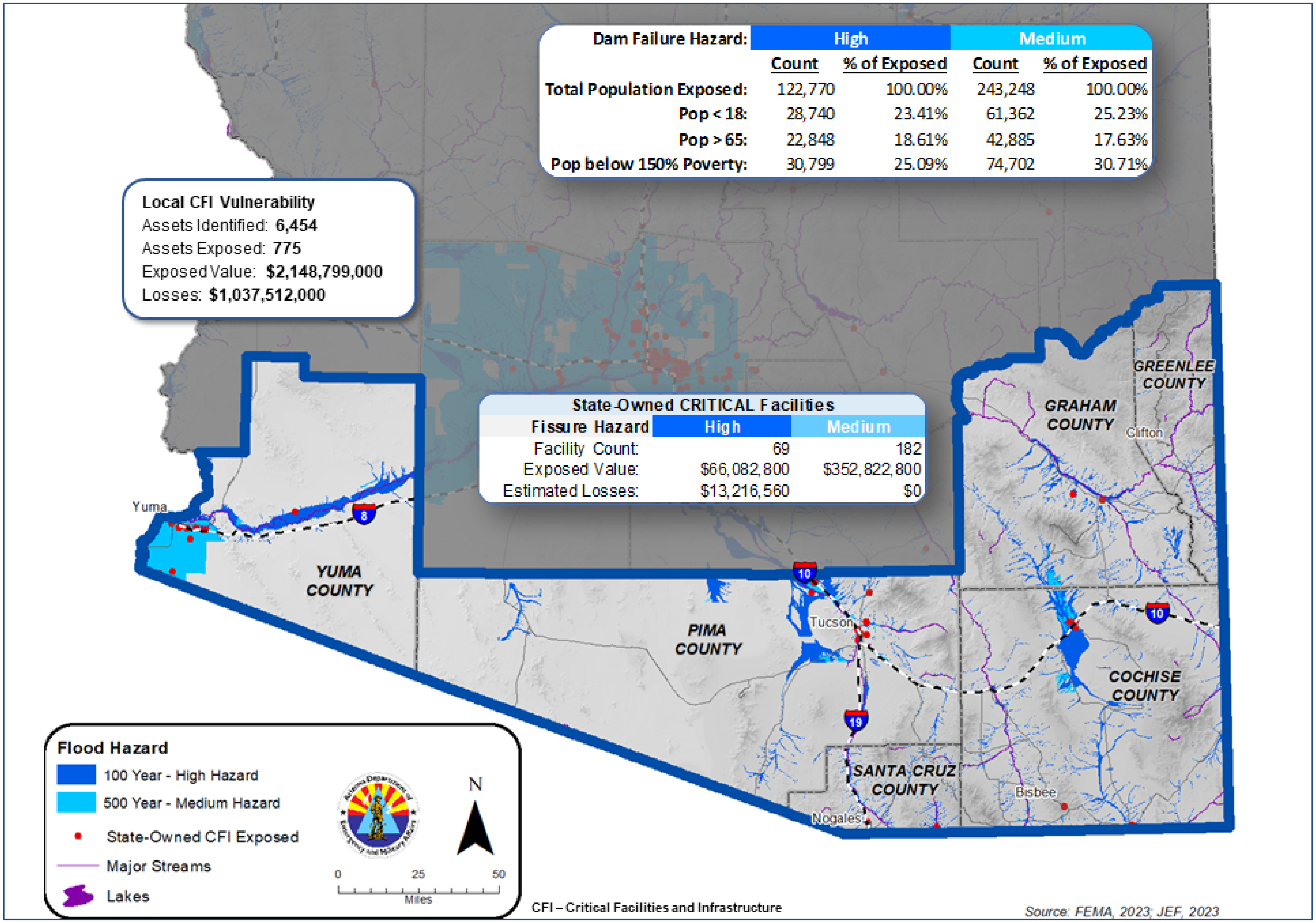
Roadways and infrastructure within the metropolitan Tucson area are designed to meet local drainage requirements and, therefore, are protected to 1% ACE flood levels. There are numerous drainage facilities (bridges, culverts, and channels) constructed with the ADOT roadways. During the 1993 flood, the Federal Highway Administration provided over $29.4 million in financial assistance to fix damaged roads in the South Region (USACE, 1994). Losses exceeding $30 million are certainly feasible with a significant storm event.

Vulnerable Population Groups

The 2022 estimated total population for the South Region is 1,487,942 people. Approximately 5.74% and 16.93% of the total population, or 122,770 and 243,248 persons, are exposed to high and medium flood hazards. Exposure statistics for the sub-population groups under 18 years of age, older than 65, and less than 150% poverty level are indicated on Map 30.

SVUC Impact Assessment

High hazard flood impacts to South Region SVUC are summarized by CDC SVI themes and percentile rankings in Table 23. The highest percentages of regional exposure are



Map 30. Flood vulnerability for the South region

highlighted using bold text. The strongest majority of exposure is to areas with index ranking centered around 0.75 between 0.50 and 0.90, which would suggest a moderately high SVUC vulnerability in South Region communities.

Table 23. Fissure high hazard SVUC exposure for South Region

Region	CDC-SVI Assigned Percentile Rank	Percent of Impacted Area by SVI Percentile Rank Range				
		THEME 1 Socio-Economic Status	THEME 2 Household Characteristics	THEME 3 Racial and Ethnic Minority Status	THEME 4 Housing Type/ Transportation	THEMES (ALL) Overall Ranking
South	NO DATA	0.000%	0.000%	0.000%	0.000%	0.000%
South	0-0.25	0.000%	1.072%	0.774%	3.251%	0.000%
South	0.25-0.50	37.770%	1.975%	15.951%	2.935%	5.191%
South	0.50-0.75	13.868%	37.155%	**60.544%**	**46.231%**	**63.429%**
South	0.75-0.90	**41.915%**	**42.034%**	6.780%	38.312%	15.488%
South	0.90-1.00	6.447%	17.763%	15.951%	9.065%	15.892%

Local Jurisdiction Vulnerability

Local hazard mitigation plans in the South Region identified a total of 775 assets with a total replacement value of $2.15 billion. Total potential losses to local CFI were estimated at $1.47 billion.

Specific Areas of Concern

Existing development that was built before the floodplain standards were enacted remain vulnerable to regular flooding. Older areas of the Tucson Metropolitan area experience local flooding due to the lack of adequate drainage facilities, and especially in areas near downtown Tucson and the older neighborhoods around the University of Arizona. Nogales Wash in Nogales and Santa Cruz County, is a high risk flood corridor that is complicated by a failing underground tunnel and concrete lining, and the presence of a regional wastewater system located in bed of the wash that when breached, spills millions of gallons of raw sewage into the watercourse, and uncontrolled development practices on the Mexican side of the border. The Town of Patagonia is another Santa Cruz County community that is impacted by a significant flood hazard that covers a substantial portion of the town limits. In the Town of Clifton, repeated flooding of Ward’s Canyon in 2005, 2010, and again in 2015 threatens several critical facilities. A significant portion of the Town of Duncan will be inundated with any Gila River flows exceeding a 10% ACE flow (10-year Flood). The citizens of the Town of Sahuarita are subject to being cut off from emergency services when flooding occurs in the Santa Cruz River and several other washes and channels in the area. Overwhelming vegetative growth in the Gila River floodplain through the Safford, Thatcher and Pima communities is lowering flood conveyance capacity and increasing flood risks to adjacent farms and crossing infrastructure.

RESOURCES

Sources

FEMA, http://www.fema.gov/

FEMA Map Service Center, FEMA Flood Map Service Center | Welcome!

FloodSmart, http://www.FloodSmart.gov

OpenFEMA Data Sets, https://www.fema.gov/about/openfema/data-sets

NCDC Storm Events Database, https://www.ncdc.noaa.gov/stormevents/

References

FEMA, Aug 2001. How-To Guide #2: Understanding Your Risks – Identifying Hazards and Estimating Loss Potential (FEMA 386-2).

Garfin, G., G. Franco, H. Blanco, A. Comrie, P. Gonzalez, T. Piechota, R. Smyth, and R. Waskom, 2014, Ch. 20: Southwest. Climate Change Impacts in the United States: The Third National Climate Assessment, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., US Global Change Research Program, 462-486. doi:10.7930/J08G8HMN

Gonzalez, P., G.M. Garfin, D.D. Breshears, K.M. Brooks, H.E. Brown, E.H. Elias, A. Gunasekara, N. Huntly, J.K., Maldonado, N.J. Mantua, H.G. Margolis, S. McAfee, B.R. Middleton, and B.H. Udall, 2018: *Southwest. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 1101–1184. doi: 10.7930/NCA4.2018.CH25. On the Web: https://nca2018.globalchange.gov/chapter/southwest

Loomis, T. R., 2003, A Brief History of Flooding in the Rural Areas of Arizona, Part II 1964 through 1993, AZ Floodplain Management Association Newsletter, Vol. 20, No. 1, April 2003.

Luong, T.M., Castro, C.L., Chang, H.I., Jares, M., Lahmers, T., Mazon, J.,Carrillo, C.M., Adams, D.K., 2015, *The More Extreme Nature Of Monsoon Precipitation In The Southwest USAs Revealed By A Long-Term Climatology Of Simulated Severe Weather Events*, Journal of Applied Meteorology and Climatology, Volume 56, No. 12. December 2017.

NCDC, 2023, *Storm Events Database*, accessed full data sets for 2018 to 2023 in August 2023. https://www.ncdc.noaa.gov/stormevents/

NWS – Flagstaff. Northern Arizona Flash Floods, https://www.weather.gov/fgz/EventSummaries

US Army Corps of Engineers, Los Angles District, 1978, Flood Damage Report, 28 February-6 March 1978 on the Storm and Floods in Maricopa County, FCDMC Library #802.024

Youberg, A., 2012, Southwest Wildfire Hydrology and Hazard Workshop Proceedings. AZ Geological Survey Open-file-report – 12-05, 50 p. 32.

US Army Corps of Engineers, Los Angles District, 1980, Phoenix Flood Damage Survey, FCDMC Library #802.029.

US Army Corps of Engineers, Los Angles District, 1994, Flood Damage Report, State of AZ, Floods of 1993.

HAZARDOUS MATERIALS INCIDENTS

DESCRIPTION

A hazardous material is any substance or material in a quantity or form that may pose a reasonable risk to health, the environment, or property. The US Department of Transportation defines hazardous materials as belonging to one of nine hazard classes (USDOT BTS, 2015), as follows:

- Class 1—Explosives
- Class 2—Gases
- Class 3—Flammable Liquids
- Class 4—Flammable Solids
- Class 5—Oxidizing Substances and Organic Peroxides
- Class 6—Toxic Substances and Infectious Substances
- Class 7—Radioactive Materials
- Class 8—Corrosive Substances
- Class 9—Miscellaneous Hazardous Materials

Hazardous materials spill incidents may involve any of the above classes of materials. Accidental or incidental releases of hazardous materials typically are associated with fixed facility incidents and transportation-related accidents.

In the case of fixed facility incidents, the hazards are usually pre-identified, and each facility is required by Arizona law to prepare a risk management plan and provide a copy to the local emergency planning committee (LEPC) and local fire departments. Arizona Tier II forms must also be filed with the Arizona State Emergency Response Commission (AZSERC) at the Arizona Department of Environmental Quality (ADEQ). For specific site plans, each county LEPC is required by law to maintain a copy of these plans.

The prediction of the exact location of transportation related hazardous materials incidents is not possible; however, certain routes are likely to carry greater amounts of materials at greater frequencies, such as interstates, major highways and railways. The close proximity of railroads, highways, airports, waterways, pipelines, and industrial facilities to populated areas, schools, and businesses could put a large number of individuals in danger at any time. In addition, essential service facilities, such as police and fire stations, hospitals, nursing homes, and schools near major transportation routes are also at risk from potential hazardous materials transportation incidents.

Increased use and transport of materials across the country has created serious problems for emergency services personnel. Many factors can increase the magnitude of an otherwise simple transportation accident into an incident of potential threat to high numbers of people. For example, over 14,000 different chemicals are estimated as being shipped by various transportation modalities. Some types of highly toxic chemicals do not require placarding if shipped in quantities of less than 1,000 pounds, even though lesser quantities could devastate a small town.

In addition to traditional chemical hazards, radiological incidents could be a legitimate threat to populations in Arizona. Transport of radioactive materials presents the most probable scenario for a radiological incident. The US Department of Energy is currently shipping radioactive waste by truck to repositories in Texas and Utah. Training and equipment for responding to peacetime radiological incidents are usually relegated to organizations located in the cities and counties near the more metropolitan areas or sites with radiological sources, leaving potentially large response times for incidents that may occur in remote areas of the state.

The federal government has finalized development of long-term repositories for spent fuel, transuranics (TRU), and other high-level radioactive wastes, at Yucca Mountain, Nevada, and Carlsbad, New Mexico. Speculations have suggested that up to 3,600 shipments per year may go to these facilities.

In addition to transportation, radiological incident scenarios could involve faulty re-entry of nuclear-equipped satellites to earth (such as COSMOS 954 in 1978 and SKYLAB in 1980). The probability of this happening and impacting an area in Arizona is highly unlikely; however, there are known to be at least 30 (Harrington, 2016) nuclear powered satellites existing within Earth's orbit.

As a fixed facility with the potential for catastrophic radiological releases, the Palo Verde Generating Station (PVGS), located on 4,250 acres near Wintersburg, approximately 55 miles west of downtown Phoenix, is the largest nuclear energy facility in the United States. It is operated by Arizona Public Service and owned by a consortium of seven utility companies.

HISTORY

According to the US Department of Transportation, Pipeline and Hazardous Materials Safety Administration (PHMSA), more than 3 billion tons of regulated hazmat, including explosive, poisonous, corrosive, flammable, and radioactive materials valued at about $1.9 trillion, was moved 383 billion miles in 2017 on the nation's interconnected transportation network.

Starting with reporting on 2002 incidents, the US Department of Transportation, Pipeline and Hazardous Materials Safety Administration (PHMSA) defines "serious incidents" as incidents that meet one or more of the following criteria:

- A fatality or major injury caused by the release of a hazardous material,
- The evacuation of 25 or more persons as a result of release of a hazardous material or exposure to fire,
- A release or exposure to fire which results in the closure of a major transportation artery,
- The alteration of an aircraft flight plan or operation,
- The release of radioactive materials from Type B packaging,

Nogales Wash – International Outfall Interceptor rupture at manhole location in Nogales, AZ
Source: AZ Governor's Office, 2017

- The release of over 11.9 gallons or 88.2 pounds of a severe marine pollutant, or
- The release of a bulk quantity (over 119 gallons or 882 pounds) of a hazardous material.

Since 1966, there have been a total of nine state declarations related to hazardous materials incidents. Seven were incident specific, and two were more general statewide declarations. A total of $2 million in state funds were expended in response to the declarations. Details for incident specific declarations, along with other examples of significant hazardous material incidents that have occurred in the last ten years, are as follows:

- August 12, 2023 – A large fire at a recycling yard, containing tires and plastics, in Glendale, Arizona resulted in the closure of US 60 and evacuation of nearby block to the south and west of the plant as a precautionary measure. The fire was originally classified as a second-alarm fire involving hazardous materials and was later upgraded to a third-alarm fire. There are no injuries or fatalities reported in association with this incident (Arizona Republic, 2023).
- February 15, 2023 – A tactor-trailer rollover triggered a hazardous chemical leak incident along Interstate 10 in Tucson, Arizona. Authorities ordered a shelter-in-place for a three mile perimeter near the incident, which was lifted later that day. The shelter in place was later reinstated for a one-mile perimeter after gassing occurred as crews attempted to remove the hazardous material load. The incident included one fatality, which was the driver of the tractor-trailer (USA Today, 2023).
- July 29, 2020 – A Union Pacific train with several cars loaded with hazardous cargo derailed on the bridge spanning the Tempe Town Lake, in Tempe, Arizona igniting a fire that consumed the bridge and melted the southern abutment. According to the National Transportation Safety Board there were no fatalities and on injury due to smoke inhalation by a first responder. The damages were estimated to be between $8 and $10 million. Of the 12 derailed cars (in positions 29 through 60), three tank cars were loaded with the hazardous material cyclohexanone. Two of these tank cars fell from the trestle and on

released 2,201 gallons of cyclohexanone. A third tank car partially drained but was not breached. A small area near the bridge was evacuated as a precautionary measure (Maricopa County Hazard Mitigation Plan, 2021).

- July 27, 2017 - Arizona declared a state of emergency following the rupture of the International Outfall Interceptor sewage conveyance pipeline near Nogales. The rupture was caused by flooding from a monsoon thunderstorm that displaced a manhole riser and broke the pipe beneath. Raw sewage was released directly into Nogales Wash, requiring in-stream chlorination measures (AZ Governor’s Office, 2017).
- May 22, 2017 - A release of ammonia solution vapors from a plastic 55-gallon drum storage drum at a FedEx Freight Facility located on Lower Buckeye Road in Phoenix. The release caused two employees to go to the hospital due to inhalation and the Phoenix Fire Department evacuated approximately 100 people from the dock for approximately 1.5 hours (NRC, 2018).

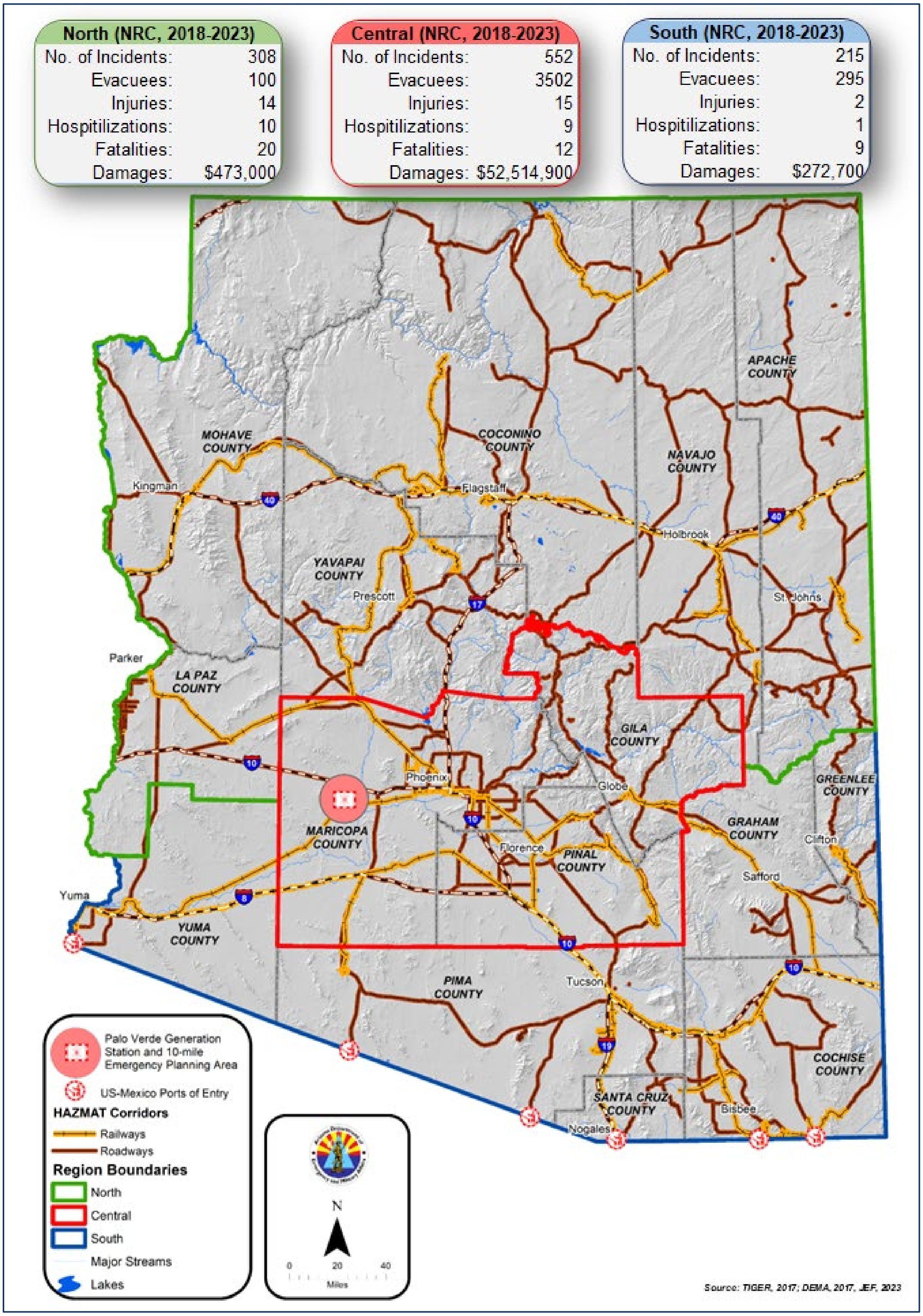
PROBABILITY/EXTENT

The probability of hazardous materials incidents occurring within the state is very high; however, PHMSA-defined "serious incidents" with injuries or fatalities caused by the force of the accident versus exposure to hazardous materials, is low to moderate. Additionally, large scale hazardous material incidents are uncommon.

According to a 2010 study (HDR, 2010), the most commonly transported hazardous materials reported include gasoline, liquid propane gas, diesel, sulfuric acid, ammonium nitrate, pesticides, and copper concentrate products. These materials have the potential to cause serious health and environmental damage in the event of an accidental release.

In 2006, AZSERC commissioned a commodity flow study (AMEC, 2006) of the Interstate 8 and 10 corridors, several arterial highways, and adjacent railroad segments. Placarded truck surveys indicated that, on average, 5.3% of the commercial trucks observed in the I-10 study area (approximately 3,500-4,500 trucks per day) contained hazardous materials. There were 78 different hazardous materials recorded during the placarded truck surveys, with gasoline, combustible liquid, and butane being the most common. Along I-10, Class 3 (flammable liquids) accounted for 45.3% of all recorded hazardous materials. Class 2 (gases) accounted for 18.9% and Class 8 (corrosive substances) accounted for 16%. Six extremely hazardous substances (EHS) - sulfuric acid, hydrazine, hydrogen chloride, hydrogen fluoride, nitric acid, and propylene oxide - were recorded in the I-10 study area. Rail transport of hazardous materials was also noted in the study and offered similar conclusions.

The US Coast Guard administers the National Response Center (NRC) – a multi-modal, multi-causality repository of reported HazMat related incidents. The NRC database was queried for incidents occurring in the last five-years (2018-2023). Over that period, a total of 1,075 incidents were logged and resulted in a total of 3,897 evacuees, 31 injuries – 20 of which required hospitalization, 41 fatalities and total damages to property estimated at $53.3 million. Details of the incidents distributed by Arizona planning region are shown in Map 31.



Map 31. Hazardous materials transportation corridors statewide

Also shown on Map 31 are the primary roadway and railway transportation routes, international points of entry with Mexico, and the general location of the Palo Verde Generation Station and its 10-mile emergency planning zone.

WARNING TIME

Hazardous material incidents occur without warning, and depending on the material type and ambient conditions, the propagation or spread of the released hazardous materials can also happen very quickly, leaving little to no warning for evacuation measures.

FUTURE CONDITIONS

Climate Considerations

Future climate changes are not anticipated to have any direct impact on the occurrence of hazardous material incidents.

Changes in Development

In general, changes in development correlate to the threat of hazardous materials incidents in the form of changed exposure to people, animals, and to a lesser extent, infrastructure. Development tends to follow major roadways, or even create new major roadways and increase the number of corridors of potential transport of hazardous materials.

North Region

North Region growth areas of significance are anticipated to primarily center around Flagstaff, Kingman, Bullhead City, and Lake Havasu City and the unincorporated areas surrounding these communities. The rest of the area is not anticipating significant growth over the next five years.

Central Region

The highest growth areas in the state are located within the Phoenix Metropolitan area of Maricopa County, with development occurring along the fringe areas. Growth to the west of Phoenix will continue to edge closer to the PVGS facilities. The continued growth of industry will also require increased deliveries of potentially hazardous materials. For example, Nikola Motor Company has recently announced plans to move its battery manufacturing from Cypress, California to its manufacturing facility in Coolidge, Arizona, which will likely lead to an increase in the flow of certain hazardous material through an area that historically would not have seen any.

South Region

Signing of the United States-Mexico-Canada Agreement (USMCA), which came into force on July 1, 2020, has resulted in an increase of trade and movement of hazardous materials across the US-Mexico border, especially at the Nogales, San Luis, and Douglas points of entry. The increased trade has increased exposure to population and properties located along the routes heading north. Also, growth in the form of development in the Tucson Metropolitan area has increased the exposure and those trends are expected to continue.

VULNERABILITY ASSESSMENT

Historically, common hazardous materials incidents do not pose a significant threat to the state-owned facilities and infrastructure.

North Region

The North Region is considered the least vulnerable to hazardous materials incidents, primarily since the North has the least population, the lowest concentration of Tier II facilities, and that the majority of past significant hazardous materials incidents are primarily associated with traffic accidents along I-40 and I-17.

State-Owned CFI Exposure and Loss Estimates

All 1,010 state-owned facilities representing $1.2 billion in replacement value are considered exposed to hazardous materials incidents, and several may be classified as Tier II facilities. No losses are estimated.

Vulnerable Population Groups

The entire 2022 estimated population of 801,655 people are considered as exposed to hazardous materials incidents, with the populations along I-40 and I-17 and the adjoining BNSF Railway being at the greatest risk. The exposed sub-group populations include 148,243 persons (18.49% of region total) under 18-years of age, 216,315 persons (26.98% of region total) older than 65, and 143,746 persons (17.93% of region total) living at or below poverty level.

SVUC Impact Assessment

Within the North Region, 30.59% of the population falls within the highest social vulnerability index (SVI) percentile rank (0.90-1.0) for racial and ethnic minority status (Theme 3), while the greatest percentage of the population lies within the 0.5 to 0.75 SVI percentile rank for socioeconomic status (34.42%), household characteristics (24.63%), and housing type/transportation (38.82%). The entire SVUC population is considered to be equally exposed to hazardous materials incidents.

Local Jurisdiction Vulnerability

Coconino, La Paz, Mohave, and Navajo Counties all included hazardous materials incidents in their mitigation plan risk assessment. Conclusions of the vulnerability analyses are similar to what is presented in this Plan.

Specific Areas of Concern

Camp Navajo near Bellemont was originally established as Navajo Ordnance Depot in 1942. Total construction of the facility was completed in less than one year and included, 800 ammunition storage igloos, 50 administrative buildings, 227 miles of road, 38 miles of railroad track, and completed utility distribution and collection systems. In 1993, the US Department of Defense moved the US Army federal ammunition mission to Hawthorne Army Ammunition Plan in Nevada and transferred the installation to the Arizona National

Guard. Expansion of the storage utility can see movement of hazardous materials into and out of the facility by both rail and road.

Central Region

The Central Region is considered the most vulnerable to hazardous materials incidents due to having the highest population density, the highest concentration of Tier II facilities, and the significant impacts associated with the variety of materials move in, out, and through the Phoenix Metropolitan area. The PVGS is also located within the Central Region.

State-Owned CFI Exposure and Loss Estimates

All 1,741 state-owned facilities representing $4.8 billion in replacement value are considered exposed to hazardous materials incidents, and indeed several may be classified as Tier II facilities. No losses are estimated.

Vulnerable Population Groups

The entire 2022 estimated population of 5,069,600 people are considered as exposed to hazardous materials incidents. The exposed sub-group populations include 1,130,454 persons (22.3% of region total) under 18-years of age, 851,837 (16.8% of region total) persons older than 65, and 573,046 persons (11.3% of region total) living at or below poverty level.

SVUC Impact Assessment

Within the Central Region, 33% of the population falls within the 0 to 0.25 percentile rank of the Social Vulnerability Index (SVI) for racial and ethnic minority status (Theme 3), while the greatest percentage of the population lies within the 0.5 to 0.75 SVI percentile rank for socioeconomic status (Theme 1 – 46.43%), household characteristics (Theme 2 – 35.53%), and housing type/transportation (Theme 4 – 36.57%). The entire SVUC population is considered to be equally exposed to hazardous materials incidents.

Local Jurisdiction Vulnerability

Gila County addressed hazardous materials incidents in their mitigation plan risk assessment. The Maricopa County mitigation plan no longer includes a hazard profile for hazardous materials but does provide a brief discussion of recent incidents within the County. Conclusions of the vulnerability analysis for the Gila County plan is similar to what is presented in this Plan.

Specific Areas of Concern

Although improbable, the consequence of a significant radiological incident at the PVGS would be catastrophic for the region and state. On a more probable basis, the continued influx of new industry to the region will also bring new hazardous materials and increased hazardous material transportation.

South Region

The South Region is considered the second-most vulnerable to hazardous materials incidents due to the moderately-high population density, major road and rail transportation corridors, the second highest concentration of Tier II facilities, and the US-Mexico border challenges.

State-Owned CFI Exposure and Loss Estimates

All 1,017 state-owned facilities representing $1.6 billion in replacement value are considered exposed to hazardous materials incidents, and indeed several may be classified as Tier II facilities. No losses are estimated.

Vulnerable Population Groups

The entire 2022 estimated population of 1,487,942 people are considered as exposed to hazardous materials incidents. The exposed sub-group populations include 310,658 persons (20.88% of region total) under 18-years of age, 313,960 (21.1% of region total) persons older than 65 and 231,653 persons (15.57% of region total) living at or below poverty level.

SVUC Impact Assessment

Within the South Region, 29.48% of the population falls within the 0.75 to 0.90 percentile rank of the Social Vulnerability Index (SVI) for household characteristics (Theme 2) and 27.38% fall within the same rank for housing type/transportation (Theme 4) , while 36.65% of the population lies within the 0.25 to 0.50 SVI percentile rank for socioeconomic status (Theme 1) and 38.83 fall within the 0.50 to 0.75 percentile rank for racial and ethnic minority status (Theme 3). The entire SVUC population is considered to be equally exposed to hazardous materials incidents.

Local Jurisdiction Vulnerability

Santa Cruz County is the only South Region county to address hazardous materials incidents in their mitigation plan risk assessment which focuses on the concentration of road and rail threats at the border community of Nogales. Other conclusions of the vulnerability analysis are similar to what is presented in this Plan.

Specific Areas of Concern

As with the Central Regions, growth of industry in the Tucson Metropolitan area will include increases in the exposure and transport of hazardous materials to service those industries. The materials crossing the US-Mexico border are heavily regulated, but increased trade with Mexico will include increased transportation of, and exposure to, hazardous materials.

RESOURCES

Sources

US Coast Guard, National Response Center, National Response Center | US EPA

US Department of Transportation, Pipeline and Hazardous Materials Safety Administration, Office of Hazardous Materials Safety, Incident Reports Database Search, https://hazmatonline.phmsa.dot.gov/IncidentReportsSearch/IncrSearch.aspx

References

AMEC, 2006, Hazardous Materials Commodity Flow Study Report, I-8 and I-10 Corridors, Arterial Highways and Railway, for Yuma, Maricopa, Pinal, Pima, and Cochise Counties, AZ.

HDR Engineering, Inc., 2010, *Hazardous Materials Transportation in Arizona*. Prepared for AZ Dept of Transportation, 206 South 17th Avenue, Phoenix, Arizona 85007, in cooperation with US Dept of Transportation, Federal Highway Administration.

Johnson, N.L., 2005, *A New Look at Nuclear Power Sources and Space Debris*. Proceedings of the 4th European Conference on Space Debris (ESA SP-587). 18-20 April 2005, ESA/ESOC, Darmstadt, Germany. Editor: D. Danesy, p.551

Schamadan, J., 1999, Final Operations Report, Explosives Remediation Project, Starflash Ranch, New River, Arizona, March 15 - July 15, 1999.

INFECTIOUS DISEASE

DESCRIPTION

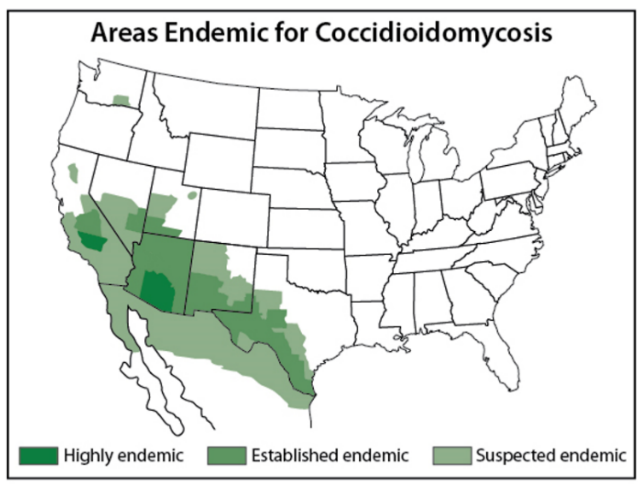
An infectious disease is defined as a clinically evident disease resulting from the presence of pathogenic microbial agents. Infectious diseases are a major threat around the world, killing millions globally each year. Fears of pandemic have risen in recent years as our globalized economy and growing population fosters large scale international travel and trade. Also, growing populations, and higher population densities, increase vulnerability to infectious disease as it can travel more quickly and create difficulty in preventing the spread of infection.

Three terms are commonly used to classify disease impacts: endemic, epidemic, and pandemic. An endemic is present at all times at a low frequency (chicken pox in the United States). An epidemic is a sudden severe outbreak of disease (the bubonic plague during medieval times) and a pandemic is an epidemic that becomes very widespread and affects a whole region, a continent, or the world (e.g., 1957 flu pandemic).

Endemic Diseases

Pathogens that are constantly present or are usually prevalent in a population within a geographic area are considered endemic. Endemic pathogens to Arizona include:

- Hantavirus Infection
- Plague
- Psittacosis
- Tularemia
- West Nile Virus
- Coccidioidomycosis (Valley Fever)
- Legionellosis (several serogroups)
- Primary Amebic Meningoencephalitis (PAM)
- Rocky Mountain Spotted Fever (RMSF)
- COVID



Map of areas endemic for Valley Fever (Coccidioidomycosis)
Source: CDC. Online at: https://www.cdc.gov/fungal/diseases/coccidioidomycosis/causes.html

Modes of Transmission

Transmission of an infectious disease may occur through direct or indirect contact as described below:

Direct Transmission

Direct transmission is when an infection spreads through skin-to-skin contact, kissing, or sexual intercourse with an infected individual; or contact with soil/vegetation that harbors infectious organisms. Direct transmission also includes droplet spread which refers to the spray produced by sneezing, coughing, or even talking.

Indirect Transmission

Indirect transmission is when an infection is spread via air particles, vehicles (inanimate objects), or vectors (animate intermediaries). Airborne transmission occurs when pathogens are carried through the air by dust or droplet nuclei. Vehicles that may transmit pathogens include food, water, blood, and fomites. Vector transmission occurs when mosquitoes, fleas, ticks, etc., carry pathogens from a host, or reservoir, to an uninfected individual.

Disease Categories

The list of nationally notifiable diseases is revised periodically. Public health officials at state health departments and the Center for Disease Control and Prevention (CDC) collaborate to determine which diseases should be nationally notifiable; the Council of State and Territorial Epidemiologists, with input from the CDC, makes recommendations annually for changes to the list. In Arizona, reporting of nationally notifiable diseases to the CDC is mandated by state legislation and regulations.[22]

The CDC has categorized bioterrorism agents and diseases of concern into three groups which are below:

Category A

High priority agents that pose a risk to national security (Anthrax, Botulism, Plague, Smallpox, Tularemia, Viral Hemorrhagic Fevers):

- Can be easily disseminated or transmitted from person to person;
- Result in high mortality rates and have the potential for major public health impact;
- Might cause public panic and social disruption; and
- Require special action for public health preparedness.

Category B

Second highest priority agents (Brucellosis, Epsilon Toxin, Food Safety Threats, Glanders, Melioidosis, Psittacosis, Q Fever, Ricin Toxin, Staphylococcal Enterotoxin B, Typhus Fever, Viral Encephalitis, Water Safety Threats):

- Are moderately easy to disseminate;
- Result in moderate morbidity rates and low mortality rates; and
- Require specific enhancements of CDC's diagnostic capacity and enhanced disease surveillance.

[22] Arizona Administrative Code, Chapter 9. Online at: https://www.azsos.gov/rules/arizona-administrative-code#ID9

Category C

Third highest priority agents include emerging pathogens that could be engineered for mass dissemination in the future (Nipha Virus, Hanta Virus, other emerging diseases):

- Availability;
- Ease of production and dissemination; and
- Potential for high morbidity rates and major health impact.

When the CDC is notified or identifies an emerging threat, they will notify and coordinate with the Arizona Department of Health Services (ADHS).

The Bureau of Epidemiology and Disease Control Services collects, analyzes, and distributes infectious disease data to internal programs, public health stakeholders, and counties to monitor public health and assist in the prevention and containment of infectious disease. When notified by the CDC or when ADHS identifies an emerging threat, ADHS will notify and coordinate with the county health departments.

Investigations into the source of an outbreak can depend on the etiology involved (viral, bacterial, parasitic or chemical), the mode of transmission (foodborne, waterborne, environmental, person-to-person), or the outbreak setting (restaurant, hospital or assisted living facility, school or community). Most infectious disease outbreaks can be classified into the following categories tracked by ADHS:

- Foodborne or Waterborne Outbreaks
- Vectorborne or Zoonotic Disease Outbreaks
- Respiratory or Influenza-Like Illness Outbreaks
- Vaccine Preventable Disease Outbreaks
- Healthcare-associated Infection Outbreaks

HISTORY

Historical records indicate that Arizona has had numerous food-borne, waterborne, environmental, and person-to-person outbreaks harming and killing people and animals. A total of 204,635 confirmed or probable cases of infectious diseases (excluding sexually-transmitted diseases, tuberculosis, hepatitis C, and HIV) have been reported from 2017-2021. Of these, 55% (112,332 cases) were influenza or RSV cases, 23% (47,733 cases) were coccidioidomycosis cases and 8% (16,719 cases) were cases of enteric diseases. The remaining 14% of the cases (27,851 cases) are divided among invasive diseases, hepatitides, other diseases, vaccine-preventable diseases and vector-borne and zoonotic diseases. The morbidities included in each category are summarized in Table 7 below (ADHS, 2015a).

The following are notable infectious disease outbreaks in Arizona, documented by ADHS:

- January 26, 2020 - Coronavirus Disease 2019 (COVID-19) was confirmed to have reached Arizona in January 2020. The first confirmed case of COVID-19 in Arizona was reported on January 26, 2020 in Tempe, Arizona. Arizona Governor Doug Ducey declared a public health emergency on March 12, 2020. On March 20th, ADHS and Maricopa County health officials announced the first death in the state from COVID-19: a Maricopa County man in his 50s with underlying health conditions. On March 30th, Gov. Ducey issued a statewide stay at home order to stop the spread of new coronavirus, barring Arizonans from leaving their residences except for food, medicine, and other essentials. The order took effect at the close of business March 31st. The order expired on May 15th and on June 17th, Governor Ducey announced that local governments would be able to set mask-wearing regulations after previously having blocked local mask wearing requirements. Soon after, many city and county officials began implementing face covering mandates or announcing plans to discuss possible regulations. As of March 10, 2023, the Arizona State death toll stood at 33,102 with 2,443,514 confirmed cases.

- August 8, 2016 – ADHS announced the end to a three-month measles outbreak that involved 22 confirmed cases that originated in a private detention facility in Eloy.
- July 2015 to February 2016 – An outbreak of 140 confirmed cases of Salmonella serotype Poona infection from garden variety cucumbers imported from Mexico caused 44 hospitalizations and six Arizonan deaths.
- June 19, 2013 - After consuming frozen berries, 110 people were confirmed to have become ill from Hepatitis A. Fifteen of the infections were Arizona residents.
- 2009 – Present - The H1N1 pandemic virus strain first appeared in Arizona in 2009 and continues through the present. For the period of April 2009 to May 2010, ADHS registered over 8,700 confirmed cases with 1,409 hospitalizations and 152 deaths. There was a total of 2,506 confirmed cases for the period of 2010-2016.
  - 2002 – Present - Arizona experienced two major outbreaks of the Norwalk-like virus (Norovirus). Norovirus continues to be a frequent cause of illness in Arizona with 36 outbreaks in 2015 alone.
- 1993 – 2016 - There have been 75 confirmed Hantavirus cases in Arizona since 1993, 36% of all cases result in death.
  - Hantavirus killed 11 people in the Navajo Nation (CNN, October 15, 1995).
  - June 7, 2013 - Coconino County Public Health Services District officials confirmed that a Flagstaff-area woman died from complications of Hantavirus.

PROBABILITY/EXTENT

The probability and magnitude of infectious disease is difficult to evaluate due to the wide variation in disease characteristics, such as the reproduction number, virulence, morbidity and mortality, detection and response time, and the availability of vaccines and other forms of prevention. There is growing concern, however, about emerging infectious diseases due to new and more resistant strains of pathogens, also called, “Super Bugs,” and viral reassortments/recombination. The probability of a serious outbreak goes up as new resilient pathogens are identified.

Infectious diseases have the potential to affect any form of life anywhere in the state and some that were thought to have been eradicated have re-emerged. New strains of infectious diseases, such as the flu, present seasonal threats to the populace and require continuous monitoring. Widespread epidemics are almost non-existent in the United States, but if an epidemic event were to occur, deaths could be in the many hundreds of thousands across the nation.

Historically, events have occurred in the farming and agricultural communities that cause great concern amongst responding governmental agencies. Due to these events, and the fact that Arizona shares an international trade border with Mexico, the probability of an infectious disease impacting livestock and crops is high.

An average of 18,460 confirmed and probable cases of infectious diseases, across all categories included in Table 7, have been reported each year from 2017-2021, with a maximum of 21,683 cases in 2021 and a minimum of 15,170 cases in 2017. ADHS tracks infections disease outbreaks, and according to ADHS officials (2015b), the large majority of outbreaks tend to result in some form of gastrointestinal illness. In 2015, over 137 outbreaks of gastrointestinal illness were reported to ADHS and were caused by various infections such as norovirus, E.coli, salmonella, and listeria. ADHS studies also show that the mode of transmission for most (72% in 2014) outbreaks is via person-to-person contact (ADHS, 2014).

According to state officials (Komatsu, 2018), ADHS deals with routine outbreaks of various diseases including plague, brucellosis, tularemia, Q fever (all select agents) as well as hantavirus pulmonary syndrome and severe influenza seasons. These instances typically never rise to the level of a local declaration of emergency. Given the state's population distribution, endemic disease, geography and climate, and healthcare system infrastructure, an estimation of the diseases that would likely impact Arizona on a scale that would result in a local, county, or statewide declaration of emergency include:

- Bioterrorism vent using one of the select agents. Additionally, with bioterrorism agents – weaponized strains may be more difficult to mitigate if they have enhanced infectivity, virulence, and drug resistance than those found in nature.
- Pandemic influenza.
- High impact animal disease such as:
    - Foot and Mouth Disease (FMD virus)
    - High pathogenic Avian Influenza
    - Tuberculosis
    - Q Fever (coxiella burnetii)
    - Newcastle Disease (Paramyxovirus 1)

WARNING TIME

There is generally no warning time for the initiation of an infectious disease outbreak. However, once an outbreak begins, there is opportunity to warn the public about the occurrence and provide health-care guidance for preventative measures.

FUTURE CONDITIONS

Climate Considerations

Changes in future climate conditions may have an impact on certain types of infectious disease, or possibly have an indirect effect. For example, increased temperatures and intensities of Arizona's

Table 24. Infectious disease categories and morbidities

Disease Category	Reportable Morbidities
Coccidioidomycosis	Coccidioidomycosis
Enteric Diseases	Amebiasis, botulism, infant botulism, campylobacteriosis, cryptosporidiosis, cyclospora infection, cysticercosis, *E. coli* enterohemorrhagic, giardiasis, hemolytic uremic syndrome, listeriosis, salmonellosis, shigellosis, typhoid fever, *Vibrio* infection, yersiniosis
Flu and RSV	Influenza virus, influenza with mortality in a child, respiratory syncytial virus (RSV)
Invasive Diseases	Invasive methicillin-resistant *Staphylococcus aureus* (MRSA), invasive streptococcal group A, invasive streptococcal group B (in children <90 days of age), invasive *Streptococcus pneumoniae*, vancomycin-intermediate *Staphylococcus aureus* (VISA), vancomycin-resistant *Staphylococcus aureus* (VRSA), vancomycin-resistant *Staphylococcus epidermidis* (VRSE)
Hepatitides	Hepatitis A, hepatitis B acute, hepatitis B chronic, hepatitis B perinatal, hepatitis D
Other	Basidiobolomycosis, blastomycosis, Creutzfeldt-Jakob disease, emerging or exotic disease, parasitic encephalitis, Hansen's disease, Kawasaki syndrome, legionellosis, Reye syndrome, toxic shock syndrome, viral encephalitis
Vaccine preventable diseases (VPD)	Invasive *Haemophilus influenzae*, measles, invasive meningococcal disease, mumps, pertussis, poliomyelitis, rubella, smallpox, tetanus, vaccinia-related event, yellow fever
Vector-borne and zoonotic diseases	
Mosquito-borne Diseases	Dengue, Eastern Equine encephalitis virus, Japanese encephalitis virus, malaria, St. Louis encephalitis virus, Venezuelan equine encephalitis virus, West Nile virus and Western equine encephalitis virus
Tick-borne Diseases	Babesiosis, Colorado tick fever, ehrlichiosis or anaplasmosis, Lyme disease, relapsing fever, Rocky Mountain spotted fever and typhus fever
Flea-borne Diseases	Plague
Zoonotic Diseases	Brucellosis, hantavirus infection, hemorrhagic fever, leptospirosis, melioidosis or glanders, psittacosis, rabies (human cases), taeniasis, trichinosis, and tularemia

Source: ADHS

summer temperatures and monsoon thunderstorms may increase the incidents of Valley Fever by creating more severe dust storms. Increased drought conditions may force the import of more food from outside the drought region, which may increase the exposure to new or foreign pathogens.

Changes in Development

The primary impacts associated with development changes is the increase in population densities that accompany the growth. The higher densities of people increase both the risk of exposure and the opportunity for transmission.

VULNERABILITY ASSESSMENT

The entire state is vulnerable to infectious diseases, however given the statistical dominance of person-to-person transmission of most infectious diseases, it is estimated that higher population density areas are inherently at a higher risk of exposure. Additionally, certain airports within the state have large populations of passengers moving in and out of the airport, both domestically and internationally, with great potential to quickly spread infectious diseases into and out of the state. Accordingly, vulnerability for each planning region is presented by the average population density in persons per acre, airport locations and departing international passenger volume for 2017-2022 (USDOT), and total communicable disease totals for the five-year period of 2017-2023 (ADHS).

The populatiInon densities were derived using the US Census Bureau's American Community Survey (ACS) data for 2021, as compiled at the Census Tract level. GIS tools were used to develop persons per acre densities for each Census Tract area, with the densest upper one-third of the Census Tracts being considered as the highest risk areas.

The volume of international passengers was estimated using US Department of Transportation aviation data for the number of passengers departing a US airport for an international destination for the 2017-2022 travel years (USDOT, 2023).

North Region

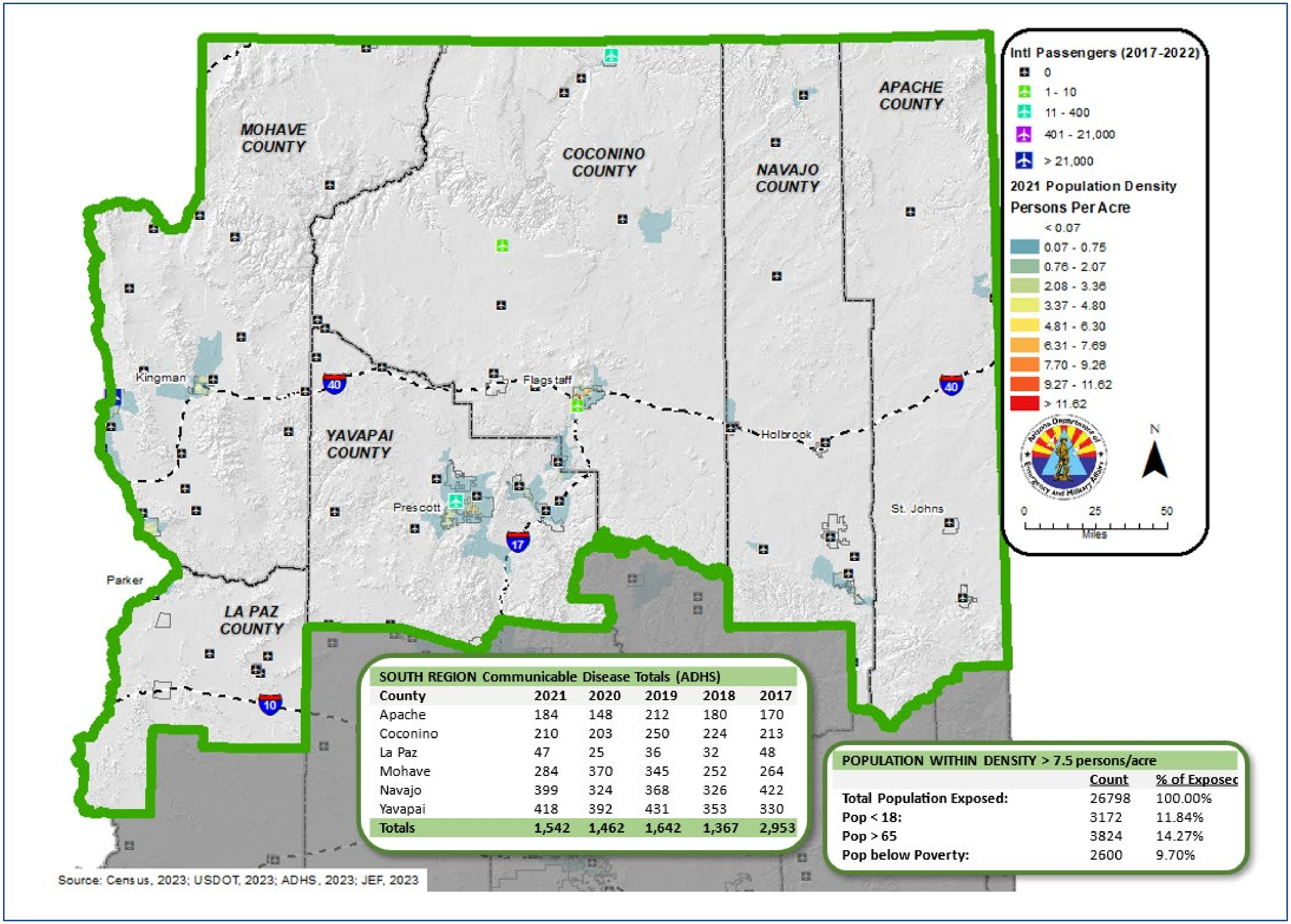
The North Region vulnerability, depicted in Map 32 is considered the least vulnerable to infectious disease, primarily since the region has the least population density, very little international air travel, and the lowest number of communicable disease cases.

State-Owned CFI Exposure and Loss Estimates

All 1,010 state-owned facilities representing $1.2 billion in replacement value are exposed to infectious diseases. No losses are estimated.

Vulnerable Population Groups

The entire 2022 estimated population of 801,655 people are considered as exposed to infectious diseases, with approximately 26,798, or 3.34% of the region-total population, being located within the upper one-third densest areas of the state. The exposed sub-group populations include 148,243 persons (18.49% of region total) under 18-years of age, 216,315 persons (26.98% of region total) older than 65, and 143,746 persons (17.93% of region total) living at or below poverty level. Estimates are provided for each of these population sectors located within upper one-third densest areas.



SOUTH REGION Communicable Disease Totals (ADHS)					
County	2021	2020	2019	2018	2017
Apache	184	148	212	180	170
Coconino	210	203	250	224	213
La Paz	47	25	36	32	48
Mohave	284	370	345	252	264
Navajo	399	324	368	326	422
Yavapai	418	392	431	353	330
Totals	1,542	1,462	1,642	1,367	2,953

POPULATION WITHIN DENSITY > 7.5 persons/acre		
	Count	% of Exposec
Total Population Exposed:	26798	100.00%
Pop < 18:	3172	11.84%
Pop > 65	3824	14.27%
Pop below Poverty:	2600	9.70%

Map 32. Infectious disease vulnerability for the South region

SVUC Impact Assessment

Within the North Region, 30.59% of the population falls within the highest social vulnerability index (SVI) percentile rank (0.90-1.0) for racial and ethnic minority status (Theme 3), while the greatest percentage of the population lies within the 0.5 to 0.75 SVI percentile rank for socioeconomic status (34.42%), household characteristics (24.63%), and housing type/transportation (38.82%). The entire SVUC poplulations are considered equally exposed to infectious disease.

Local Jurisdiction Vulnerability

Only Mohave County included infectious diseases in their mitigation plan risk assessment. Conclusions of the vulnerability analyses are similar to what is presented in this Plan and no local critical facility losses were estimated.

Specific Areas of Concern

According to ADHS (2021), Navajo County has some of the highest incident rates of outbreak in the state for reporting year 2021. For the five-year period of 2017-2021, the ADHS data indicates that the North Region counties have some of the highest incident rates for campylobacteriosis, coccidioidomycosis, invasive *Streptococcus pneumoniae*, streptococcal group A, and salmonellosis The North Region is home to the Laughlin-Bullhead City International Airport (IFP), which has the second largest volume of international traffic of all the airports in Arizona. According to the USDOT (2023), there have been approximately 31,562 passengers that departed from IFP to international destinations during the five-year period of 2017-2022. The portion of those departures that are US citizens will eventually return home to the United States. The rest are foreign visitors that are now leaving the United States. In either case, there is a significant risk of exposure to international diseases and introduction of new foreign strains to Arizona.

Central Region

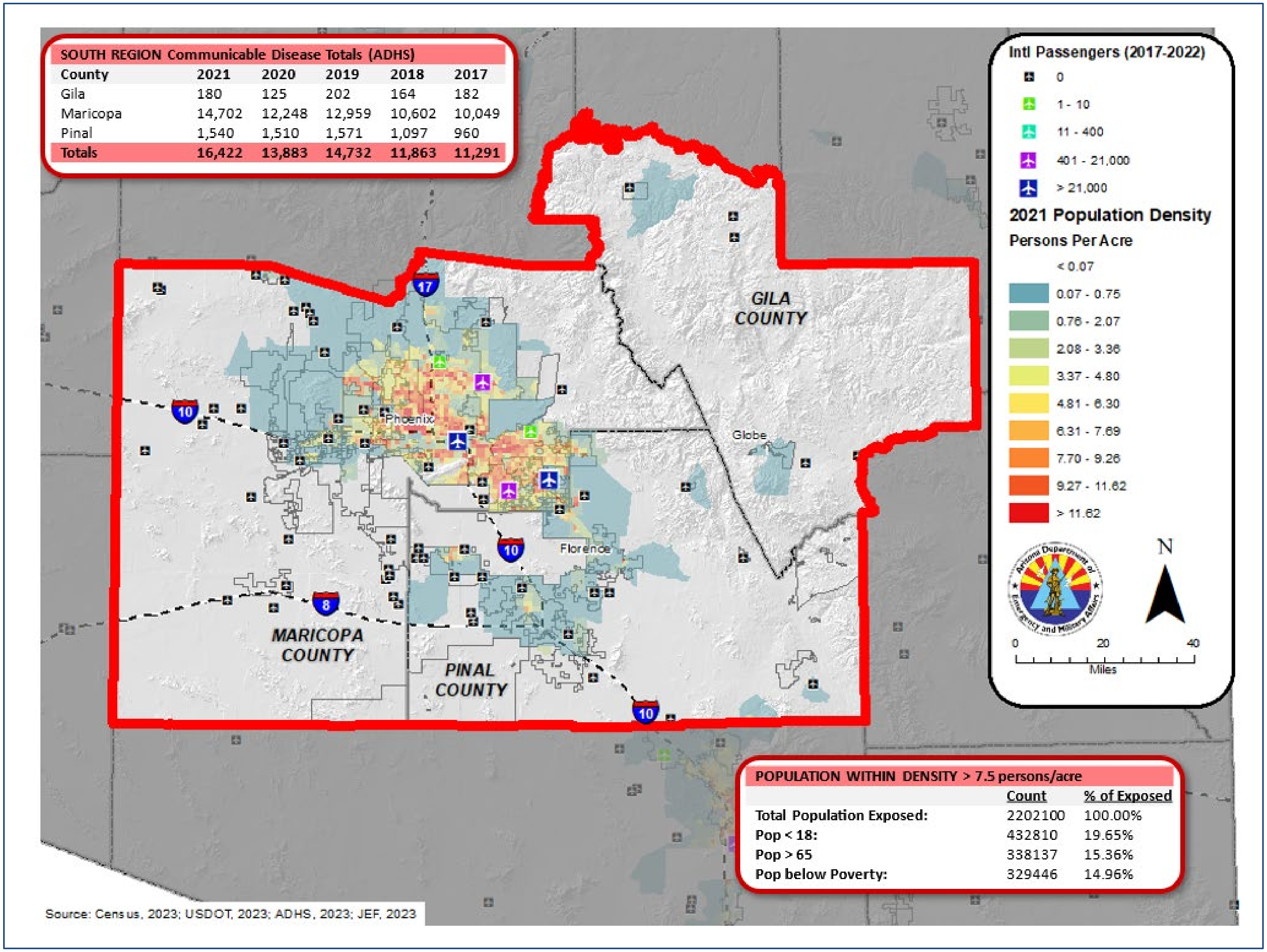
The Central Region vulnerability, depicted in Map 33 is considered the most vulnerable to infectious disease, primarily since the regions has the most population density, substantial international air travel volume, and the highest number of communicable disease cases.

State-Owned CFI Exposure and Loss Estimates

All 1,741 state-owned facilities representing $4.8 billion in replacement value are exposed to infectious diseases. No losses are estimated.

Vulnerable Population Groups

The entire 2022 estimated population of 5,069,600 people are considered as exposed to infectious diseases, with approximately 2,202,100, or 43.44% of the region-total population, being located within the upper one-third densest areas of the state. The exposed sub-group populations include 1,130,454 persons (22.3% of region total) under 18-years of age, 851,837 (16.8% of region total) persons older than 65, and 573,046 persons (11.3% of region total) living at or below poverty level. Estimates are provided for each of these population sectors located within upper one-third densest areas.



Map 33. Infectious disease vulnerability for the Soutth region

SVUC Impact Assessment

Within the Central Region, 33% of the population falls within the 0 to 0.25 percentile rank of the Social Vulnerability Index (SVI) for racial and ethnic minority status (Theme 3), while the greatest percentage of the population lies within the 0.5 to 0.75 SVI percentile rank for socioeconomic status (Theme 1 – 46.43%), household characteristics (Theme 2 – 35.53%), and housing type/transportation (Theme 4 – 36.57%). The entire SVUC poplulations are considered equally exposed to infectious disease.

Local Jurisdiction Vulnerability

None of the Central Region Counties provide a detailed hazard profile and vulnerability assessment for infectious diseases. However, Maricopa County did provide a narrative regarding the Covid 19 pandemic to document the occurrence and acknowledge that the hazards do exist and are of concern to the overall health and safety of the county.

Specific Areas of Concern

For the five-year period of 2017-2021, the ADHS data indicates that the Central Region counties have some of the highest incident rates for Valley Fever (coccidioidomycosis) campylobacteriosis, MRSA, streptococcal group A, pertussis, West Nile virus, and Rocky Mountain spotted fever (mainly Gila County). The Central Region is home to Sky Harbor International Airport (PHX), which is one of the largest airports in the country. According to the USDOT (2023), there have been approximately 10.4 million passengers that have departed from Sky Harbor to international destinations during the five-year period of 2017-2022. The portion of those departures that are US citizens will eventually return home to the United States. The rest are foreign visitors that are now leaving the United States. In either case, there is a significant risk of exposure to international diseases and introduction of new foreign strains to Arizona**.**

South Region

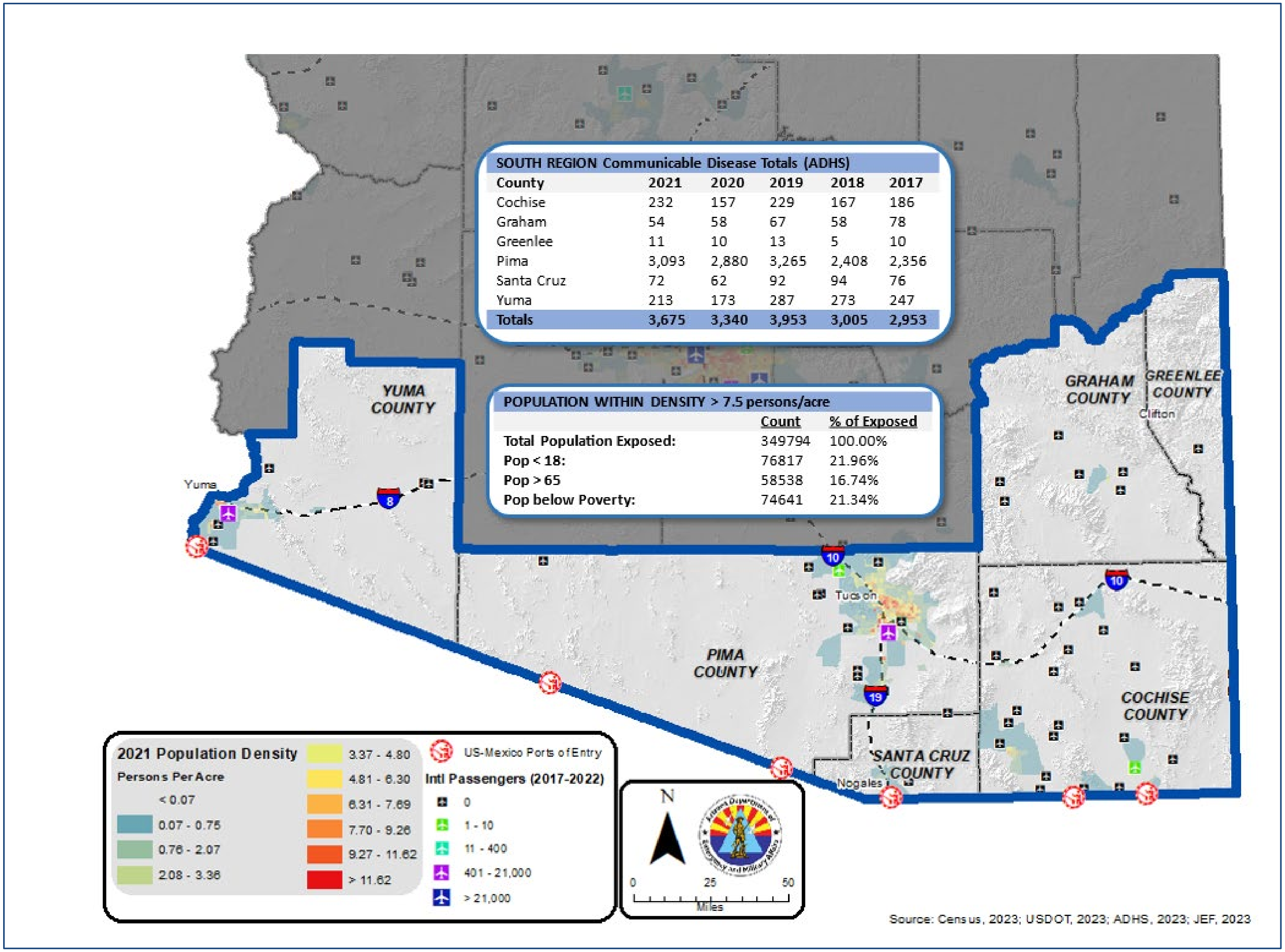
The South Region vulnerability, depicted in Map 34 is considered the second-most vulnerable to infectious disease, primarily since the region has the second-highest population density, moderate international air travel volume, international foot traffic from Mexico, and the second-highest number of communicable disease cases. Influences of the international border crossings are also a factor.

State-Owned CFI Exposure and Loss Estimates

All 1,017 state-owned facilities representing $1.6 billion in replacement value are considered equally exposed to infectious diseases. No losses are estimated.

Vulnerable Population Groups

The entire 2022 estimated population of 1,487,942 people are considered as exposed to infectious diseases, with approximately 349,794, or 23.5% of the region-total population, being located within the upper one-third densest areas of the state. The exposed sub-group populations include 310,658 persons (20.88% of region total) under 18-years of age,



Map 34. Infectious disease vulnerability for the South region

313,960 (21.1% of region total) persons older than 65 and 231,653 persons (15.57% of region total) living at or below poverty level. Estimates are provided for each of these population sectors located within upper one-third densest areas.

SVUC Impact Assessment

Within the South Region, 29.48% of the population falls within the 0.75 to 0.90 percentile rank of the Social Vulnerability Index (SVI) for household characteristics (Theme 2) and 27.38% fall within the same rank for housing type/transportation (Theme 4) , while 36.65% of the population lies within the 0.25 to 0.50 SVI percentile rank for socioeconomic status (Theme 1) and 38.83 fall within the 0.50 to 0.75 percentile rank for racial and ethnic minority status (Theme 3). The entire SVUC poplulations are considered equally exposed to infectious disease.

Local Jurisdiction Vulnerability

None of the local counties in the South Region included infectious disease in their mitigation plan risk assessments.

Specific Areas of Concern

For the five-year period of 2017-2021, the ADHS data indicates that the South Region counties have some of the highest incident rates for Valley Fever (coccidioidomycosis) campylobacteriosis, MRSA, West Nile virus, and legionellosis. The South Region is home to Tucson International Airport (TUS), which has the third largest volume of international traffic of all the airports in Arizona. According to the USDOT (2023), there have been approximately 12,168 passengers departing from TUS to international destinations during the five-year period of 2017-2022. The portion of those departures that are US citizens will eventually return home to the United States. The rest are foreign visitors that are now leaving the United States. In either case, there is a significant risk of exposure to international diseases and introduction of new foreign strains to Arizona. Additionally, the South Region borders the country of Mexico where there is limited monitoring, and unaccounted immigration can lead to an increased vulnerability.

RESOURCES

Sources

AZ Dept of Health Services, Public Health Preparedness, Epidemiology & Disease Control, Infectious Disease Services, https://www.azdhs.gov/preparedness/epidemiology-disease-control/index.php#data-stats-past-years

Centers for Disease Control and Prevention, https://www.cdc.gov/

World Health Organization, http://www.who.int/en/

References

AZ Dept of Health Services, 2017-2021, Communicable Disease Reports by County and Year, http://www.azdhs.gov/preparedness/epidemiology-disease-control/index.php#data-stats

AZ Dept of Health Services, 2015, *Infectious Disease Epidemiology 2008-2013 Report.* Office of Infectious Disease Services, Bureau of Epidemiology and Disease Control, http://www.azdhs.gov/documents/preparedness/epidemiology-disease-control/disease-data-statistics-reports/annual-reports-archive/infectious-disease-epidemiology-report-2008-2013.pdf

AZ Dept of Health Services, 2014, *Infectious Disease Outbreak Summary Report for 2014.* Office of Infectious Disease Services, http://www.azdhs.gov/documents/preparedness/epidemiology-disease-control/disease-data-statistics-reports/annual-reports-archive/2014-infectious-disease-outbreak-summary-report.pdf

AZ Dept of Health Services, 2015, *Infectious Disease Outbreak Summary Report for 2015.* Office of Infectious Disease Services, http://www.azdhs.gov/documents/preparedness/epidemiology-disease-control/disease-data-statistics-reports/annual-reports-archive/2015-infectious-disease-outbreak-summary-report.pdf

AZ Dept of Health Services, 2018, *Infectious Disease Outbreak Summary Report for 2017 and 2018.* Office of Infectious Disease Services, https://www.azdhs.gov/documents/preparedness/epidemiology-disease-control/disease-data-statistics-reports/annual-reports-archive/2017-infectious-disease-outbreak-report.pdf

Komatsu, Kenneth, 2018, Personal communication via email dated March 1, 2018.

Meltzer M.I., N.J. Cox, K. Fukuda, 1999, *The Economic Impact of Pandemic Influenza in the United States: Priorities for Intervention*. Journal: Emerging Infectious Diseases, Volume: 5; Issue: 5; Year: 1999; Article ID: 99-0507, DOI: 10.321/eid0505.990507.

Molinari, Noelle-Angelique M., I. R. Ortega-Sanchez, M. L. Messonnier, W. W. Thompson, P. M. Wortley, E. Weintraub, C. B. Bridges, 2007, *The annual impact of seasonal influenza in the US: Measuring disease burden and costs.*

US Dept of Transportation, Aviation Statistics, Transportation.gov., 2023, US Internationally Destined Passenger Departures for Travel Years 2017-2022, https://www.transportation.gov/policy/aviation-policy/us-international-air-passenger-and-freight-statistics-report

LANDSLIDE

DESCRIPTION

Landslide damage to US 89 at Echo Cliffs near Page, AZ
Source: AzDEMA, 2013

Landslide is the general term used to describe the downslope movements of soil, rock and organic material under the influence of gravity. Other terms, such as mass movement or slope failure, are technically more accurate but are not as commonly used.

Landslides result from disturbances in the natural stability of a slope. Frequently, they accompany heavy rains, earthquakes, or volcanic eruptions, and are principally associated with mountainous areas, although they can occur in areas of low relief, as well. Common landslide triggers include heavy rain, rapid snow melt, earthquakes, volcanic eruptions, and freeze and thaw cycles.

Landslides are classified by the type of movement and the type of material moving. According to recent work performed by the Arizona Geological Survey (Youberg, et.al., 2018), the three most common movement types in Arizona are slides, falls/topples, and flows. Table 25 and Figure 13 combine to provide a matrix description and illustration of each landslide type with further discussions below.

Table 25. Landslide Types

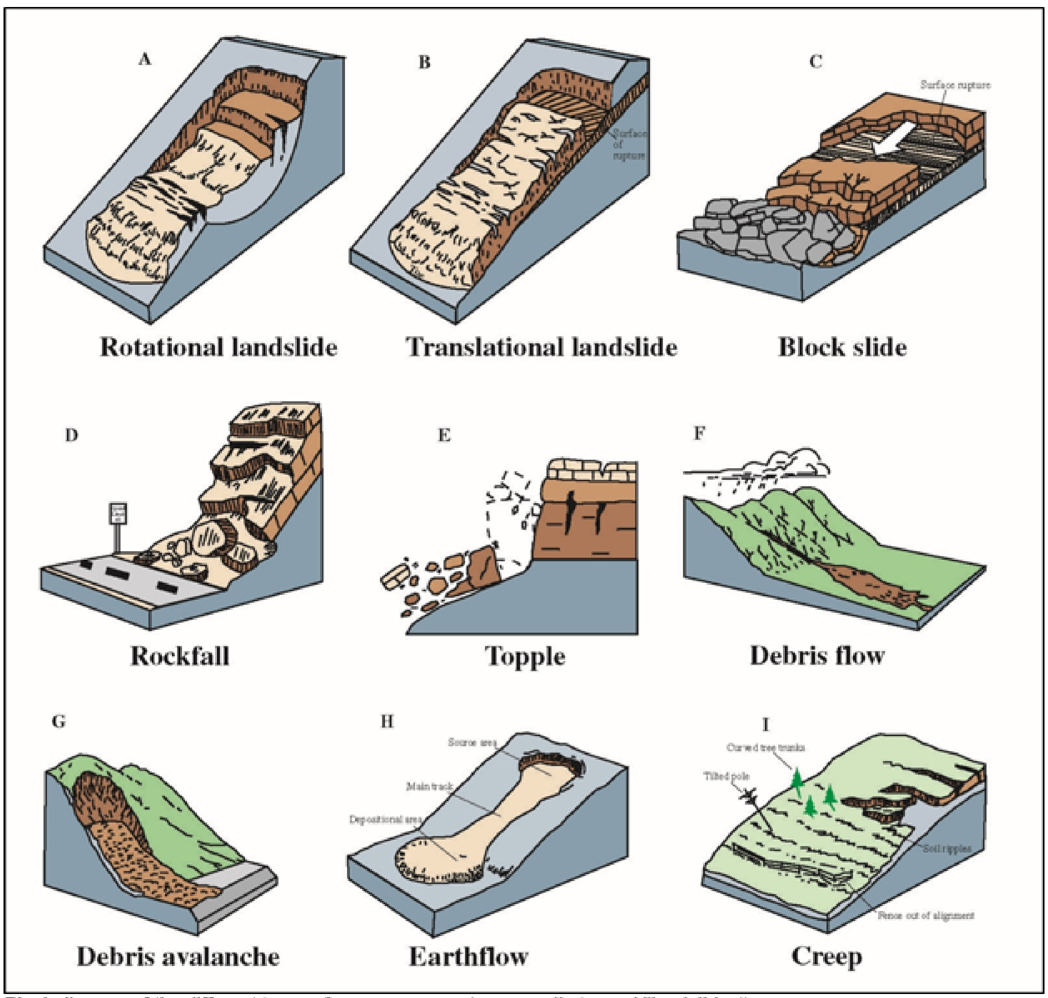
Type of Movement	Type of Material		
	Bedrock	Engineering Soils	
		Predominantly Coarse	Predominantly Fine
Slides (Rotational or Translational)	Rock slide or Toreva-block	Debris slide	Earth slide
Falls	Rock fall	Debris fall	Earth fall
Topples	Rock topple	Debris topple	Earth topple
Flows	Rock flow	Debris flow	Earth flow (fast) Earth creep (slow)
Lateral Spreads	Rock spread	Debris spread	Earth spread
Complex	Combination of two or more principal types of movement		
Source: Cook, et.al., 2017			

Slides

Slides are downslope movements of soil or rock along a surface of rupture, also sometimes called a rupture plane. The sliding mass may move beyond the rupture plane to deposit on original ground surface, which is called the surface of separation. The shape of the rupture plane reflects the type of movement (e.g. - rotational or translational). Slides can vary in size from a small localized area measured in acres to very large areas covering 10s to 100s of acreas. Slides can be found across the state and have historically been the cause of significant damages.

Falls and Topples

Downslope movement of soil and/or rock that detaches along a surface with little or no shear displacement and descends by falling through the air or bouncing and rolling on lower slopes. A topple begins by the forward rotation of rock or a soil mass out of a slope, pivoting about a point or axis. Topples may lead to falls or slides depending on the rock or soil mass and the geometry of the slope. Rock falls and topples are common in Arizona along steeper sections of slopes with cliff-forming strata. Oak Creek Canyon, Mount Lemmon Hwy, and the Vermillion Cliffs are just a few places where frequent rockfalls or topples occur.



Block diagram of the different types of mass movements, generally termed "landslides"
Source: Figure 1 from Youberg, et.al., 2018

Figure 13. Landslide type illustrations

Flows

Spatially continuous, non-cohesive, downslope movement of soil and/or rock with a behavior more similar to a plastic or viscous fluid. Generally, the structure of the soil or rock mass in a flow is not preserved. Flows velocities can range and often are triggered by slides that transition into flows. Debris flows are rapidly moving, saturated, unsteady, non-uniform, very poorly sorted sediment slurries that form in steep channels and gullies. Debris avalanches are similar to debris flows but form on and travel down open hillslopes instead of in channels. Faster moving earth flows and slower moving earth creeps can occur on lower gradient slopes and are generally composed of fine-grained material, silt and clay, or very weathered bedrock. Debris flows occur across the state and are currently considered to be the most common landslide type in Arizona.

HISTORY

There has only been one state disaster declaration for a landslide event. It is noted, however, that several other state and federal declared events included impacts from post-wildfire and flood triggered debris flows. Notable landslides that have occurred in Arizona over the last half-century are listed below:

- February 2013 – A large translational landslide in northern Arizona, about 23 miles south of Page, destroyed a significant section of US 89A. Costs to establish the "Page Detour" and repair the highway were approximately $60 million (Cook, et.al., 2017).
- January 2010 – A large mudslide covered State Hwy 87 about two miles south of Sunflower in the same location a previous slide had heavily damaged the road in 2008 (see below). The slide caused a closure of the four-lane roadway for several days. The mudslide was precipitated by major winter rainfall in the area during the January 2010 flooding that ultimately resulted in the FEMA-1888-DR presidential disaster declaration.
- March 2008 – A rotational slump landslide buckled pavement on State Hwy 87 between Sunflower and Rye, in the Slate Creek area. The southbound lanes of the four-lane divided highway were most severely affected. The road was closed for over a week and the southbound lanes were closed for several months while repairs were made (AZGS, 2008). Repair costs were estimated to exceed $18 million and communities like Payson, Strawberry, Pine, Heber-Overgaard, and Forest Lakes were negatively impacted by a significant downturn in tourists and camping travelers (Arizona Republic, 2008).
- July 2006 – Extreme precipitation caused approximately 1,000 debris flows in four mountain ranges in southern Arizona. The cost to repair infrastructure destroyed in Sabino Canyon, near Tucson, was estimated to exceed $1.5 million. Coronado National Memorial in the

Sabino Canyon Debris Flow (2006)
Source: AZGS website

southern Huachuca Mountains was temporarily closed due to debris flows and flood damage, and Mount Lemmon Hwy was damaged in several places (AZGS, 2007; Youberg, et.al., 2018).

- December 1995 – A massive landslide blocked the Moenkopi Wash near Tuba City in Coconino County. The landslide deposit created an unstable dam and with the threat of an imminent flash flood impacting downstream communities, a state of emergency was declared (DEMA/EM, March 2003; AZNG, 1997). Tuba City was evacuated until the threat passed and no deaths or injuries were reported.
- The Grand Canyon is also littered with landslides and debris flows of various types and sizes that occasionally dam and alter the river morphology and cause repeated damage to a water supply pipeline at Phantom Ranch, destroyed hiking trails, destroyed vehicles, and threatened lives at Diamond Creek (Griffith, et.al., 2004).

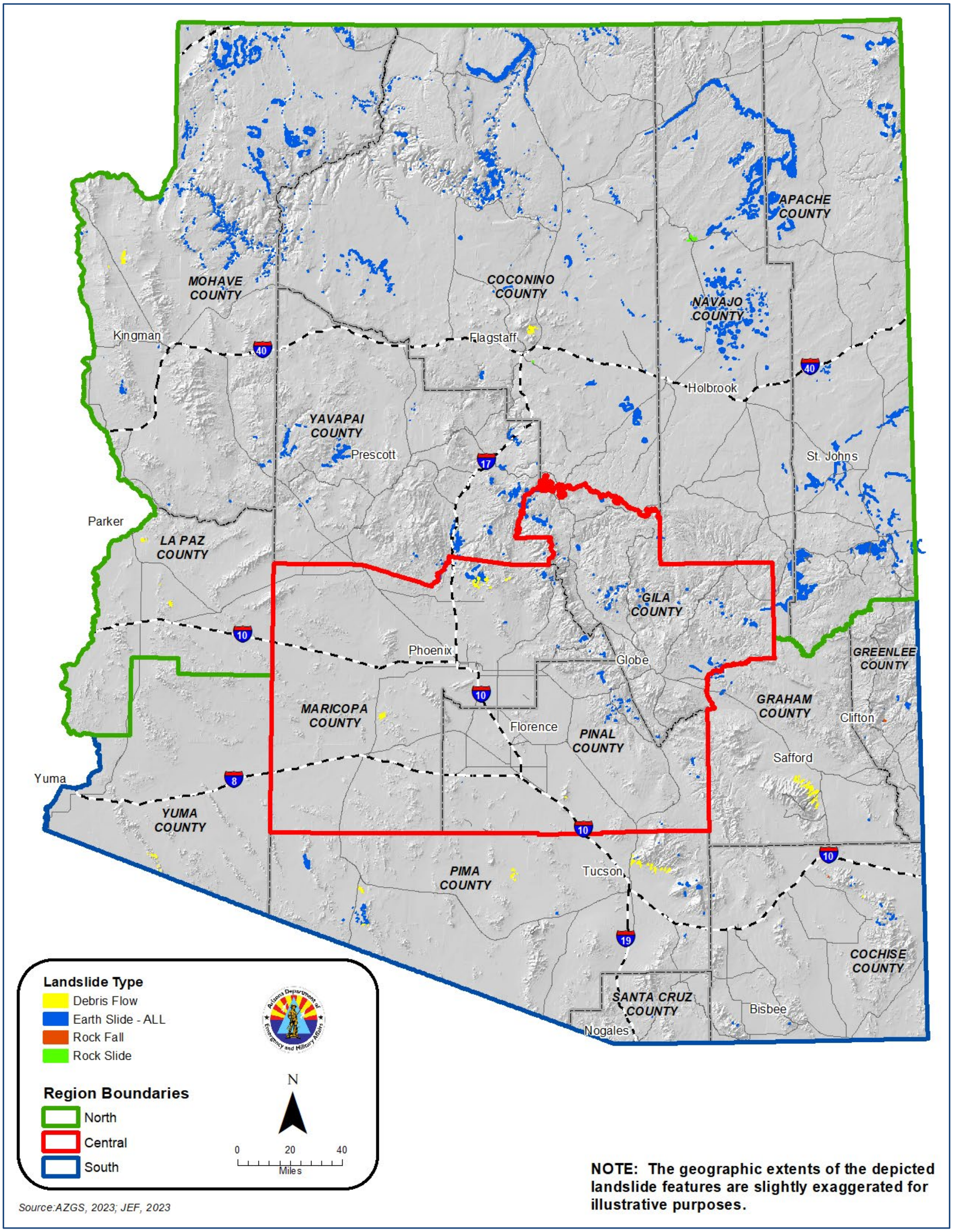
PROBABILITY/EXTENT

The probability of a landslide occurring somewhere in the state in any given year is a near certainty, and the likelihood of an event causing severe damage to infrastructure, or injury or loss of life is highly dependent on its location, type and timing. AZGS recently initiated a Landslide Hazards Program to compile and publish the Arizona Statewide Landslide Inventory Database (AzSLID) (Cook et. al., 2017), which constituted the first comprehensive landslide inventory for the State of Arizona. AZGS researched and compiled all forms of landslides from available maps, reports, and journal articles, and also added unmapped landslides features based on interpretation of aerial imagery and topography. The identified features were compiled into a database and attributed according to failure type, mechanism, and source. AzSLID is a work-in-progress and now contains more than 6,300 landslide features covering approximately 780 square miles of land area across the state.

Recent updates to the AzSLID database made by AZGS included:

- Mapping new slides and updated mapping for known slides along I-17 from Anthem to Flagstaff in 2020-21 (Cook and Gootee, 2021). Of note in the update:
    - Mapping included large rotational/translational slides along I-17 (some exposed in roadcuts) near Black Canyon City and at Sunset Point Rest Area.
    - ADOT currently widening I-17 through the Black Canyon City area
    - I-17 passes through very large landslide complex near the Hwy 179 junction. I-17 MP 300-301
- AZGS is currently mapping landslides along State Route 87 from Fountain Hills to Payson and along Hwy 260 along the Mogollon Rim from Strawberry to east of Payson. Of note in the update:
    - Very large landslide complex (3.2 sq. miles) along State Route 87 north of Sunflower (MP 222.5 - 226). The Easter Weekend slide is part of this complex.

Map 35 presents the current AzSLID database features on a statewide basis and provides context for landslide hazard profile.



Map 35. AzSLID mapped landslides

WARNING TIME

Most landslides occur without warning and are often triggered by other hazard events such as heavy rain, rapid snow melt, earthquakes, volcanic eruptions, freeze and thaw cycles, and post-wildfire conditions. Indirect warning may occur in the form of indicators pointing to slope weakening before a landslide, however, this is not always the case. These indicators may include sunken road beds, cracked foundations, leaning trees or fences[23]. Impacts of these events in Arizona are often localized and limited in scope.

FUTURE CONDITIONS

Climate Considerations

Climate change impacts on the frequency and severity of landslides in Arizona, is better correlated to climate change induced alterations to triggering events such as monsoon thunderstorm intensities, winter freeze and thaw, winter rain and snow events, and vegetation altering changes due to drought and wildfire. Projections of intensifying monsoon thunderstorms, changing winter precipitation patterns and intensities, and a hotter and drier environment leading to deeper droughts and increased wildfires, will all translate to increased landslide activity (Garfin, et.al., 2014) (Luong, et.al., 2015).

Changes in Development

Development of mountainsides, areas with steep terrains, or areas located at the base of steep mountain slopes, are all at an elevated risk of landslide. Construction of new or widened highway segments through mountainous or steep terrain areas also have an elevated landslide risk. Housing and roadway/highway development in the aforementioned areas can also increase the probability and risk to the population. Landslide hazard-specific changes in vulnerability to state CFI due to changes in development are essentially neutral, with a remote possibility of an increased vulnerability due to improperly design development of landslide area that would trigger slides onto state CFI.

North Region

The majority of the anticipated growth in the North Region is expected to expand from the existing jurisdictions, such as Sedona and Flagstaff. Hillside development is popular and sometimes necessary in the North Region, as hillside cuts are required for many roadway improvements in the area and to also create building sites. Expanding and widening of major interstates and highways such as I-17, Hwy 260, and State Routes 77, 87, 93, etc., may expose or re-activate an otherwise unknown or unmapped landslide feature. Areas of greater slope will also be areas of greatest risk for landslides. Natural erosion on hillsides can also create conditions that may sporadically cause rockfalls that may impact roads and structures in the immediate area.

[23] USGS (2017) Landslide Preparedness: Landslide Warning Signs. https://landslides.usgs.gov/learn/prepare.php

Central Region

The most significant development in the Central Region is expected to primarily occur in the greater Phoenix Metropolitan Area and near populated areas of the rest of the region. Gila County landslides are mostly outside of the populated areas and are not expected to experience significant changes in development. Highway widening projects such as ADOT's recent widening of the Devil's Canyon and the US 60 Oak Flat project between Superior and Miami will create significant cuts through steep canyon walls in an area that already has a history of rock fall activity.

Soldier Canyon debris flow. Small arrows at top of photo show where cobbles and boulders were deposited just upstream of several homes during 2006 event (Figure 9 in reference).
Source: Pearthree and Youberg, 2006

South Region

The Tucson Metropolitan Area is one of the most significant areas for development in the South Region. Growth of development in the surrounding Tucson area mountains and associated foothill regions are expected to continue at a slow pace and will effectively broaden the exposure and risk to landslides and debris flows. Other landslide areas of the South region are not expected to experience any significant development or growth.

VULNERABILITY ASSESSMENT

Landslides can result in deaths, injuries, and significant damages to impacted infrastructure and assets. For this Plan, the Planning Team chose to classify the AzSLID identified landslide areas as high hazard areas, with the recognition that landslide hazards exist outside of those currently studied and mapped areas. For this Plan update, the high hazard limits were established by buffering the AzSLID polygons by 500-feet. The estimation of potential exposure to the identified high hazard areas was accomplished by using GIS mapping and analysis tools to intersect the vulnerable population and state-owned facility data with the landslide hazard limits depicted on the maps that follow in each region's descriptions. The GIS analyses revealed that none of the state-owned buildings or structures are located in or within 500 feet of the landslide high hazard areas. Many of the state-owned and operated roadways, however, do intersect the high hazard landslide areas. There were also small segments of population that were identified to be located within a census tract proximity to the high hazard areas. For this vulnerability assessment, two sets of data are presented. The first is the state-owned and maintained roadway miles[24] exposed to, or

[24] Highways classified as either interstate, US highway, or state routes.

within 500 feet of, a currently mapped landslide zone. The second is a summary of population sectors and SVUC exposure located within the landslide high hazard zone. Summaries of these results by state planning region are provided below.

North Region

The North Region, depicted in Map 36, is the most vulnerable region of the state, primarily due to the history, population and mileage of highways exposed.

State-Owned CFI Exposure and Loss Estimates

None of the state-owned CFI are located in, or within 500 feet of, the identified landslide hazard zones. Approximately 19.5 miles of state-owned roadway is located in or within 500 feet of an identified landslide hazard zone, with the longest continuous segment being 6.0 miles and the shortest being less than 100 feet. Approximately 3.4 miles of the exposed roadway is I-17.

Vulnerable Population Groups

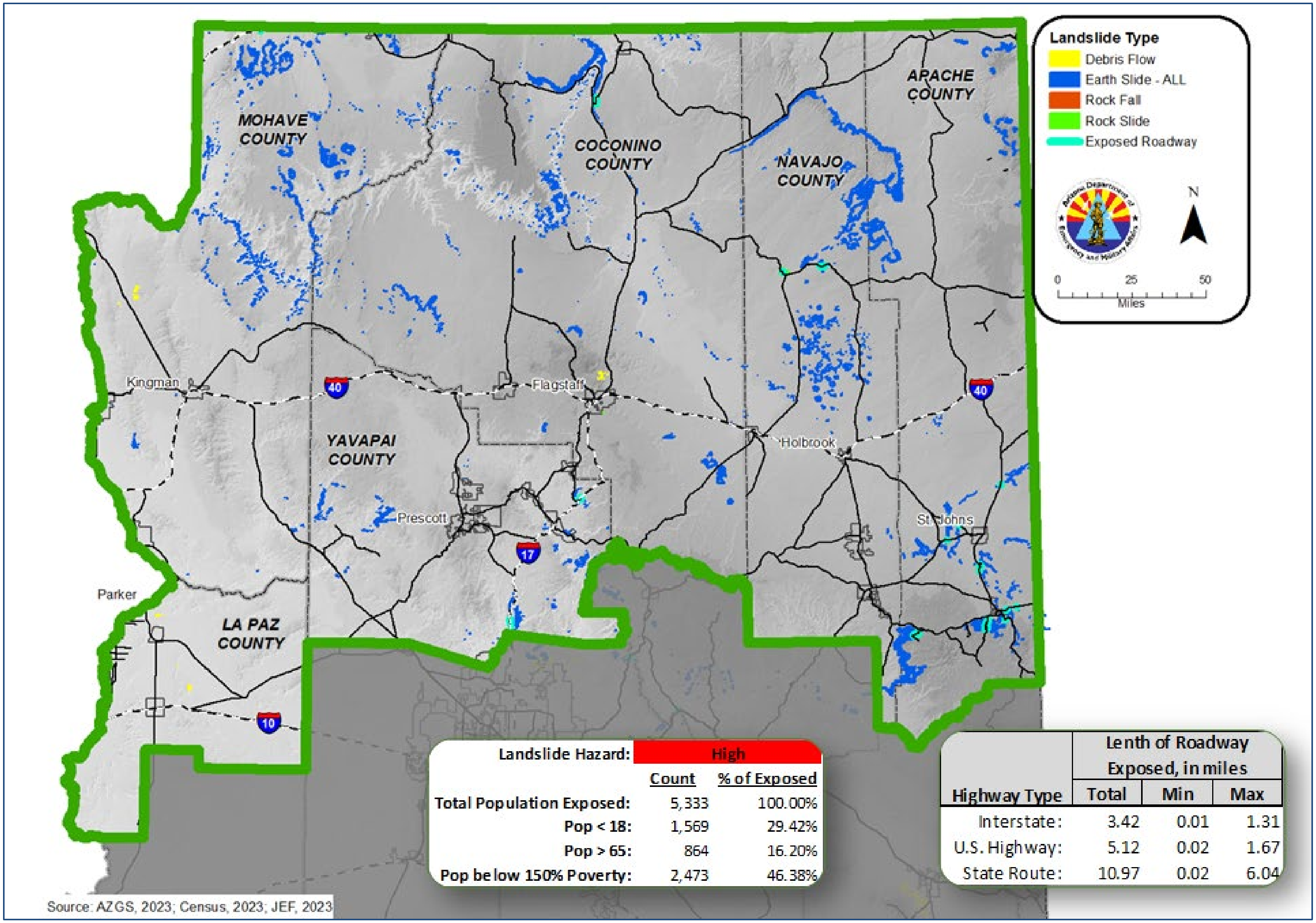
The 2022 estimated total population for the North Region is 801,655 people. Approximately 0.64% of the total region population, or 5,133 persons, are located within the high landslide hazard areas. Exposure statistics for the sub-population groups of under 18-years of age, older than 65, and less than 150% poverty level are indicated on Map 36.

SVUC Impact Assessment

Landslide high hazard impacts to North Region SVUC are summarized by CDC SVI themes and percentile rankings in Table 26. The highest percentages of regional exposure are highlighted using bold text. The results indicate that the SVUC exposure is moderately high for the region with the majority of impacts centering on the 0.75 to 0.90 rank for North Region communities and populations. It is also noteworthy that for Themes 2 and 3, the highest exposure is within flagged percentiles (0.90 to 1.00). This is likely due to the number of landslide hazards identified on the regions tribal lands.

Table 26. Landslide high hazard SVUC exposure for North Region

Region	CDC-SVI Assigned Percentile Rank	Percent of Impacted Area by SVI Percentile Rank Range				
		THEME 1 Socio-Economic Status	THEME 2 Household Characteristics	THEME 3 Racial and Ethnic Minority Status	THEME 4 Housing Type/ Transportation	THEMES (ALL) Overall Ranking
North	NO DATA	0.00%	0.00%	0.00%	3.88%	3.88%
North	0-0.25	8.10%	10.24%	12.93%	3.43%	4.12%
North	0.25-0.50	30.41%	8.67%	17.86%	22.74%	11.00%
North	0.50-0.75	27.89%	29.59%	28.20%	**31.34%**	**36.59%**
North	0.75-0.90	**32.66%**	14.32%	0.00%	26.93%	26.43%
North	0.90-1.00	0.93%	**37.19%**	**41.01%**	11.67%	17.97%



Landslide Hazard:	High	
	Count	% of Exposed
Total Population Exposed:	5,333	100.00%
Pop < 18:	1,569	29.42%
Pop > 65:	864	16.20%
Pop below 150% Poverty:	2,473	46.38%

	Lenth of Roadway Exposed, in miles		
Highway Type	Total	Min	Max
Interstate:	3.42	0.01	1.31
U.S. Highway:	5.12	0.02	1.67
State Route:	10.97	0.02	6.04

Map 36. Landslide vulnerability for the North region

Local Jurisdiction Vulnerability

Pima and Yavapai Counties included landslide in their risk assessment but did not specifically estimate quantitative landslide related losses for locally identified critical and non-critical facilities. The Yavapai County plan did note that historic losses primarily occurred along major roadways with repair and cleanup costs ranging from $1,500 to $150,000. Jerome was also identified as an area of elevated risk. Pima County risk is mostly identied to be in the Santa Catalina Mountains and the communities/facilities located in or near them. No specific losses were estimated, but historic damages from previous precipitation triggered debris flow events have exceeded $1 million.

Specific Areas of Concern

As noted in the Yavapai County plan, the Town of Jerome is constructed entirely on the side of a mountain (Cleopatra Hill) and has experienced significant ground movement over the past century, and remains at an elevated risk to ground movement. The AZGS (Cook, et.al., 2017) has noted that the potential risk of debris flow is greatly under-appreciated and warrants further study across the whole state, especially in wildfire prone areas with significant population and infrastructure located at the base of steep slopes such as Williams, Sedona, and the Fort Valley community outside of Flagstaff.

Central Region

The Central Region, shown in Map 37, is considered the second-most vulnerable region in the state. Contributing effects include the mileage of highway exposure, history of damaging slides, and the potential economic impacts of closures on the exposed roadways (primarily State Route 87).

State-Owned CFI Exposure and Loss Estimates

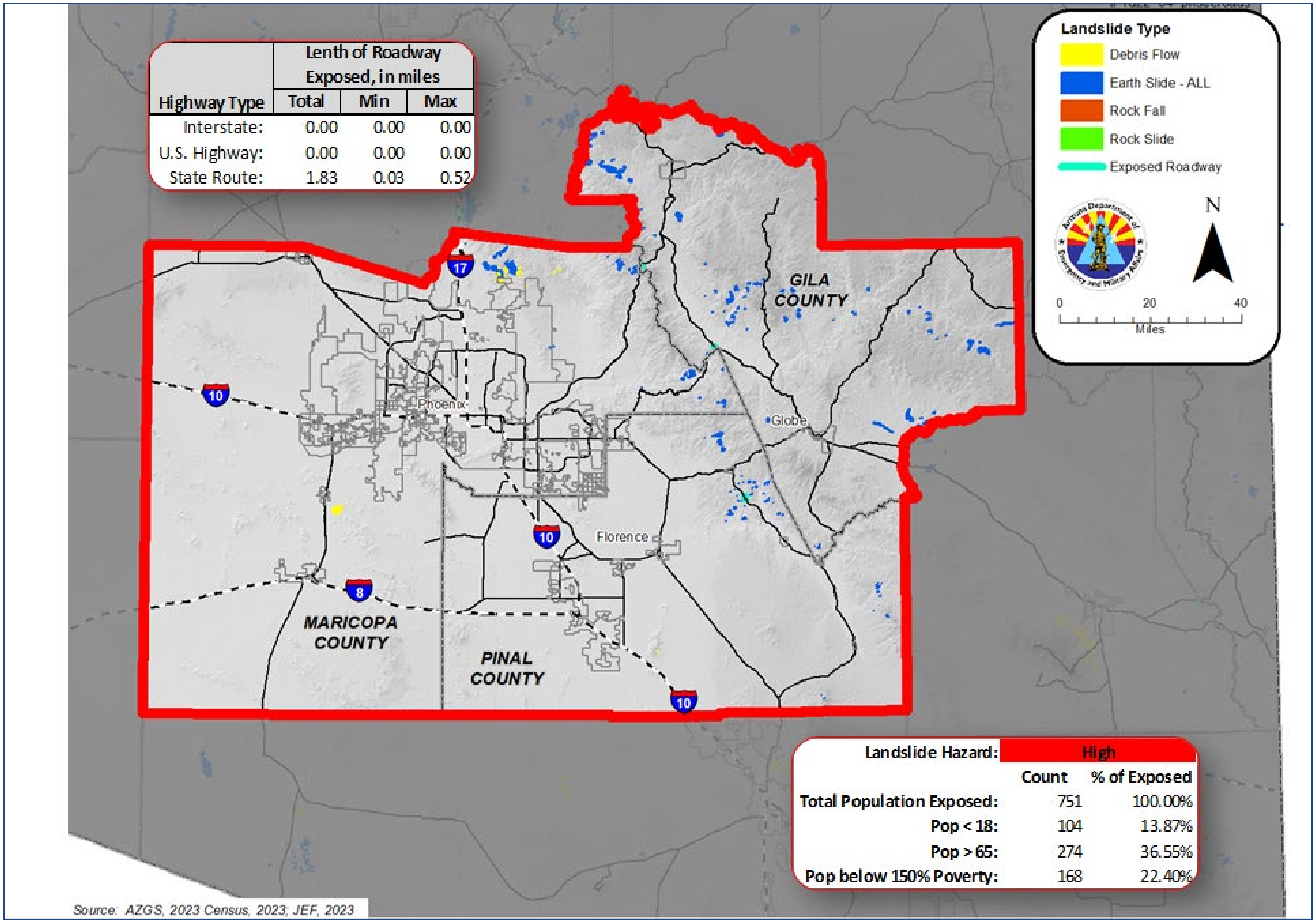
None of the state-owned CFI are located in, or within 500 feet of, the identified landslide hazard zones. Approximately 1.8 miles of state-owned roadway is located in, or within 500 feet of, an identified landslide hazard zone, with the longest continuous segment being 0.5 miles and the shortest being less than 100 feet. All of the exposed roadway (1.8 miles) is composed of segments of SR 87 between Phoenix and Payson.

Vulnerable Population Groups

The 2022 estimated total population for the Central Region is 5,069,600 people. Less than 0.01% of the total population, or 751 persons, are located within the landslide high hazard areas. Exposure statistics for the sub-population groups of under 18-years of age, older than 65, and less than 150% poverty level are indicated on Map 37.

SVUC Impact Assessment

Landslide high hazard impacts to Central Region SVUC are summarized by CDC SVI themes and percentile rankings in Table 27. The highest percentages of regional exposure are highlighted using bold text. The strongest majority of exposure is generally centered around the 0.25 index and within a range between 0.01-0.50, which would suggest a moderately low SVUC vulnerability in Central Region communities.



Map 37. Landslide vulnerability for the Central region

Table 27. Landslide high hazard SVUC exposure for Central Region

Region	CDC-SVI Assigned Percentile Rank	Percent of Impacted Area by SVI Percentile Rank Range				
		THEME 1 Socio-Economic Status	THEME 2 Household Characteristics	THEME 3 Racial and Ethnic Minority Status	THEME 4 Housing Type/ Transportation	THEMES (ALL) Overall Ranking
Central	NO DATA	0.29%	0.29%	0.29%	0.29%	0.29%
Central	0-0.25	26.97%	29.54%	**69.99%**	**46.35%**	**46.35%**
Central	0.25-0.50	**29.71%**	**34.47%**	0.63%	9.93%	12.99%
Central	0.50-0.75	24.55%	28.53%	8.18%	28.80%	20.29%
Central	0.75-0.90	18.49%	5.23%	2.43%	0.83%	20.08%
Central	0.90-1.00	0.00%	1.94%	18.49%	13.79%	0.00%

Local Jurisdiction Vulnerability

None of the Central Region counties included landslide in their hazard mitigation plan risk assessments. Accordingly, no loss estimates were made for locally identified critical facilities and infrastructure.

Specific Areas of Concern

State Route 87 is a prominent and well-traveled corridor that serves the Phoenix Metropolitan area as a primary access to the Mogollon Rim country. Loss of use due to past or future landslide-based closures has had, and will have, a significant negative impact on the tourism economy of Rim country communities like Payson, Strawberry, Pine, Star Valley, Heber-Overgaard, and Forest Lakes.

South Region

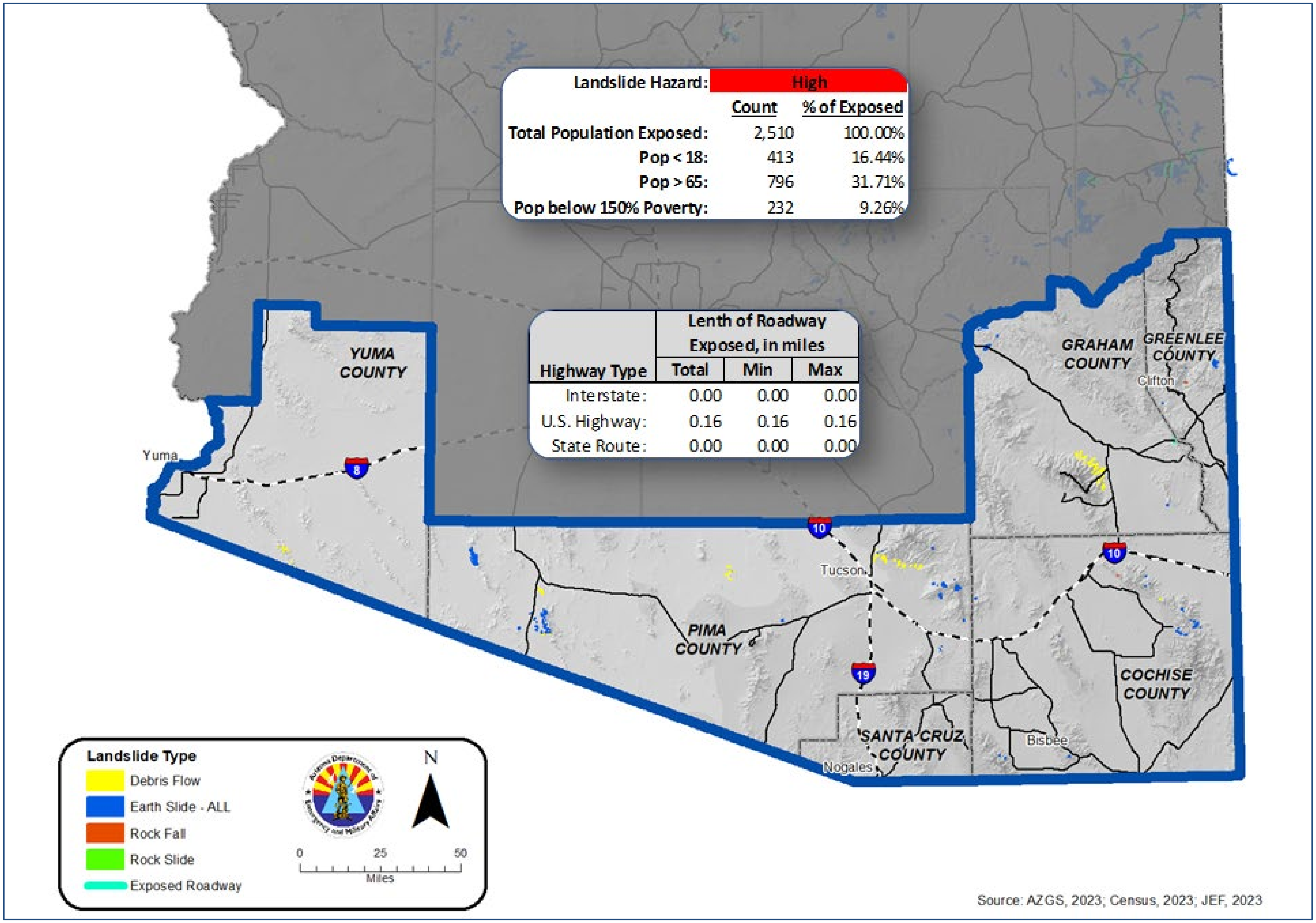
The South Region, shown in Map 38, is the least vulnerable region in the state, largely due to the small mileage of exposed roadway and limited landslide hazard areas.

State-Owned CFI Exposure and Loss Estimates

None of the state-owned CFI are located in, or within 500 feet of, the identified landslide hazard zones. Only one 0.16 mile segment of Hwy 191 in eastern Graham County is located in, or within 500 feet of, an identified landslide hazard zone. It is noted that SR 366 on Mount Graham threads very near several zones, but is not within the hazard zone currently mapped.

Vulnerable Population Groups

The 2022 estimated total population for the South Region is 1,487,942 people. Approximately 0.17% of the total population, or 2,510 persons, are located within the high landslide hazard areas. Exposure statistics for the sub-population groups of under 18-years of age, older than 65, and less than 150% poverty level are indicated on Map 38.



Map 38. Landslide vulnerability for the South region

SVUC Impact Assessment

Landslide high hazard impacts to South Region SVUC are summarized by CDC SVI themes and percentile rankings in Table 28. The highest percentages of regional exposure are highlighted using bold text. The strongest majority of exposure is to areas with index ranking centered around the 0.50 to 0.75 range with some approaching the 0.25 and 0.90 extremes. This would suggest a moderately high SVUC vulnerability in South Region communities.

Table 28. Landslide high hazard SVUC exposure for South Region

Region	CDC-SVI Assigned Percentile Rank	Percent of Impacted Area by SVI Percentile Rank Range				
		THEME 1 Socio-Economic Status	THEME 2 Household Characteristics	THEME 3 Racial and Ethnic Minority Status	THEME 4 Housing Type/ Transportation	THEMES (ALL) Overall Ranking
South	NO DATA	1.30%	1.30%	1.30%	1.30%	1.30%
South	0-0.25	8.48%	7.48%	22.73%	22.25%	7.85%
South	0.25-0.50	29.07%	**42.64%**	16.27%	5.15%	22.10%
South	0.50-0.75	21.20%	2.90%	**40.53%**	**44.54%**	24.56%
South	0.75-0.90	**39.96%**	41.49%	0.07%	14.20%	**40.77%**
South	0.90-1.00	0.00%	4.20%	19.10%	12.57%	3.41%

Local Jurisdiction Vulnerability

Pima County included landslide in their risk assessment but did not specifically estimate quantitative landslide related losses for locally identified critical and non-critical facilities. The Pima County plan did note that Santa Catalina Mountain areas have the greatest risk and a demonstrated history of losses with the Sabino Canyon debris flow event of 2006 as exceeding $1 million.

Specific Areas of Concern

The steep upper slopes of the Santa Catalina Mountains north of Tucson are prone to debris flows, rock falls, and translational landslides (Cook, et.al., 2017). The mountains are heavily used by Tucson Metropolitan area residents for various kinds of outdoor recreation and access via the roadways along known debris flow areas on the Catalina Hwy up Mount Lemmon within the Coronado National Forest. Past debris flows have traveled down-the mountain slopes and into developed foothill areas, posing a moderate risk to property and infrastructure located along the areas closest to the base of the mountains. Bisbee and Clifton are also both situated at the base of mountainous terrain with elevated risks to landslide events.

RESOURCES

Sources

AZ Geological Survey, Hazards Viewer, https://uagis.maps.arcgis.com/apps/webappviewer/index.html?id=98729f76e4644f1093d1c2cd6dabb584

AZGS Landslide Data, https://library.azgs.arizona.edu/item/AGSP-1677617242995-114

United States Geological Survey, Landslide Hazards Program, https://landslides.usgs.gov/

References

Harris, R.C., Pearthree, P.A., 2002, *A Home Buyer's Guide to Geologic Hazards in Arizona*. AZGS, Down-to-Earth 13.

Cook, J.P., and 6 others, 2017, *Building a Statewide Inventory of Landslides in Arizona*, In De Graff, J.V. and Shakoor, A. (eds.), Landslides: Putting Experience, Knowledge and Emerging Technologies into Practice, AEG Special Publication No. 27, p. 787-793. https://repository.arizona.edu/handle/10150/629700

Cook, J.P. and Gootee, B.F., 2021, *Landslide mapping along the Interstate-17 corridor from Anthem to Flagstaff, AZ*. Arizona Geological Survey Special Paper 12, 38 p. https://library.azgs.arizona.edu/item/AGSP-1677617242995-114

Gonzalez, P., G.M. Garfin, D.D. Breshears, K.M. Brooks, H.E. Brown, E.H. Elias, A. Gunasekara, N. Huntly, J.K., Maldonado, N.J. Mantua, H.G. Margolis, S. McAfee, B.R. Middleton, and B.H. Udall, 2018: *Southwest. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 1101–1184. doi: 10.7930/NCA4.2018.CH25. On the Web: https://nca2018.globalchange.gov/chapter/southwest

Garfin, G., G. Franco, H. Blanco, A. Comrie, P. Gonzalez, T. Piechota, R. Smyth, and R. Waskom, 2014, *Ch. 20: Southwest. Climate Change Impacts in the United States: The Third National Climate Assessment*, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., US Global Change Research Program, 462-486. doi:10.7930/J08G8HMN

Griffiths, P. G., R. H. Webb, and T. S. Melis, 2004, *Frequency and initiation of debris flows in Grand Canyon, Arizona*, J. Geophys. Res., 109, F04002, doi:10.1029/2003JF000077.

Luong, T.M., Castro, C.L., Chang, H.I., Jares, M., Lahmers, T., Mazon, J.,Carrillo, C.M., Adams, D.K., 2015, The More Extreme Nature Of Monsoon Precipitation In The Southwest USAs Revealed By A Long-Term Climatology Of Simulated Severe Weather Events, Journal of Applied Meteorology and Climatology, Vol. 56, No. 12. December 2017.

Pearthree, P.A., and Youberg, A., 2006, *Recent Debris Flows and Floods in Southern Arizona.* Arizona Geology, Vol. 36, No. 3, p. 1-5.

Schuster, R., L. Highland, 2004, *Impact of Landslides and Innovative Landslide-Mitigation. Measures on the Natural Environment.* Conference on Slope Engineering, Hong Kong, China. https://pubs.usgs.gov/op/HongKongJuly/HongKongJuly21.pdf

Winter, M. B. Shearer, D. Palmer, D. Peeling, C. Harmer, J. Sharpe, 2016, *The Economic Impact of Landslides and Floods on the Road Network*. Procedia Engineering Vol. 143.pp 1425-1434.

LEVEE FAILURE

DESCRIPTION

Levees have been part of the Arizona landscape for centuries, first along rivers and streams and then in agricultural communities to protect fields and facilitate irrigation. In urban areas, flood control systems have been constructed to increase the amount of developable land and to protect existing populations and infrastructure from flooding.

Clifton Levee along San Francisco River (looking southerly)
Source: Gila Valley Central, photo by Gualterio Casias

Levees impound water above the natural prevailing grade or natural conveyance of a watercourse, creating an artificially constrained floodway. Areas protected by a levee, referred to as leveed areas, become the areas at-risk during a levee failure event. Levees are usually artificial structures comprised of earthen, cement stabilized aggregate (CSA) or roller compacted concrete (RCC) embankments, or structural concrete or steel walls. A levee is typically constructed parallel and adjacent to an existing watercourse. In some cases, the levee will function as a diversion structure that will re-direct flood-waters along an alignment that allows for positive flow along the levee to the intended outlet. All of Arizona's levees are for flood control.

Levee failures result in an uncontrolled release of water to the leveed areas, with potentially catastrophic impacts. Failures may be attributed to a variety of modes and causes. The three most common are: 1) foundation leakage and piping, 2) overtopping, and 3) embankment erosion.

In 2007, Congress established the National Committee on Levee Safety (NCLS) to develop recommendations for a National Levee Safety Program (NLSP). The NCLS, with guidance from Congress, developed the following definition for a levee: *"A manmade barrier (embankment, floodwall or structure) along a watercourse constructed for the primary purpose to provide hurricane, storm, and flood protection relating to seasonal high water, storm surges, precipitation and other weather events; and that normally is subject to water loading for only a few days or weeks during a year. Levees also may be embankments, floodwalls and structures that provide flood protection to lands below sea level and other lowlands and that may be subject to water loading for much, if not all, portions of the year, but that do not constitute barriers across watercourses or constrain water along canals."*

For the purpose of administering the National Flood Insurance Program (NFIP), FEMA provides accreditation for levee systems that are certified to meet the FEMA standards for major storm related flood risk reduction. In that capacity, FEMA defines levees as: *"man-made structures, usually earthen embankments 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."*

In November 2017, Governor Ducey received a letter from the United States Army Corps of Engineers (USACE) notifying the Governor of the Congressional authorization of USACE to work with interested states and levee owners/operators to conduct and inventory and review of levees across the nation. The purpose of the action was to work with Arizona agencies to inventory, review and assess critical information for levees within Arizona, with a particular focus on levees not currently identified to be within USACE authority. The collected information will be included in the USACE's National Levee Database (NLD), which is publicly available and used to promote awareness of the benefits and flood risks associated with levees.

Non-levee embankment failures in Pinal County
Source: Pinal County MJHMP, 2015

In February 2018, the USACE met with state officials and local levee owners and operators to kick-off the effort. USACE inspected and reviewed levees in only Maricopa County and there were a fairly large number of total levees that were amended or removed from the database in other counties including Cococino, La Paz, Navajo, Pima, Santa Cruz, and Yuma. One work product was to assign a Levee Safety Action Classification (LSAC) value to each levee studied. The LSAC will provide state and local officials with a risk-based aid to determine mitigation priorities.

The state does not currently have a lead agency for levee safety. Instead levee owners coordinate directly with federal sources such as the USACE (NLD program, WRDA appropriations, and Silver Jackets programs) and FEMA (Cooperating Technical Partner (CTP) program and HMA grants and programs).

HISTORY

The occurrence of significant levee failures has been limited in Arizona. Since 1966, there have not been any levee-specific state or federal declarations; however, levee failures related to major flooding events receiving state and federal declarations, such as those for the 1978 and 1993 floods, have occurred. Details of those incidents are described more thoroughly below.

There are no recorded failures of FEMA accredited levees for Arizona. There have, however, been several damage-producing failures of non-accredited levees, and embankments that were intended to function as levees, as follows:

- July 2021 – Widespread rain occurred on July 24 and 25 in the Santa Cruz River watershed in Pinal County and upstream in much of eastern Pima County with 48 hour rain totals of 3 to 4 inches common. High flows in the river traveled downstream into Greene Wash. A levee breached in the wash near Toltec Buttes and washed out a road, then flowed into and damaged a 0.75 mile reach of canal. Damages were estimated to exceed $250K (NCDC, 2023).

- February 2005 – Smaller dikes along the Gila River in the Town of Duncan broke allowing water to backup into the town. Damage occurred to a residence near Duncan High School, and a trailer downstream of the high school. Also, Hwy 70 near the high school was covered with four feet of water and the approach ramps to the highway were overtopped with flowing water. East Avenue and low-lying areas in the west end of Duncan were evacuated on the evening of Saturday February 12, 2005. The railroad tracks also on the west end of Duncan were covered with water and power went out in the west side of the town. Damages were estimated at nearly $1.5 million (NCDC, 2009).
- December 2004 – A piping failure developed through the Winslow Levee along a sand lens located in the foundation soils below the levee. Entry paths to the sand layer were believed to have been caused by desiccation cracks, root channels, and/or rodent burrows. Emergency repairs to the levee were estimated at $75,000 (Navajo County BOS, 2005; USACE, 2016).

2004 Winslow Levee Piping Failure – Landslide photos
Source: USACE, 2016

- January 1993 – A 345-foot-long section of the Winslow Levee breached by overtopping and flooded the Ames Acres, Bushman Acres, and Winslow Plaza subdivisions. The resulting flooding inundated 204 parcels and 140 structures and required the evacuation of 900 people for as long as three days. Fifty homes were flooded up to four feet deep. One business and one farm received damages. At McHood Park the recreational lake silted up. The Corps of Engineers repaired the breach during the flood at a cost of $350,050. Navajo County worked in 24-hour shifts to continue reinforcing the breach (USACE, 1994 and NCDC, 2009).
- January 1993 – The National Guard was called out to repair and reinforce the dike around San Lucy cemetery, near Gila Bend. Three houses north of Gila Bend were inundated from the rising water from Painted Rock Reservoir. Crops and fields were also inundated by floodwaters (USACE, 1994).
- December 1978 – The Gila River near Duncan reached a flow of nearly 60,000 cfs, breaching the existing levee embankments and severely damaging local infrastructure, homes and stores, and agricultural properties. The total damage of the flood was estimated at over $2.5 million (Greenlee County Hazard Mitigation Plan, 2016).
- October 1972 – Gila River flooding of the Duncan Valley occurred when the levees protecting the Town of Duncan were overtopped and eroded. Most of the Town of Duncan was inundated with water up to four feet deep, and several adobe structures were destroyed or sufficiently

damaged to require demolition. Silt over four inches deep in many places was deposited in yards and inside homes and stores ruining contents. Floors buckled, and foundations and walls cracked in several homes because of settling. The largest single structural loss was the elementary school building of the Duncan Unified School District. Total non-agricultural damage in Duncan Valley was over $1.5 million, nearly all of which was in the Town of Duncan (FEMA, 2007).

PROBABILITY/EXTENT

The probability of a FEMA accredited or USACE Authority levee failing is low for Arizona. According to the latest NLD accessed in July 2023, there are 21 and 124 USACE authority and non-USACE authority levee systems within Arizona. Those systems equate to 29 and 336 total miles of USACE and non-USACE authority levees.

FEMA maintains a database of FEMA accredited levees as a part of the National Flood Hazard Layer (NFHL). Areas of reduced flood risk protected by a levee, are specially designated as such on FEMA maps and in the NFHL database. These special FEMA zones are considered a "best available" data source for mapping potential levee failure zones that may exceed the high flood hazard zones in the flood section of this report. The NLD also contains a data layer that shows the leveed areas for most of the USACE authority levees; however, currently, the NFHL data-set is more comprehensive. This may change once the USACE completes the inventory and review process, and future updates should query the NLD as a possible source for defining levee failure hazard areas.

shows a statewide depiction of FEMA accredited levees and the reduced flood risk zones (or leveed areas) that are protected by the levees.

WARNING TIME

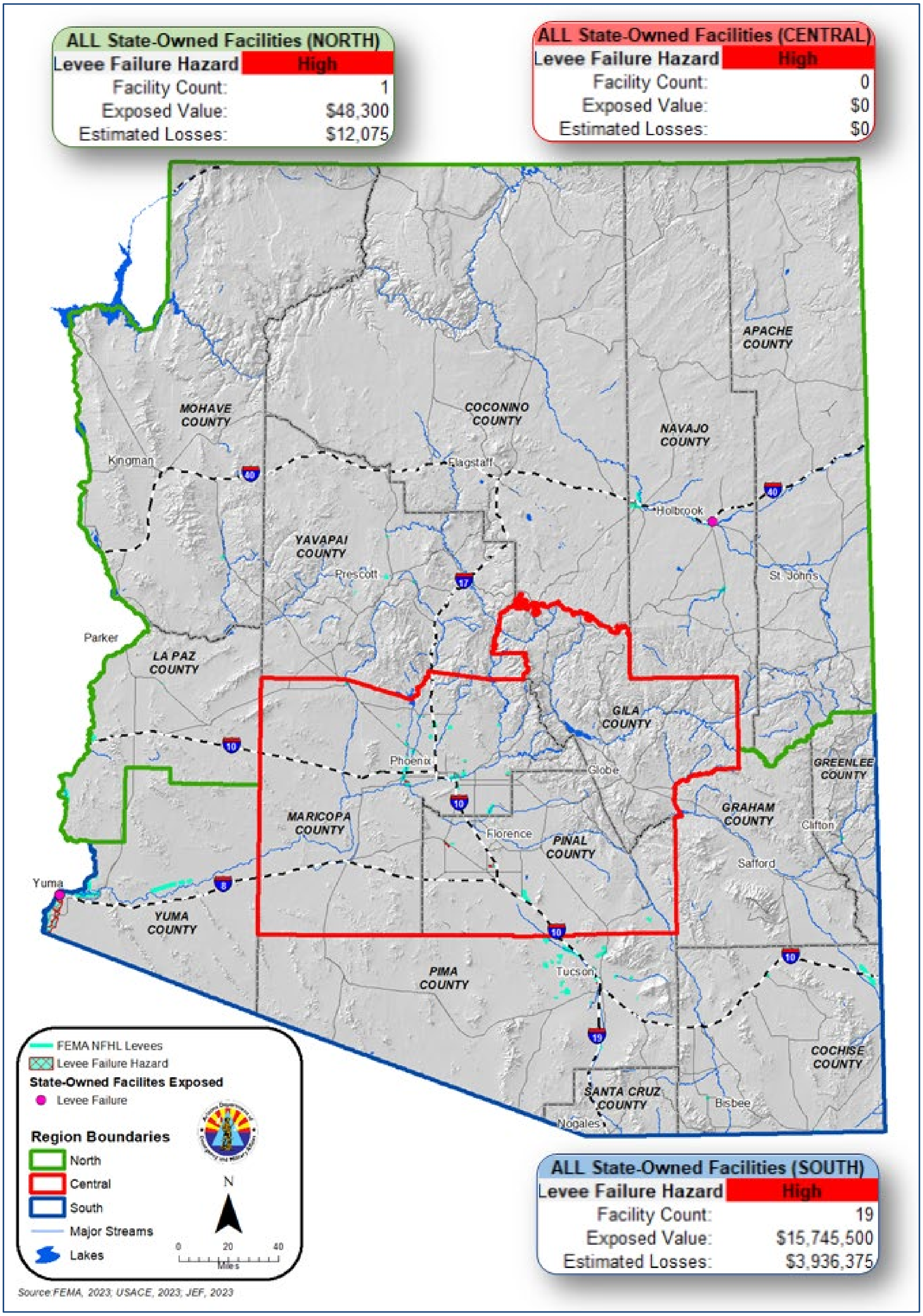
Once initiated, a levee failure can occur very rapidly, with a sudden, uncontrolled release of the stored or impounded water. Warning times for populations located in the leveed areas are dependent upon the speed of the flood-wave and distance from the breach. In most cases for Arizona, this is usually measured in tens of minutes. Extreme weather events with a potential to trigger or cause a failure will also have at least hours of warning if not a few days.

FUTURE CONDITIONS

Climate Considerations

From a levee safety perspective, the primary climate change impacts will be related to potential changes in the way precipitation and resultant flood patterns may vary, and influence of the potential for increased wildfire activity. The National Climate Assessment (NCA) reports (Gonzales, et.al., 2018 and Garfin, et.al., 2014) note the following regarding climate change for the Southwest:

- A possible reduction in average annual precipitation and streamflow volumes.
- Winter storm intensities are anticipated to increase, which may lead to increased event-based flooding during winter months.



Map 39. Levee failure statewide profile

- Winter precipitation will be less in the form of snow and more frequently rain, which may indicate more frequent winter flooding.
- Overall flooding conditions for watersheds upstream of levee facilities could also be exacerbated by the potential for reduced vegetation due to increases in drought and post-wildfire flooding conditions.

Changes in Development

Development related impacts to levee failure risk include a phenomenon referred to as “development creep”, which is when development begins to encroach into the leveed areas, increasing the exposure of population and infrastructure to the levee failure risk. Another change includes potential increases in watershed rainfall-runoff characteristics due to the addition of significant impervious areas that translate into increased runoff volumes that may exceed or challenge the design capacities of the levee structures and cause increased vulnerability to downstream state CFI.

Hazard specific changes in vulnerability to state CFI due to changes in development are also slightly increased due to secondary impacts of levee failure. For example, additional development damaged by a levee failure may increase the debris loading on a downstream state owned CFI. It is difficult to quantify the vulnerability increase, but in concept, the risk exists..

Regions specific changes in development are discussed below.

North Region

Areas of anticipated significant growth that may extend into levee failure areas are identified in Flagstaff and Tusayan (Coconino), Prescott Valley and Chino Valley (Yavapai), Bullhead City and Lake Havasu City (Mohave), plus several populated areas within the unincorporated areas of Coconino, Mohave, and Yavapai Counties. None of the anticipated development is expected to alter the current levee certifications.

Central Region

The federal and local levees impacting Maricopa County have been actively studied and evaluated for failure inundation limits by the Flood Control District of Maricopa County (FCDMC) resulting in small pockets of the county being situated within an identified levee failure inundation zone. Development over the next five years will at least partially occur within these mapped areas, however the risk of failure is relatively low due to the high level of maintenance and mitigation of potential failure modes. Planned growth in Pinal County areas subject to levee failure inundation is low to moderate and anticipated in or near Apache Junction, Coolidge, Florence, Maricopa, areas along the Santa Cruz River, and portions of the San Tan Valley. Gila County does not currently have any mapped levee failure areas.

South Region

Moderate growth is expected to continue in Pima and Yuma Counties, primarily near or within the Tucson and Yuma Metropolitan areas, expanding the exposure to existing levee failure inundation zones. Future growth into levee failure zones within Cochise, Graham, Greenlee, and Santa Cruz Counties is not anticipated to be significant.

VULNERABILITY ASSESSMENT

The estimation of potential exposure to the identified levee failure inundation hazards was accomplished by using GIS mapping and analysis tools to intersect the vulnerable population and state-owned critical facilities and infrastructure (CFI) data with the inundation limits which are considered the high hazard areas for this analysis. The loss calculations assume that exposed structures are subject to a loss-to-exposure ratio of 0.20 (or 20% damaged). The exposure loss estimates presented are based on a single event and aggregated to the entire region.

Four of the 15 county multi-jurisdictional hazard mitigation plans included levee failure in their risk assessment. Further details are summarized by region in the sections below.

North Region

The North Region, depicted in Map 40, is the second-most vulnerable state region when considering the history of events, the exposure estimates, and number of local plans that included levee failure in their risk assessment.

State-Owned CFI Exposure and Loss Estimates

One state-owned CFI, or 5% of the statewide exposure, is located within a levee failure inundation zone. The exposed facility represents a total exposed replacement value of $48,300, with an estimated $12,075 in potential losses.

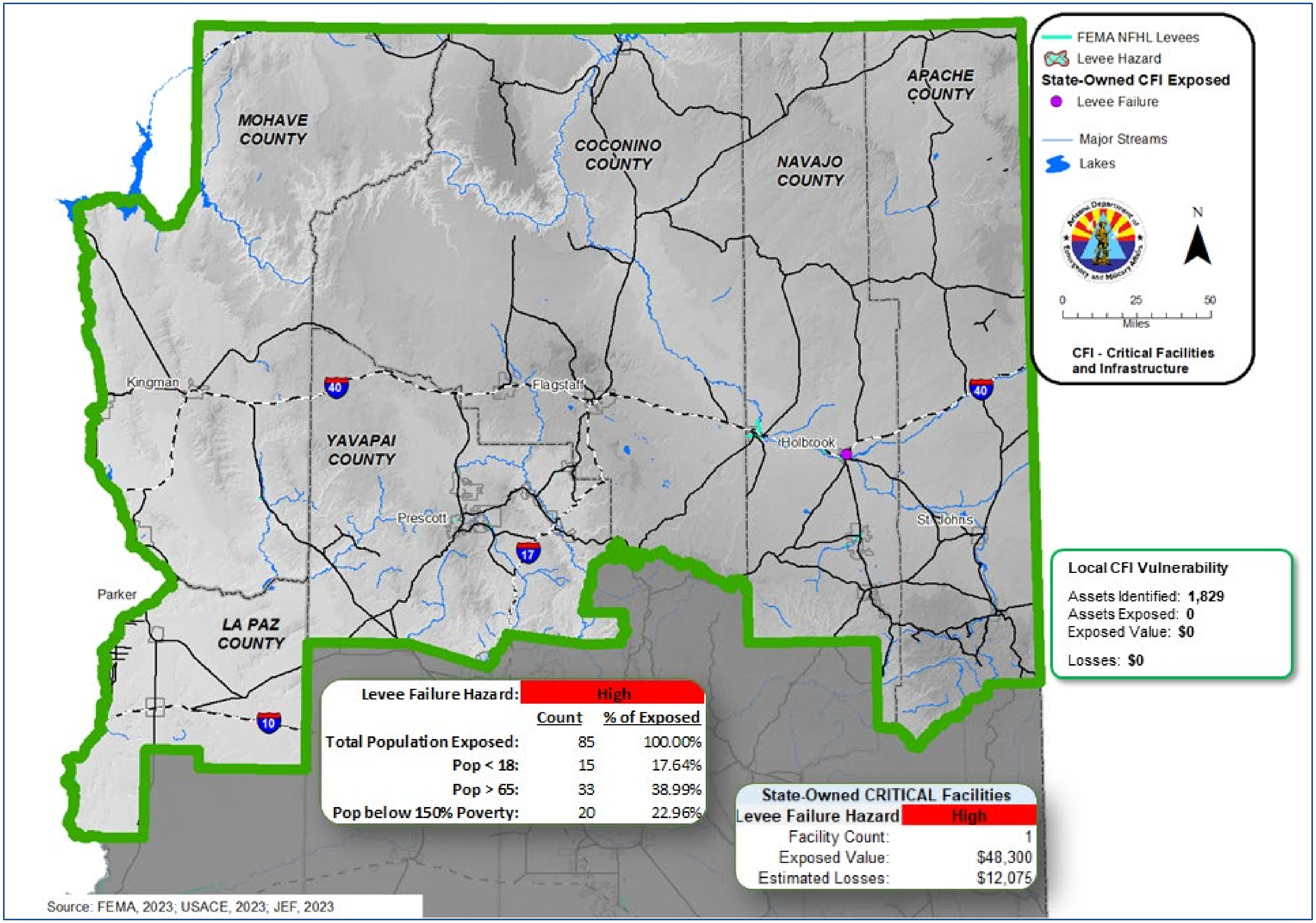
Additional state-owned facilities vulnerable to levee failure inundation hazards are the Arizona Department of Transportation (ADOT) operated and maintained freeways, highways and state routes located within the inundation zones. The drainage facilities (bridges, culverts, and channels) constructed with the ADOT roadways are not expected to have capacity for handling the types of flows associated with a levee failure. Typical impacts might include erosion of roadway embankments and pavements, culvert and bridge failures, and significant sedimentation.

Vulnerable Population Groups

The 2022 estimated total population for the North Region is 801,655 people. Approximately 0.01% of the total population, or 85 persons, are exposed to levee failure inundation hazards. Exposure estimates for at-risk population groups like persons under 18-years of age, over 65-years of age, and those living at or below 150% poverty level are included on Map 40.

SVUC Impact Assessment

Levee failure high hazard impacts to North Region SVUC are summarized by CDC SVI themes and percentile rankings in Table 29. The highest percentages of regional exposure are highlighted using bold text. The results indicate that the SVUC exposure is moderately high for the region with the majority of impacts centering on the 0.75 rank between 0.50 and 0.90 for North Region communities and populations.



Map 40. Levee failure vulnerability for the North region

Table 29. Levee failure high hazard SVUC exposure for North Region

Region	CDC-SVI Assigned Percentile Rank	Percent of Impacted Area by SVI Percentile Rank Range				
		THEME 1 Socio-Economic Status	THEME 2 Household Characteristics	THEME 3 Racial and Ethnic Minority Status	THEME 4 Housing Type/ Transportation	THEMES (ALL) Overall Ranking
North	NO DATA	0.00%	0.00%	0.00%	0.00%	0.00%
North	0-0.25	0.00%	0.17%	2.43%	0.00%	0.00%
North	0.25-0.50	2.17%	1.96%	0.17%	2.13%	2.13%
North	0.50-0.75	**97.83%**	2.53%	**95.03%**	2.53%	2.53%
North	0.75-0.90	0.00%	**95.29%**	2.38%	**74.13%**	**95.29%**
North	0.90-1.00	0.00%	0.05%	0.00%	21.21%	0.05%

Local Jurisdiction Vulnerability

Local hazard mitigation plans for the North Region identified no assets or losses for levee failure hazards.

Specific Areas of Concern

The Winslow Levee and other levees along or near the Little Colorado River in Navajo County have a history of failure risk, and especially in and around the City of Winslow. An additional area of concern regarding levees located near or within North Region communities, is the possibility for significant post-wildfire flooding that could significantly overwhelm existing capacities.

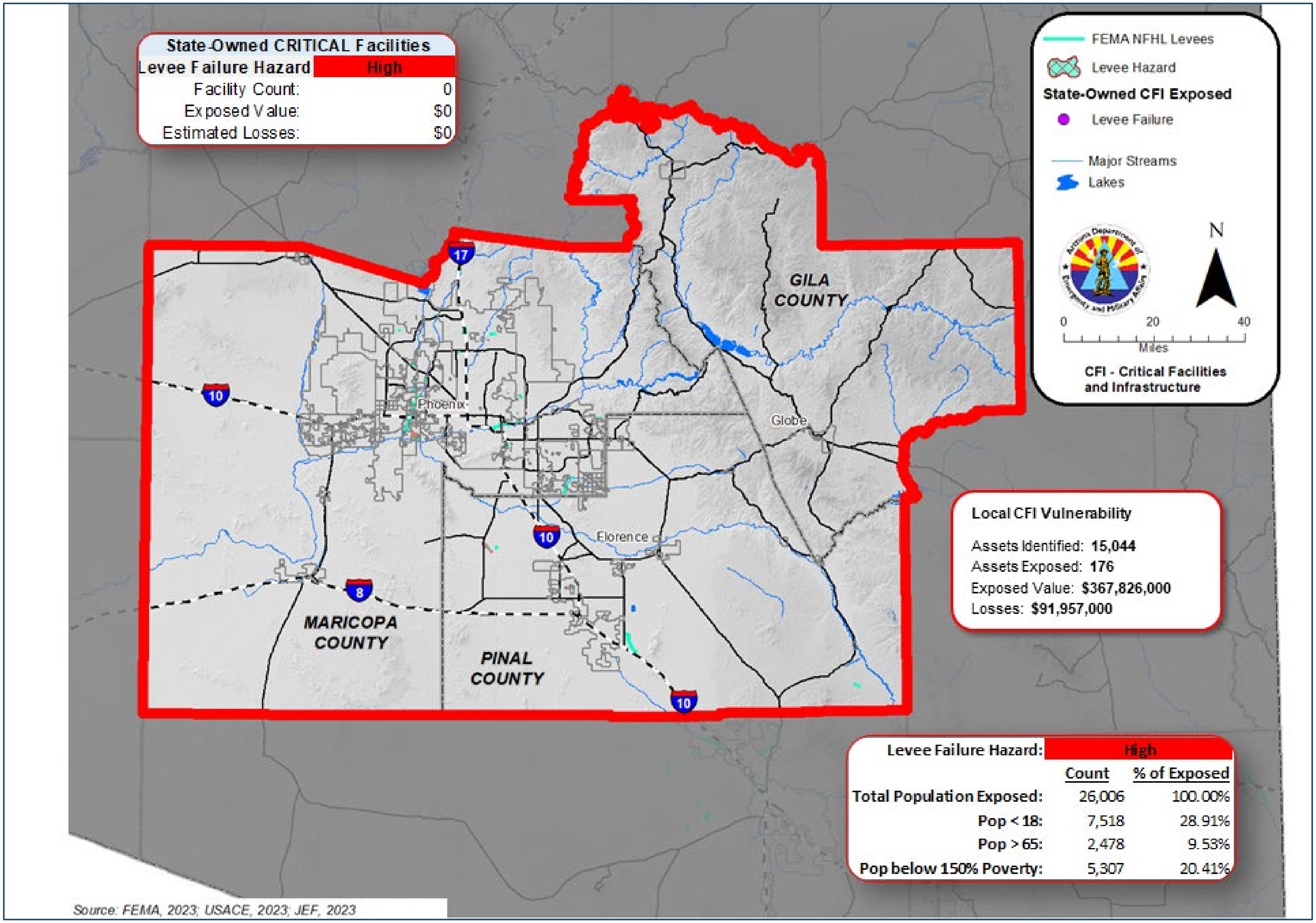
Central Region

Among the three state regions, the Central Region, depicted in Map 41, has the most significant vulnerability when considering the history of events, the exposure estimates, and number of local plans that included dam and/or levee failure in their risk assessment. Alternately, the Central Region arguably has the greatest amount of resources for active levee maintenance and repair, as well as modeling and mapping of hazard areas.

State-Owned CFI Exposure and Loss Estimates

No state-owned CFI are located within levee failure inundation zones.

State-owned and maintained roadways and infrastructure within the metropolitan Phoenix area are designed to meet local drainage requirements, and therefore are protected to 1% annual flood level. Although better than their rural counterparts, the numerous drainage facilities (bridges, culverts, and channels) constructed with the ADOT roadways are still not expected to have capacity for handling the types of flows associated with a levee failure. Typical impacts might include erosion of roadway embankments and pavements, culvert and bridge failures, and significant sedimentation.



Map 41. Levee failure vulnerability for the Central region

Vulnerable Population Groups

The 2022 estimated total population for the Central Region is 5,069,600 people. Approximately 0.51% of the total population, or 26,006 persons, are exposed to levee failure inundation hazards. Exposure estimates for at-risk population groups like persons under 18-years of age, over 65-years of age, and those living at or below 150% poverty level are included on Map 41.

SVUC Impact Assessment

Levee failure high hazard impacts to Central Region SVUC are summarized by CDC SVI themes and percentile rankings in Table 30. The highest percentages of regional exposure are highlighted using bold text. The strongest majority of exposure is generally centered around the 0.25-0.50 index and within a range between 0.01-0.90, which would suggest a moderately low SVUC vulnerability in Central Region communities.

Table 30. Levee failure high hazard SVUC exposure for Central Region

Region	CDC-SVI Assigned Percentile Rank	Percent of Impacted Area by SVI Percentile Rank Range				
		THEME 1 Socio-Economic Status	THEME 2 Household Characteristics	THEME 3 Racial and Ethnic Minority Status	THEME 4 Housing Type/ Transportation	THEMES (ALL) Overall Ranking
Central	NO DATA	0.00%	0.00%	0.00%	0.00%	0.00%
Central	0-0.25	22.65%	**32.34%**	18.34%	**39.60%**	28.11%
Central	0.25-0.50	26.25%	20.17%	6.56%	20.26%	16.87%
Central	0.50-0.75	**34.96%**	10.95%	32.91%	20.92%	**32.69%**
Central	0.75-0.90	14.47%	27.95%	**38.98%**	13.47%	17.74%
Central	0.90-1.00	1.67%	8.58%	3.21%	3.43%	4.60%

Local Jurisdiction Vulnerability

Local hazard mitigation plans for the Central Region identified a total of 176 assets with a total replacement value of $434.4 million. Total potential losses to local CFI for levee failure inundation were estimated at $108.6 million.

Specific Areas of Concern

There are numerous non-accredited and unstudied levee embankments located in the Central Region that were constructed by various entities and are still in place today. A detailed analysis of those structures is not currently available. The presence of those facilities can give residents a false sense of security, and a failure could result in significant damage to downstream properties. These non-accredited embankments are not reflected in the vulnerability analysis numbers presented herein but may become available for future updates via the USACE NLD discussed earlier.

South Region

The South Region, depicted in Map 42, is the least vulnerable state region when considering the history of events, the exposure estimates, and number of local plans that included dam and/or levee failure in their risk assessment.

State-Owned CFI Exposure and Loss Estimates

No state-owned CFI are located within South region levee failure inundation zones.

Additional state-owned facilities vulnerable to levee failure inundation hazards are the ADOT operated and maintained freeways, highways and state routes located within the inundation zones. The drainage facilities (bridges, culverts, and channels) constructed with the ADOT roadways are not expected to have capacity for handling the types of flows associated with a dam or levee failure. Typical impacts might include erosion of roadway embankments and pavements, culvert and bridge failures, and significant sedimentation.

Vulnerable Population Groups

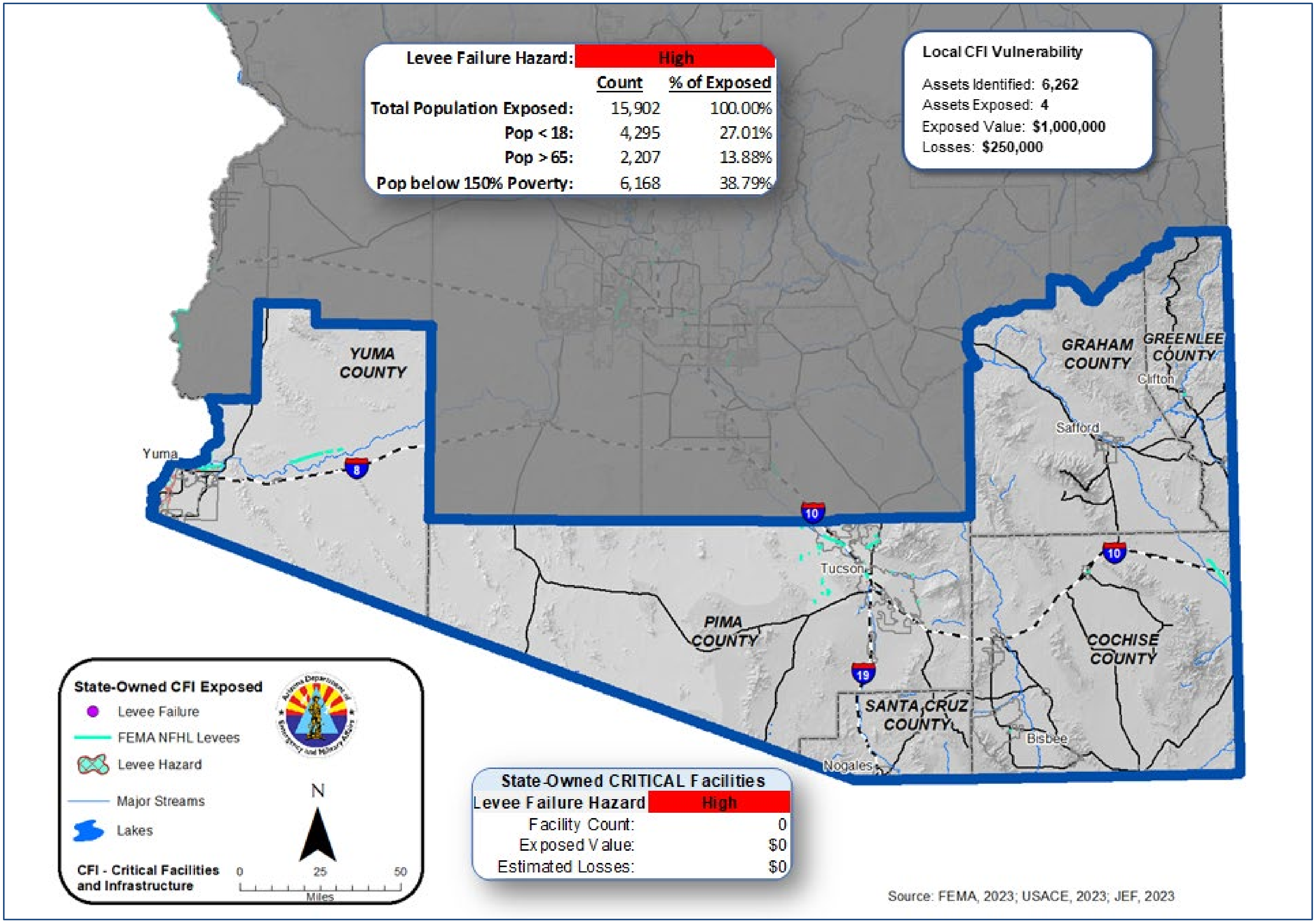
The 2022 estimated total population for the South Region is 1,487,942 people. Approximately 1.06% of the total population, or 15,902 persons, are exposed to levee failure inundation hazards. Exposure estimates for at-risk population groups like persons under 18-years of age, over 65-years of age, and those living at or below 150% poverty level are included on Map 42.

SVUC Impact Assessment

Levee failure high hazard impacts to South Region SVUC are summarized by CDC SVI themes and percentile rankings in Table 31. The highest percentages of regional exposure are highlighted using bold text. The strongest majority of exposure is to areas with index ranking centered around the 0.50 to 0.75 range with the Theme 2 majority in the 0.90 to 1.00 (flaggable) range. This would suggest a moderately high SVUC vulnerability in South Region communities.

Table 31. Levee failure high hazard SVUC exposure for South Region

Region	CDC-SVI Assigned Percentile Rank	Percent of Impacted Area by SVI Percentile Rank Range				
		THEME 1 Socio-Economic Status	THEME 2 Household Characteristics	THEME 3 Racial and Ethnic Minority Status	THEME 4 Housing Type/ Transportation	THEMES (ALL) Overall Ranking
South	NO DATA	0.00%	0.00%	0.00%	0.00%	0.00%
South	0-0.25	12.85%	0.19%	1.61%	1.99%	3.07%
South	0.25-0.50	1.28%	11.59%	10.61%	15.32%	9.97%
South	0.50-0.75	**32.13%**	18.01%	**44.56%**	**43.12%**	**37.32%**
South	0.75-0.90	27.53%	33.22%	9.02%	29.99%	12.65%
South	0.90-1.00	26.21%	**36.99%**	34.20%	9.59%	36.99%



Map 42. Levee failure vulnerability for the South region

Local Jurisdiction Vulnerability

The local hazard mitigation plan for Greenlee County in the South Region, identified a total of four CFI assets with a total replacement value of $1 million. Total potential losses to local CFI for levee failure inundation were estimated at $250,000.

Specific Areas of Concern

There are numerous non-accredited and unstudied levee embankments located in the South Region that were constructed by various entities and are still in place today. A detailed analysis of those structures is not currently available. The presence of those facilities can give residents a false sense of security, and a failure could result in significant damage to downstream properties. An example is the 1972 failure of the Duncan embankments on the Gila River. According to FEMA (2007), residents were provided with ample warning to evacuate themselves and even some of their belongings, but most did not leave their homes. These non-accredited embankments are not reflected in the vulnerability analysis numbers presented herein but may become available for future updates via the USACE NLD discussed earlier.

RESOURCES

Sources

FEMA Map Service Center, https://www.fema.gov/flood-maps

NCDC Storm Events Database, https://www.ncdc.noaa.gov/stormevents/

US Army Corps of Engineers, National Levee Safety, Civil Works Levee Safety Program (army.mil)

US Army Corps of Engineers, National Levee Database, https://levees.sec.usace.army.mil/#/

References

AZ Dept of Water Resources, 1981, Reconnaissance Report of the Gila River Flood Control Project.

FEMA 2001, How-To Guide #2: Understanding Your Risks – Identifying Hazards and Estimating Loss Potential. FEMA 386-2.

FEMA 2007, Flood Insurance Study: Greenlee County and Incorporated Communities. Flood Insurance Study Number: 04011CV000A.

Flood Control District of Maricopa County 1997, *Storm Report, Tropical Storm Nora - Sept 1997.*

Gonzalez, P., G.M. Garfin, D.D. Breshears, K.M. Brooks, H.E. Brown, E.H. Elias, A. Gunasekara, N. Huntly, J.K., Maldonado, N.J. Mantua, H.G. Margolis, S. McAfee, B.R. Middleton, and B.H. Udall, 2018: *Southwest. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 1101–1184. doi: 10.7930/NCA4.2018.CH25. On the Web: https://nca2018.globalchange.gov/chapter/southwest

Garfin, G., G. Franco, H. Blanco, A. Comrie, P. Gonzalez, T. Piechota, R. Smyth, and R. Waskom, 2014, *Ch. 20: Southwest. Climate Change Impacts in the United States: The Third National Climate Assessment*, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., US Global Change Research Program, 462-486. doi:10.7930/J08G8HMN

Loomis, T. R., 2003, *A Brief History of Flooding in the Rural Areas of Arizona, Part II 1964 through 1993*, AZ Floodplain Management Association Newsletter, Vol 20, No. 1, April 2003.

National Committee on Levee Safety 2011, The Definition of a “Levee” under a National Levee Safety Program.

Youberg, A., 2012, *Southwest Wildfire Hydrology and Hazard Workshop Proceedings*. AZ Geological Survey Open-file-report – 12-05, 50 p. 32. https://hdl.handle.net/10150/630664

US Army Corps of Engineers, Los Angeles District, 1994, *Flood Damage Report, State of Arizona, Floods of 1993*. US Dept of the Interior, Bureau of Reclamation, Phoenix Area Office.

US Army Corps of Engineers, Los Angeles District, 2016, Little Colorado River, Winslow, Arizona, Flood Risk Management Project: Draft Integrated Feasibility Report with Environmental Impact Statement. Appendix F, Geotechnical, http://cdm16021.contentdm.oclc.org/cdm/ref/collection/p16021coll7/id/2692

SEVERE WIND

DESCRIPTION

Dust Storm in Phoenix - 2018
Source: My Modern Met – Jason Ferguson

For this Plan, the hazard of severe wind encompasses all climatic events that produce damaging winds. For Arizona, severe winds typically result from either extreme pressure gradients that usually occur in the spring and early summer months, or from thunderstorms. Occasionally, tropical storm activity (remnant hurricanes) can be accompanied by severe winds, but the wind speeds usually dissipate by the time the tropical storm front approaches the state, with greater threat to the southern portions of the state. 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.

Since February 1966, the state has experienced 3 severe wind related incidents of sufficient magnitude to prompt a Gubernatorial disaster declaration. Total allocations from the Governor's Emergency Fund over that period exceeded $2.73 million. Severe winds have also accompanied other disaster declarations that were primarily for flooding and snow events, which are not included in the previous tallies.

Three types of damaging wind-related features may accompany a typical Arizona 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. There 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 airspeed. In a microburst, the wind speeds are highest near the location where the downdraft reaches 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. Aircraft caught in the downdraft can be forced to the ground.

Straight line winds are developed similar to downbursts, but are usually sustained for greater periods as a thunderstorm reaches the mature stage. Straight line winds travel (or are pushed), parallel to the ground surface on the leading edge of a thunderhead, reaching speeds of 75 mph or higher. These winds are frequently responsible for generating the large dust and sand storms seen moving across the desert regions of Central and Southern Arizona. The blowing dust can reduce visibility to near zero, creating hazardous driving conditions.

Strong wind events not associated with thunderstorms can occur throughout the year, but are frequently strongest in the late winter to late spring months and can generate high-speed winds that last for hours and often include exceptionally strong gusts. The NWS office notes this type of wind events as strong pressure gradients, mesoscale events, channeled winds; Foehn/Chinook/downslope winds, and winds associated with tropical storm remnants.

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 Arizona, tornadoes are the least common severe wind to accompany a thunderstorm.


October 2010 Bellmont Tornado Damage
Source: Rim Country Gazette

HISTORY

The following are examples of significant severe wind events that have occurred in the state:

- February 22, 2023 – An anomalously intense low pressure system for February caused very strong winds across southeast Arizona resulting in damage such as roof damage, downed trees, power poles and communication antennas. The Tucson International Airport recorded its strongest February wind gust (51 MPH) in at least the past 50 years. Elsewhere, especially across Cochise, Santa Cruz, Graham and Greenlee Counties, wind gusts in excess of 60 mph were common in valleys with gusts higher than 70 mph at higher elevations. A 92 mph gust was recorded at the Guthrie RAWS. The combination of the strong winds and snow (6 to 12 in the mountains) resulted in blizzard-like conditions at times above 7000 feet. Damage was estimated at $10,000 (NCEI, 2023).
- October 15, 2022 – Severe wind damage occurred from a thunderstorm microburst in the Tonopah area from the second of two storms that passed through the area. Some of the damages included: two mobile homes destroyed; damage to some of the structures at the Belmont Dairy Farm (specifically a milking barn), which had some damage to some of the cow enclosures as well; 3 destroyed AC unit condensers; creosote bushes being fully defoliated in a field; and several large downed trees. Downed power poles affecting 121 customers were reported by the utility company in an area between 379th Avenue and 355th Avenue and between Missouri Avenue and I-10. There was also loss of livestock (unknown how many or type). Winds were estimated at around 80 mph. Damage was estimated at $200,000 (NCEI, 2023).
- August 16, 2020 – Monsoon thunderstorms developed across portions of the south central Arizona deserts during the evening hours on August 16th. Some of the stronger storms generated very strong and gusty outflow winds that approached 80 mph in strength at times. At about 2050MST a traveler on Interstate 8 reported significant roof, tree and car damage from a collapsing thunderstorm near the Sentinel rest area. Earlier, at about 1745MST a member of the public located 7 miles northeast of Wittmann reported about 20 trees blown

down on a local golf course. The larger trees had diameters of about 12 inches, and the damage was consistent with wind gusts of at least 60 mph. There were no reports of injuries due to the strong and damaging winds. The thunderstorm winds knocked over 63 power poles along Palomas road between Ave 64E and Agua Caliente Rd, as reported by the Yuma County Sheriff and confirmed by APS electric. APS also reported 300 customers lost power during the height of the storm. Damages were estimated at $475,000 (NCEI, 2023).

- September 26, 2019 – A low pressure system southwest of Arizona brought significant moisture over northern Arizona which resulted in strong thunderstorms, heavy rain, and strong winds. In Yavapai County, Approximately 20 mobile homes were damaged by very strong thunderstorm winds. One home was so damaged that it was no longer habitable. Four homes suffered moderate damage. Power poles were snapped off with many with out power. Close to 100 trees were damaged as well. Damage was estimated at $500,000 (NCEI, 2023)
- July 11, 2018 – Scattered thunderstorms developed over portions of the greater Phoenix metropolitan area, including the community of Glendale, during the late afternoon and evening hours on July 11th. Atmospheric conditions on this day were favorable for both gusty and damaging thunderstorm outflow winds as well as locally heavy rainfall. Reports from the public and trained spotters indicated locally heavy rains with peak rain rates approaching 2 inches per hour. This resulted in street flooding as well as the issuance of multiple flood advisories for the Phoenix area. In addition, some of the stronger storms produced gusty and damaging down burst winds; trees were damaged in the community of Surprise and a Safeway grocery store in Glendale suffered wind and water damage. The damage was a contributing factor to a fire which almost completely destroyed the store. Damage was estimated at $2 million (NCEI, 2023).
- July 17, 2017 – Mid-level flow of 25-30 kts and divergence aloft combined with sufficient MLCAPE of greater than 1000 J/kg to result in an environment favorable for the development of organized severe thunderstorms. A cluster of thunderstorms developed across southeast Pinal County during the late afternoon hours and moved northwestward through the Phoenix Metro after dark while becoming severe in the process. One of the more significant damage areas was along SR-87 in Salt River Reservation Community, where a mobile home and trailer park were destroyed and large transmission lines were downed. Power was knocked out for some for more than 2 days. A large dust storm also impacted parts of Pinal County. Damage was estimated at $5 million (NCEI, 2023)

PROBABILITY/EXTENT

Based on history, the probability for a severe thunderstorm or high wind event to occur somewhere in the state, in any given year, is essentially one or 100%. In the last 10-years (2013-2023), there have been 498 days with reported severe thunderstorm events, or approximately 49.8 event-days per year on a statewide basis. For the same period, the number of event days associated with thunderstorms is 367, or 74% of the total. The remaining 131 event days are associated with non-thunderstorm events.

Again based on history, the probability for tornado events in Arizona is low, and especially when compared to national standards. In the last 10-years (2013-2023), there have only been three damaging tornados (category EF1 or higher – see below) recorded for the whole state. On average, that is less than one damaging tornado a year. In 2017, the National Centers for Environmental Information reported an average of five tornados per year for Arizona, as compared to 60-90+ tornados for central US states.

The strength and magnitude of severe wind events is primarily based on wind speed. Thresholds and categories are detailed below.

Thunderstorm or Other Non-Tornado High Winds

The NWS considers a thunderstorm as severe if it produces hail at least one-inch in diameter, wind gusts of 58 mph or higher, or any tornadoes. 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. According to NCEI data, at least 1,263 severe thunderstorm or other non-tornado high wind event locations that recorded or estimated three-second wind gusts of over 58 mph were identified in Arizona between 1955 and 2023. During that period, four deaths, 157 injuries, and $406.6 million in damages were reported.

The Beaufort Wind Scale, shown in Figure 14, provides a measure of overland wind magnitude versus expected damages. According to the Beaufort Scale, wind gusts of 55-63 mph can result in uprooted trees and considerable structural damage to poorly constructed buildings. Wind gusts between 64-73 mph can result in more widespread structural damage to moderately constructed buildings. Wind gusts over 74 mph are able to do widespread damage to moderately constructed buildings and even well-constructed buildings.

Tornadoes

Tornado severity is measured using the Enhanced Fujita Scale. Table 9 provides a summary of the Enhanced Fujita scale values with a general description of damage associations.

To date, Arizona has not experienced anything higher than an EF3 category tornado but has experienced many EF0, EF1, and to a lesser extent, EF2 tornadoes. According to the NCEI database, there were 282 tornadoes ranging from EF0 to EF3 on the Fujita scale(s) recorded across Arizona between 1952-2023. The total property damage was approximately $49.4 million with three fatalities and 152 injuries. Total crop damage was approximately $30,000.

WARNING TIME

Warning time with severe wind events associated with thunderstorms, including tornadoes, is usually measured in hours, with warnings being issued by the nearest NWS office. Spring-time winds are generally associated with regional atmospheric conditions that can be forecasted in hours or days.

FUTURE CONDITIONS

Climate Considerations

The study by Luong (Luong, et al., 2015), notes that monsoon thunderstorms in the Central and Southern Regions of the state have become more intense over a recent 20-year period (1991-2010) when compared to events recorded in the past (1950-1970). The study concludes that the trend will likely continue as the temperatures rise and provide more moisture storage capacity in the lower atmosphere. The increased thunderstorm intensities may correlate to increased wind intensities, and especially if the thunderstorm cells are stronger and larger. A 2017 study conducted by the University of Arizona found similar results. University researchers compared precipitation records from 1950 to 1970 to those from 1991 to 2010 for Arizona. This data was also used to validate the results of their climate model. While the record data only included rainfall, the high-resolution model developed by researchers modeled the winds induced by the summer monsoon and indicated that rainier monsoon storms were accompanied by higher winds and more downbursts.

Beaufort number	Wind Speed (mph)	Seaman's term		Effects on Land
0	Under 1	Calm		Calm; smoke rises vertically.
1	1-3	Light Air		Smoke drift indicates wind direction; vanes do not move.
2	4-7	Light Breeze		Wind felt on face; leaves rustle; vanes begin to move.
3	8-12	Gentle Breeze		Leaves, small twigs in constant motion; light flags extended.
4	13-18	Moderate Breeze		Dust, leaves and loose paper raised up; small branches move.
5	19-24	Fresh Breeze		Small trees begin to sway.
6	25-31	Strong Breeze		Large branches of trees in motion; whistling heard in wires.
7	32-38	Moderate Gale		Whole trees in motion; resistance felt in walking against the wind.
8	39-46	Fresh Gale		Twigs and small branches broken off trees.
9	47-54	Strong Gale		Slight structural damage occurs; slate blown from roofs.
10	55-63	Whole Gale		Seldom experienced on land; trees broken; structural damage occurs.
11	64-72	Storm		Very rarely experienced on land; usually with widespread damage.
12	73 or higher	Hurricane Force		Violence and destruction.

Figure 14. Beaufort Wind Scale

Table 32. Enhanced Fujita Scale for tornado classification

Enhanced Fujita Scale		Damage Description
ID	**Wind Speed (MPH)**	
EF0	65-85	**Minor or no damage**. Peels surface off some roofs; some damage to gutters or siding; branches broken off trees; shallow-rooted trees pushed over. Confirmed tornadoes with no reported damage are always rated F0 or EF0.
EF1	86-110	**Moderate damage.** Roofs severely stripped; mobile homes overturned or badly damaged; loss of exterior doors; windows and other glass broken.
EF2	111-135	**Considerable damage.** Roofs torn off well-constructed houses; foundations of frame homes shifted; mobile homes completely destroyed; large trees snapped or uprooted; light-object missiles generated; cars lifted off the ground.
EF3	136-165	**Severe damage.** Entire stories of well-constructed houses destroyed; severe damage to large buildings such as shopping malls; trains overturned; trees debarked; heavy cars lifted off the ground and thrown; structures with weak foundations are badly damaged.
EF4	166-200	**Extreme damage.** Well-constructed and whole framed houses completely leveled; cars and other large objects thrown and small missiles generated.
EF5	>200	**Total Destruction of Buildings.** Strong-framed, well-built houses leveled off foundations are swept away; steel-reinforced concrete structures are critically damaged; tall buildings collapse or have severe structural deformations; some cars, trucks, and train cars can be thrown approximately one mile.

Changes in Development

Development and population increases in all areas of the state will increase the exposure and risk associated with severe wind events. It is likely that most of the development and growth will be located near urbanized metropolitan areas. Use of modern building codes will significantly reduce the risk of damage and loss. Hazard specific changes in vulnerability to state CFI due to changes in development are essentially neutral for severe wind related hazards on a direct cause basis. Secondary increases in debris impacts may slightly increase vulnerability to state CFI.

North Region

The majority of current and anticipated growth in the North Region is expected to expand from existing cities and towns with concentrations around Flagstaff,, Prescott and Kingman areas. Increases in development will increase the population and structural vulnerability to severe wind events by increasing the overall exposure.

Central Region

The most significant development in the Central Region is expected to occur in the Phoenix Metropolitan Area (Maricopa and Pinal County) and the growing communities of Maricopa, Casa Grande, Coolidge (Pinal County), and Payson (Gila County). The Maricopa and Pinal County communities have the greatest exposure to regulary severe wind events. Increases in development will increase the population and structural vulnerability to severe wind events by increasing the overall exposure.

South Region

The most significant development in the South Region is expected to occur in the Tucson Metropolitan Area, with slow to moderate growth in the other communities. The majority of South Region communities are subject to regular severe wind events and increases in development will increase the population and structural vulnerability to severe wind events by increasing the overall exposure.

VULNERABILITY ASSESSMENT

As demonstrated by the hazard maps for each region, the entire state is assumed to be equally exposed to severe wind hazards where wind gusts may exceed 58 mph. The risk of damage or injury is greatest in the more populated urban areas due to the higher density of human and structural assets exposed. On average, individual incidents are fairly localized, and damages associated with individual events are relatively small. Extreme events, such as the July 2017 storm in the Phoenix Metropolitan area, can generate significant losses when they intersect with urbanized areas.

Damages to state-owned facilities are difficult to estimate without more detailed data on individual building type, construction material, and building size. According to the technical documentation for the wind loss component of the hurricane module of the HAZUS MH program, annualized building losses for wind gust speeds generally less than 90 mph, are reported as negligible (FEMA, 2009). In the entire record of events for Arizona, only two wind and three tornado records indicate 90 mph or more wind gusts. Accordingly, the expected annual losses to state-owned facilities are negligible. No severe wind-related losses are estimated for state-owned facilities.

There are also no local county risk assessments that provide any loss estimations to locally identified critical and non-critical facilities.

North Region

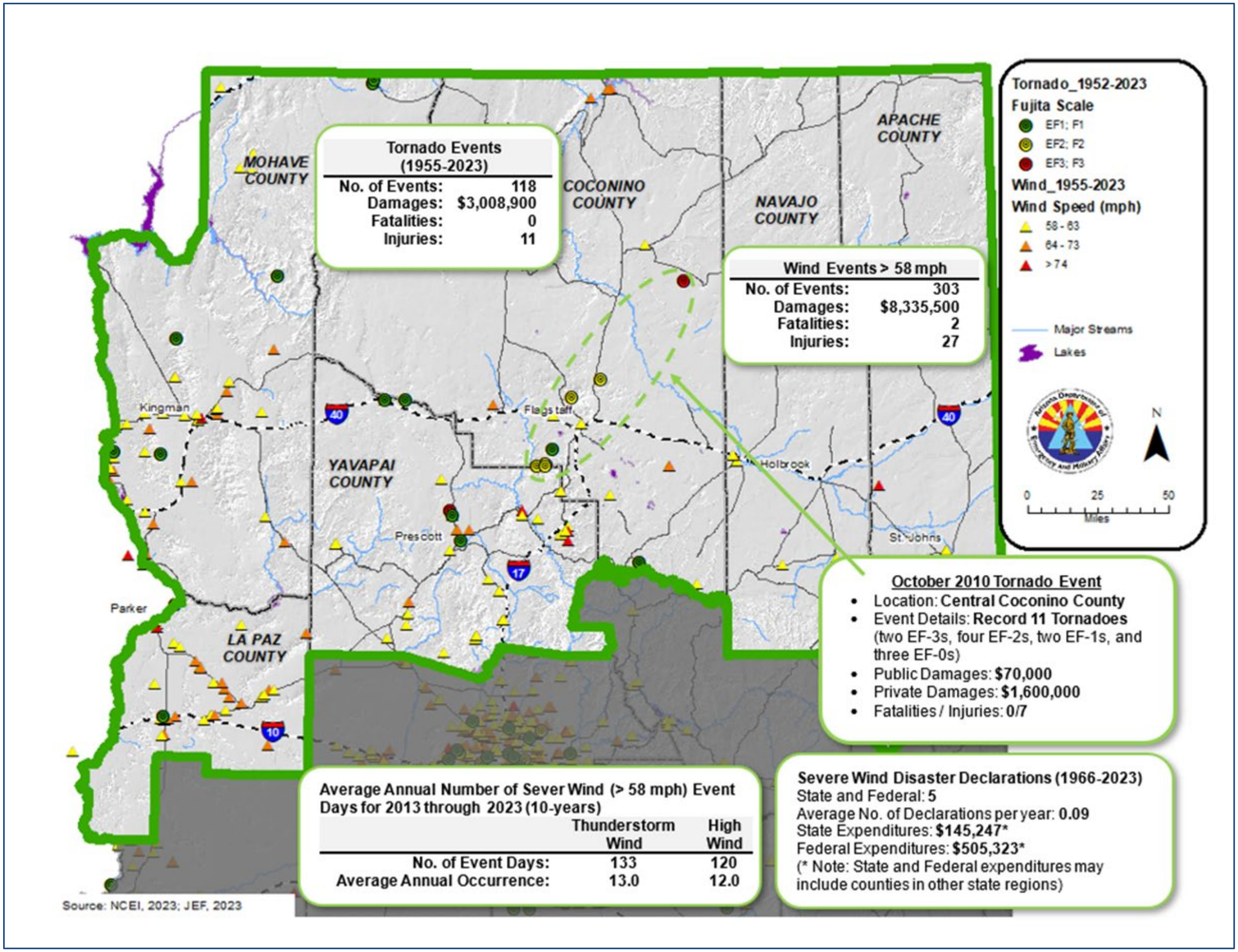
The North Region, depicted on Map 43, is the least vulnerable region of the state, primarily due to the limited density of structures and people when compared to the other regions. However, the North Region does have the most non-thunderstorm related severe wind events and tornadoes.

State-Owned CFI Exposure and Loss Estimates

All 1,010 state-owned facilities representing $1.2 billion in replacement value are exposed to extreme heat. No losses are estimated.

Vulnerable Population Groups

The entire 2022 estimated population of 801,655 people are considered to be equally exposed to severe wind events. This includes all of the sub-population groups of under 18-years of age, older than 65, and at poverty level.



Map 43. Severe wind vulnerability for the North region

SVUC Impact Assessment

Within the North Region, 30.59% of the population falls within the highest social vulnerability index (SVI) percentile rank (0.90-1.0) for racial and ethnic minority status (Theme 3), while the greatest percentage of the population lies within the 0.5 to 0.75 SVI percentile rank for socioeconomic status (34.42%), household characteristics (24.63%), and housing type/transportation (38.82%). The entire SVUC population is considered to be equally exposed to severe wind events.

Local Jurisdiction Vulnerability

None of the local jurisdictions in the North Region estimated losses for locally identified critical and non-critical facilities. All assumed that local facilities and populations were equally exposed.

Specific Areas of Concern

Severe wind events along I-40 have been documented to blow tractor-trailer and recreational vehicle rigs off of the road. Formulation of tornadoes is a fairly rare occurrence, and as such, it is estimated that much of the public are not aware of what to look for as warning signs of an impending tornado. Sustained high wind events associated with spring in the North Region can turn loose building materials, trash, and small tree limbs into airborne projectiles that can cause structure damage and pose a safety threat.

Central Region

The Central Region, depicted on Map 44, is considered to be the most vulnerable region in the state, largely due to the high risk associated with the density of structures and people in the Phoenix Metropolitan Area.

State-Owned CFI Exposure and Loss Estimates

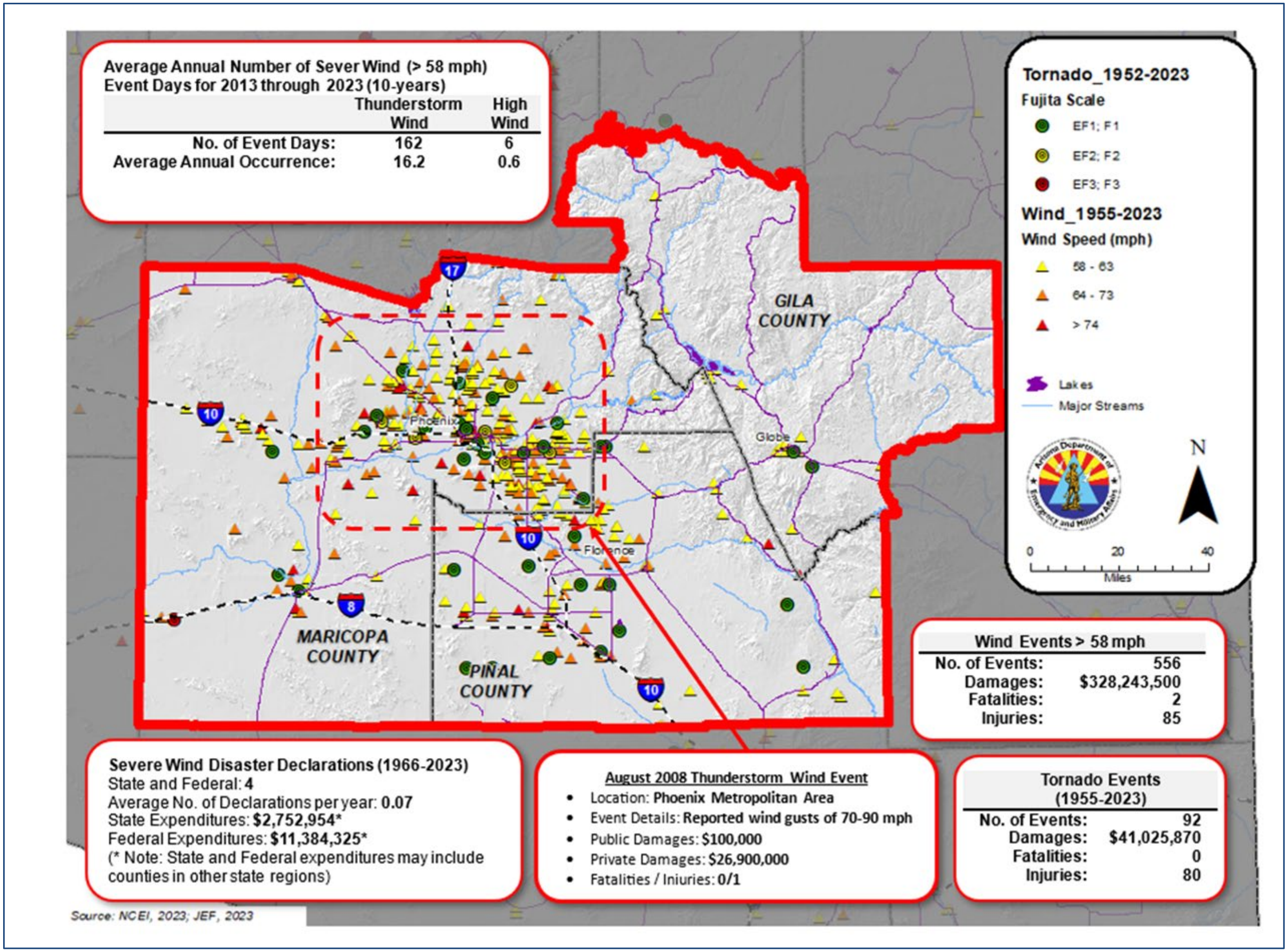
All 1,741 state-owned facilities representing $4.8 billion in replacement value are exposed to extreme heat. No losses are estimated.

Vulnerable Population Groups

The entire 2022 estimated population of 5,069,600 people are considered to be equally exposed to severe wind events. This includes all of the sub-population groups of under 18 years of age, older than 65, and at poverty level.

SVUC Impact Assessment

Within the Central Region, 33% of the population falls within the 0 to 0.25 percentile rank of the Social Vulnerability Index (SVI) for racial and ethnic minority status (Theme 3), while the greatest percentage of the population lies within the 0.5 to 0.75 SVI percentile rank for socioeconomic status (Theme 1 – 46.43%), household characteristics (Theme 2 – 35.53%), and housing type/transportation (Theme 4 – 36.57%). The entire SVUC population is considered to be equally exposed to severe wind events.



Map 44. Severe wind vulnerability for the Central region

Local Jurisdiction Vulnerability

None of the local jurisdictions in the Central Region estimated losses for locally identified critical and non-critical facilities. All assumed that local facilities and populations were equally exposed.

Specific Areas of Concern

Dust storms generated by strong winds create a unique hazard and vulnerability to vehicular traffic traveling the interstates and highways of the region, as well as health risks to people with respiratory illness or other intolerance to airborne particulates. Visibility during a dust storm can be reduced to tens of feet, which when combined with the normal highway speeds, creates a recipe for severe and often fatal, multi-vehicle accidents. The areas of most vulnerable transportation corridors lay along Interstates 8, 10, and 17, as well as the metro area freeways (Loops 101, 202, and 303, US 60, and SR 51). Another area of particular concern relates to downed power lines in urbanized areas that have the potential to kill or seriously injure anyone that might come in contact with the lines.

South Region

The South Region, depicted on Map 45, is considered to be the second most vulnerable region in the state, largely due to the high risk associated with the density of structures and people in the Tucson Metropolitan Area.

State-Owned CFI Exposure and Loss Estimates

All 1,017 state-owned facilities representing $1.6 billion in replacement value, are exposed to extreme heat. No losses are estimated.

Vulnerable Population Groups

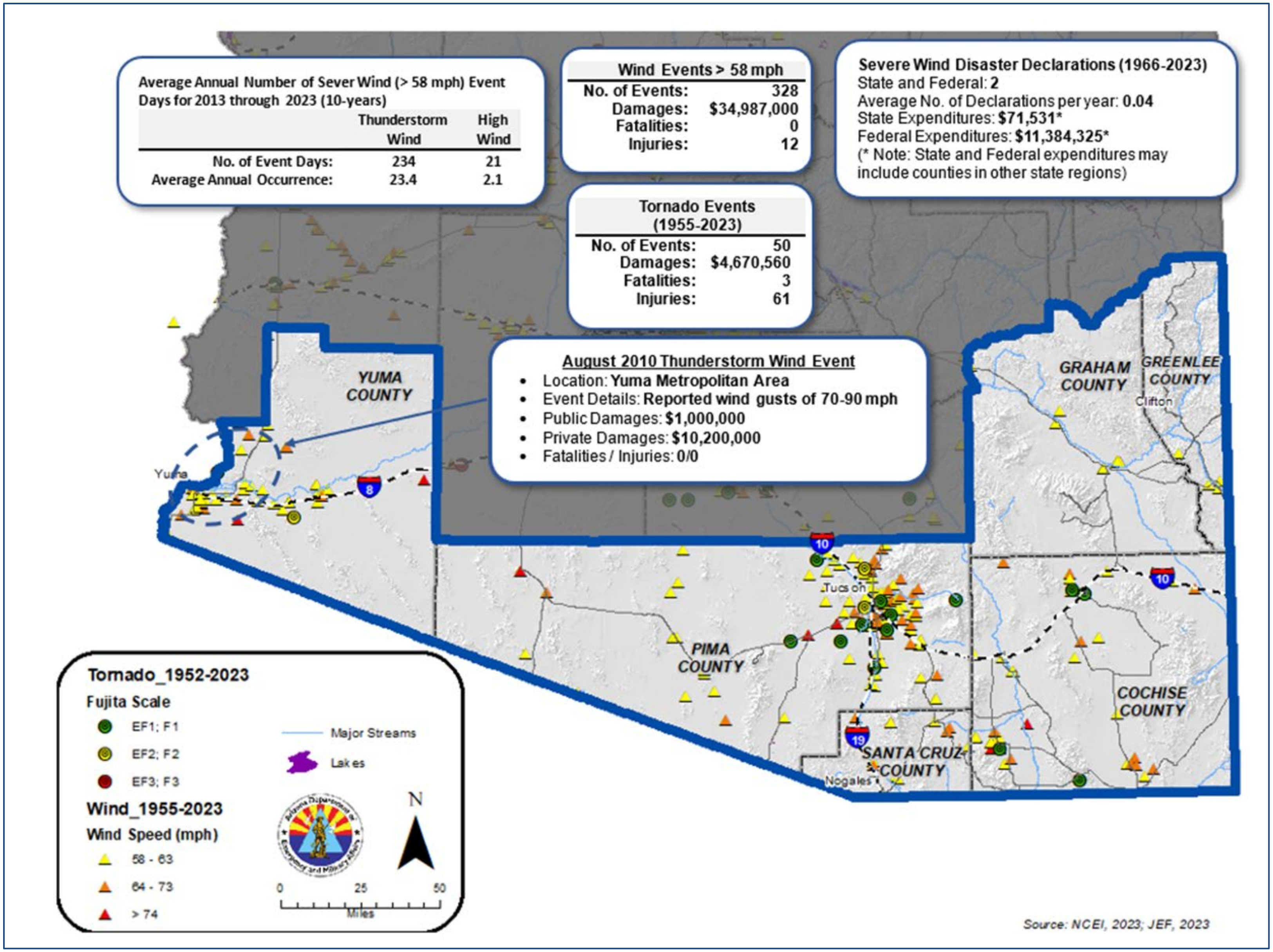
The entire 2022 estimated population of 1,487,942 people are considered to be equally exposed to severe wind events. This includes all of the sub-population groups of under 18-years of age, older than 65, and at poverty level.

SVUC Impact Assessment

Within the South Region, 29.48% of the population falls within the 0.75 to 0.90 percentile rank of the Social Vulnerability Index (SVI) for household characteristics (Theme 2) and 27.38% fall within the same rank for housing type/transportation (Theme 4) , while 36.65% of the population lies within the 0.25 to 0.50 SVI percentile rank for socioeconomic status (Theme 1) and 38.83 fall within the 0.50 to 0.75 percentile rank for racial and ethnic minority status (Theme 3). The entire SVUC population is considered to be equally exposed to severe wind events.

Local Jurisdiction Vulnerability

None of the local jurisdictions in the North Region estimated losses for locally identified critical and non-critical facilities. All assumed that local facilities and populations were equally exposed.



Map 45. Severe wind vulnerability for the South region

Specific Areas of Concern

Similar to the Central Region, dust storms present a unique hazard and vulnerability to vehicular traffic traveling the interstates and highways of the region, as well as health risks to people with respiratory illness or other intolerance to airborne particulates. The areas of most vulnerability lie along Interstates 8, 10 and 19. The eastern stretch of I-10 in Cochise County near the New Mexico border has repeatedly been impacted, resulting in several fatalities and numerous injuries. Exposure to downed power lines in the urbanized areas is prevalent in this region as well.RESOURCES

Fatal Dust Storm Accident on I-10 in Eastern Cochise County
Source: USA Today

Sources

National Centers for Environmental Information, Storm Event Database, [Storm Events Database | National Centers for Environmental Information (noaa.gov)]

NOAA Storm Prediction Center Events Archive, http://www.spc.noaa.gov/wcm/index.html#data

Spatial Hazard Events and Losses Database for the United States, SHELDUS™ | Spatial Hazard Events and Losses Database for the United States (asu.edu)

References

American Society of Civil Engineers, 1999, ASCE 7-98: *Minimum Design Loads for Buildings and Other Structures*.

Coconino County, 2015, Coconino County Multi-Jurisdictional Hazard Mitigation Plan.

FEMA, July 2000, *Design and Construction Guidance for Community Shelters* (FEMA 361)

FEMA, August 2009, Multi-Hazard Loss Estimation Methodology, Hurricane Model, HAZUS MH-MR4, User Manual.

SUBSIDENCE

DESCRIPTION

Subsidence occurs when the established land surface elevation lowers due to changes in the subsurface. Causes of subsidence include, but are not limited to, removal or reduction of fluids (water, oil, gas, etc.), mine subsidence, and hydro compaction. Of these causes, hydro compaction and mine subsidence tend to be localized events, while fluid removal may occur either locally or regionally. Land subsidence in the basins of Arizona is generally due to compaction of the alluvium caused by lowering of the groundwater table. As the water table declines, pores in the alluvium once held open by water pressure are no longer supported and collapse. Collapse and subsequent lowering in elevation of the land surface is defined as land subsidence. This subsidence is generally not recoverable. If this subsidence occurs over areas of bedrock, differential subsidence can occur. Once an area has subsided, the ground elevation will often not rise again due to consolidation of the soils within the aquifer, even if the removed fluid is replaced.

Subsidence at well casings
Source: AZGS

Subsidence can result in altered regional drainage patterns, indirectly affecting surface flooding, storm drain flow, and damaging infrastructure both in the subsurface (water and electric lines, well casings, etc.) and surface (roads, canals, drainages, surveyed benchmarks, etc.). It aggravates riverine flooding, alters topographic gradients, and ruptures the land surface in addition to causing other hazards related to deterioration of land and water resources. Earth fissures are caused by differential land subsidence and are often found along the margins of subsiding areas.

HISTORY

There are no state or federal disaster declarations for subsidence occurrences for Arizona. Land subsidence, however, has been occurring in Arizona since the early 1920s, with the greatest activity occurring post-1945. The following are descriptions of losses or damages with direct connection to local subsidence.

- Central Arizona Project (CAP) Canal Pools 23 and 24 - Freeboard loss was first detected in north Scottsdale near the Via Linda Road Bridge in June 1999. Approximately 1.4 feet of subsidence occurred in this area raising the water level to within a few inches of the top of the canal lining. In response, CAP raised the canal lining three feet over a one-mile segment of affected area at a cost of $350,000. A second and much larger subsidence area was later identified near the Scottsdale Airpark. This elongated subsidence area extends northwest into Phoenix and up to 1.2 feet of subsidence has occurred near the Scottsdale Road Bridge. The canal lining was raised in this area at an estimated cost of $820,000. Recently, a third subsidence area has been identified east of the Scottsdale Airpark (CAP, 2007).

CAP Canal lining raise in Pool 24
Source: Central Arizona Project

- Luke Air Force Base – Land subsidence of up to 20 feet has been measured in the area around Luke Air Force Base over the last 60-years. The gradient, or slope, and corresponding capacity of the Dysart Drain, which is a major flood-control channel along the north side of the base, was significantly reduced by differential land subsidence. On September 20, 1992, a high-intensity storm produced about four inches of rain immediately north of the base which resulted in extensive flooding on the base. Floodwater overtopped the Dysart Drain and spilled onto the runways, into the aircraft parking areas, and into the base-housing area. The flooding closed the base for three days, inundated more than 100 homes, and generally disrupted base operations. Preliminary estimates of flood damage exceeded $3 million (Cook, 2013). Redesign and reconstruction of the Dysart Drain system to correct for the land subsidence was estimated to exceed $16 million (Schumann and O'Day, 1995).
- Paradise Valley – Subsidence of up to five feet has occurred in the area generally bounded by Bell Road on the north, Scottsdale Road on the east, Shea Boulevard on the south and 36th Street on the west, during the period of 1960-1980. At 56th Street and Mountain View, excessive sewage gases were produced in a city sewer main due to slope change and a significant reduction in the system's capacity to self-clean. Expensive chemical feeder countermeasures were needed to mitigate the gas production and other sewer mains in the area are also vulnerable. The subsidence also caused the collapse of a municipal well casing and the need to re-establish local vertical survey benchmarks (Harmon, 1982).

PROBABILITY/EXTENT

The probability of subsidence occurring in the state is high at 100%, with occurrences generally being located in southern half of the state situated in the Basin and Range Province. Since 1900, the south-central Arizona's groundwater pumping for irrigation, mining, and municipal use has outpaced the recharge by 500 times in some areas (Schumann and Cripe, 1986). Over 3,000 square miles of the state is affected by subsidence, including the surrounding and expanding areas of the Phoenix and Tucson Metropolitan areas, and the rapidly growing areas of northern Pinal County. Before many communities became established, agriculture was the driving force for groundwater pumping. In Arizona, groundwater accounts for 40% of all water use (ALSG, 2007).

Land subsidence in Arizona correlates closely with groundwater level declines associated with overdraft of the state's aquifers. According to the USGS (Galloway, et.al., 1999), groundwater pumping prior to 1980 was responsible for water levels declines of up to 400 feet. Figure 15, developed by ADWR, generally illustrates the historic to-date maximum subsidence amounts for the active subsidence areas currently identified in the state.

The magnitude of a land subsidence event is low due to the fact that subsidence is unlikely to cause sudden wide spread damage to life and infrastructure. Subsidence has been detected over the years using surveying techniques such as differential leveling and high accuracy Global Navigation Satellite System (GNSS) surveying. In the early 1990's, scientists began to use satellite-based radar technology called Interferometric Synthetic Aperture Radar (InSAR) to detect land surface elevation changes. InSAR has been developed into a highly reliable land subsidence monitoring technique that can potentially measure centimeter-scale changes in deformation over timespans of days to years. InSAR has been successfully utilized by the ADWR since 2002, and is especially effective for areas that do not undergo mechanical surface alterations on a regular basis. For the purpose of this Plan, the active subsidence areas are considered by the Planning Team to be high hazard areas. Map 46, Map 47, and Map 48 depict subsidence hazard profiles for the North, Central and South regions, respectively.

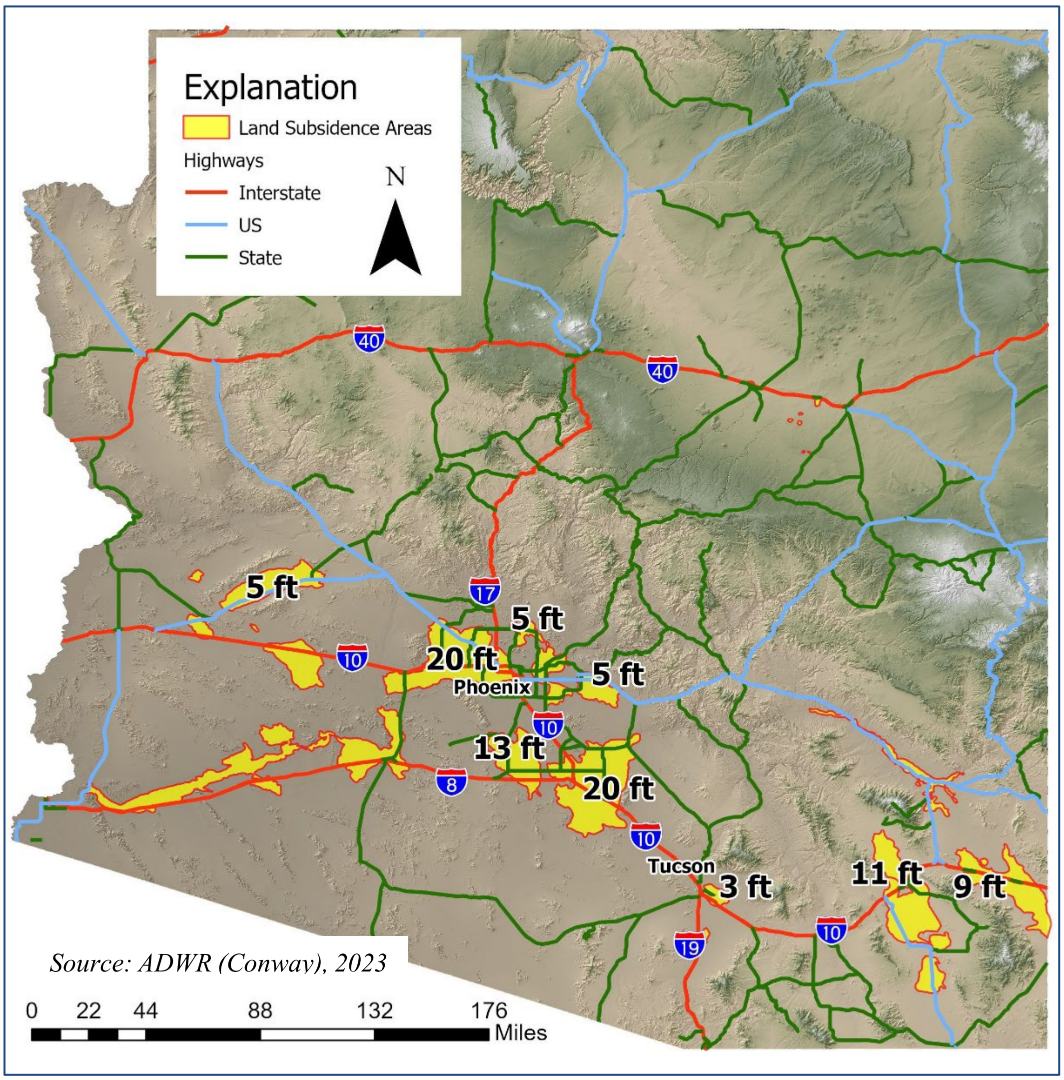
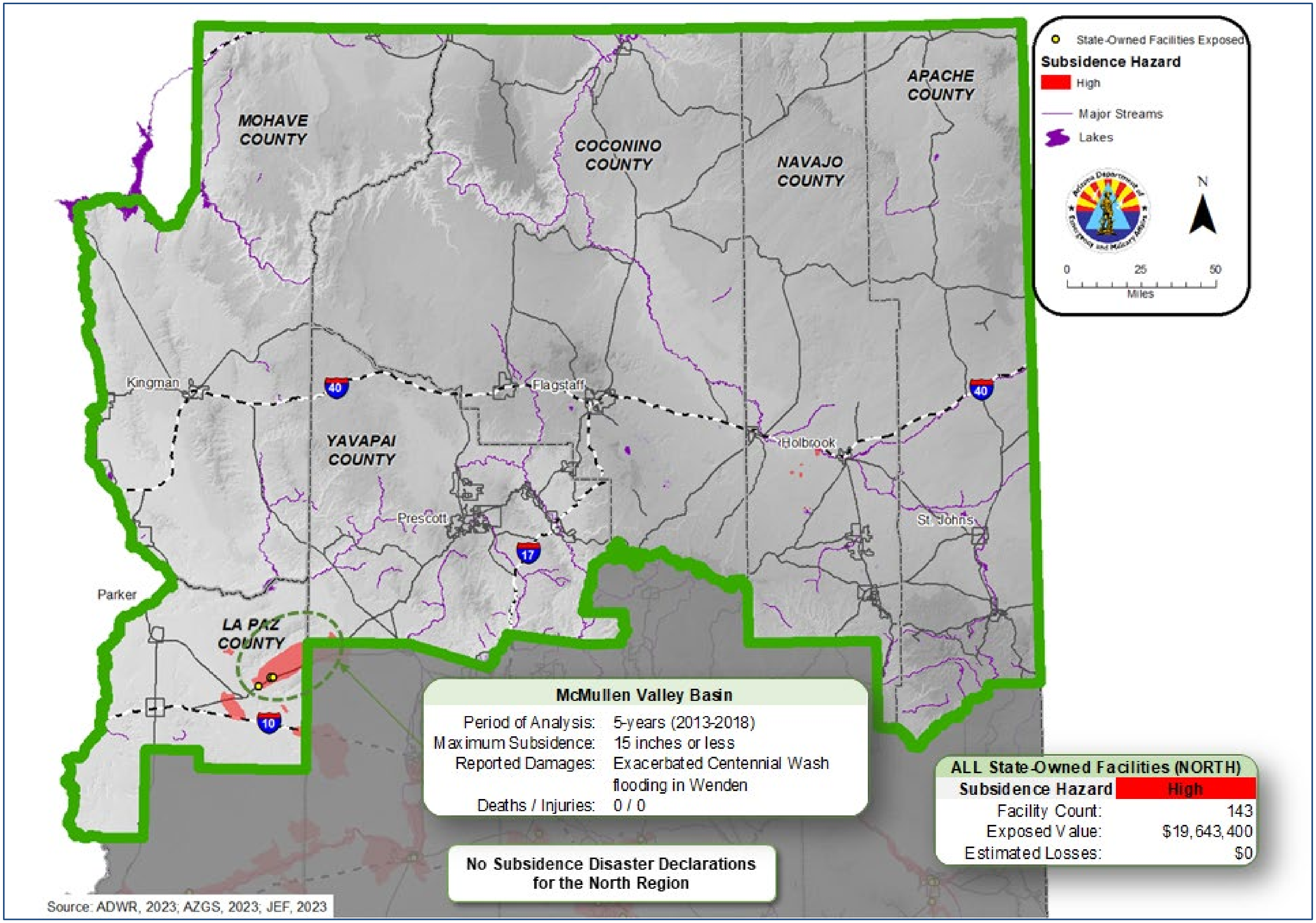
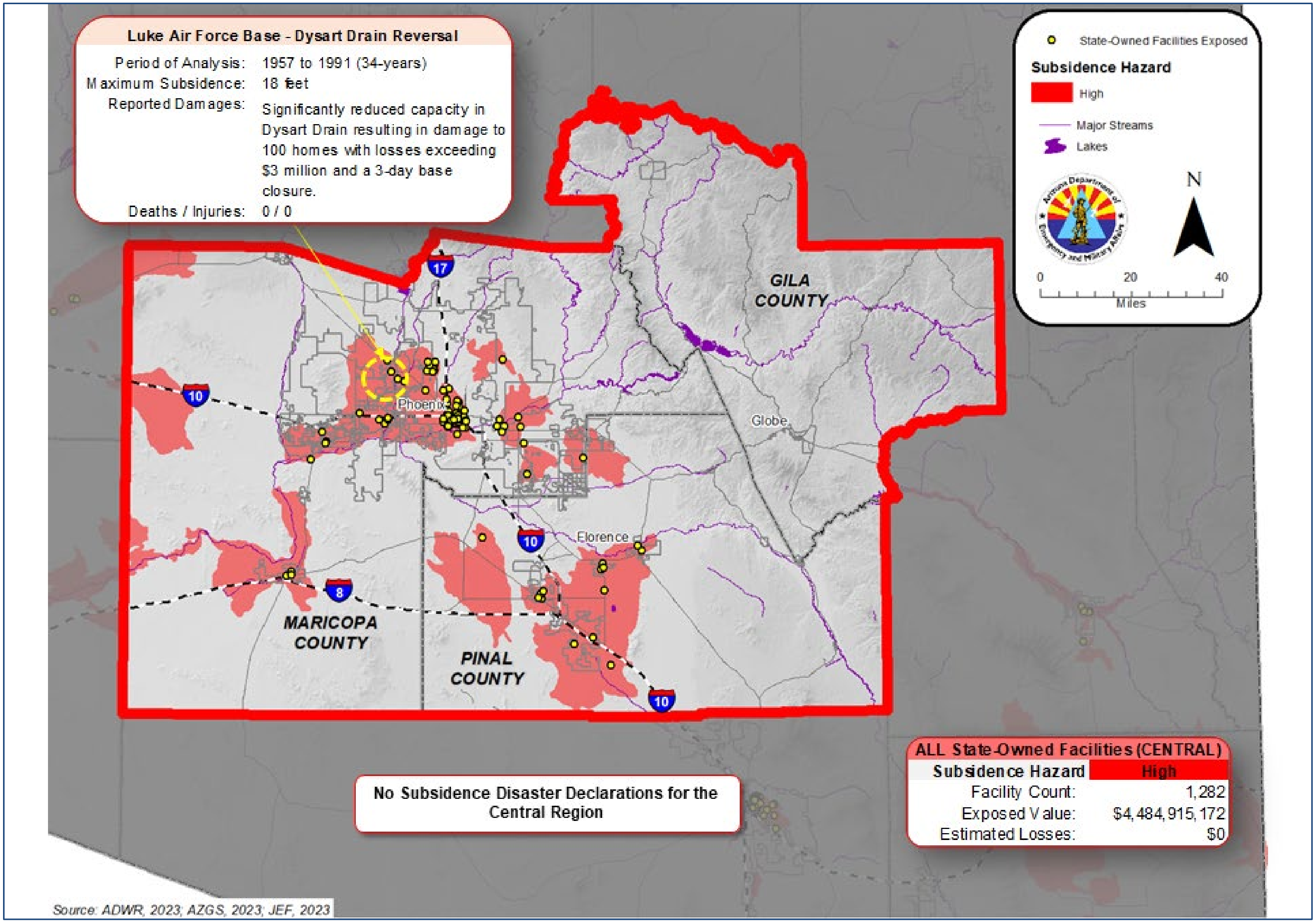


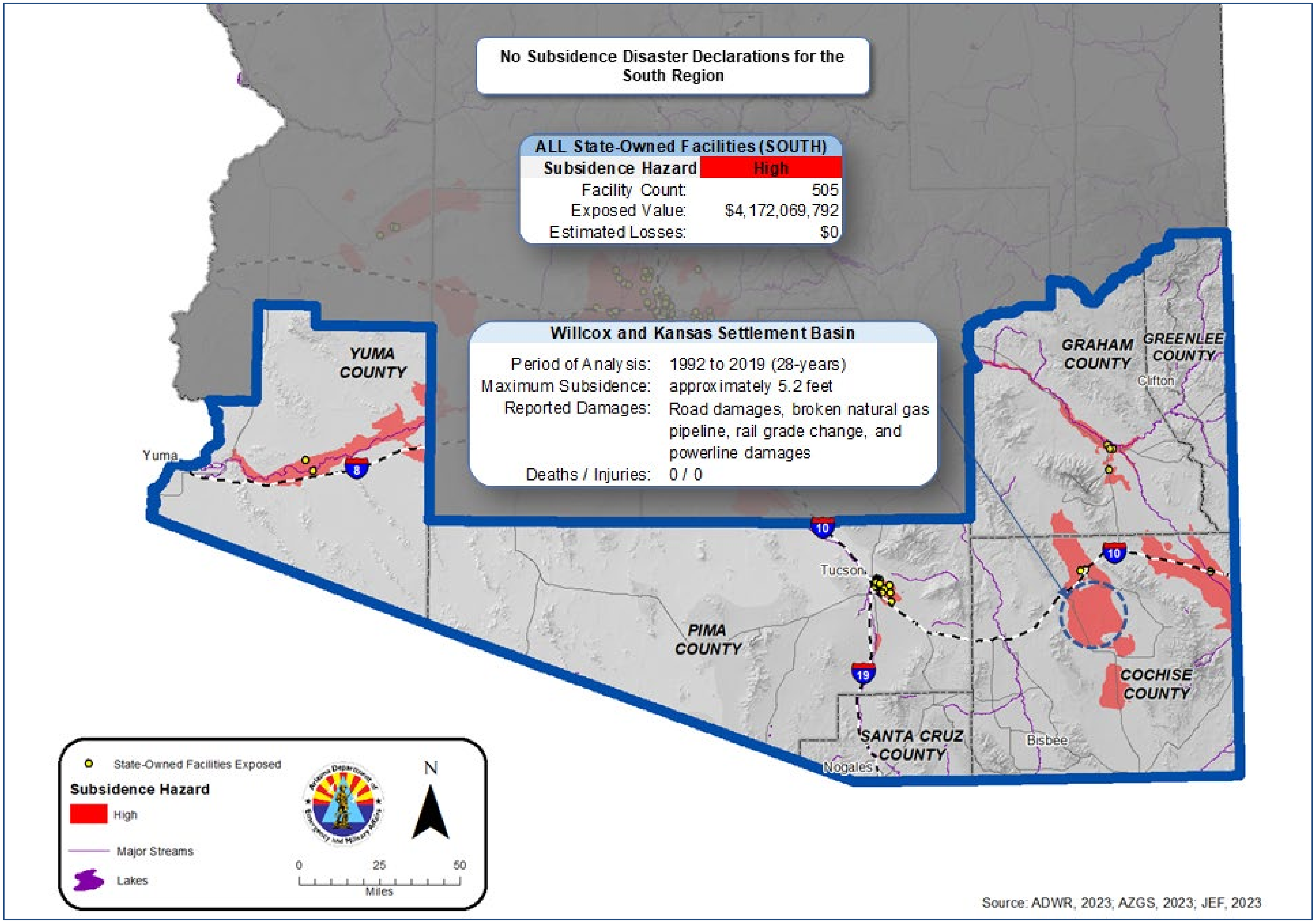
Figure 15. Active land subsidence areas with maximum depths of lowering as of 2023



Map 46. Subsidence hazard for the North region



Map 47. Subsidence hazard for the Central region



Map 48. Subsidence hazard for the South region

WARNING TIME

The process of land subsidence is gradual, and the lowering of the land surface occurs almost imperceptibly and over the course of many years. Accordingly, warning time is not relevant to subsidence and especially not in the way of emergency response or prediction. Changes or initiation of subsidence can be effectively monitored and evaluated using current survey and InSAR tools.

FUTURE CONDITIONS

Climate Considerations

Arizona subsidence is primarily the result of groundwater depletion, and climate change factors increase the use of groundwater and effect changes to the recharge of aquifers. The projected long-term worsening or intensifying of drought periods through warming trends and precipitation influences may also have the effect of increasing the rate of subsidence if groundwater sources continue to be depleted. The Arizona Land Subsidence Group (2007) states: "*The problems encountered with subsidence and earth fissures in Arizona will increase as groundwater continues to be withdrawn at unsustainable levels. More damage to structures and infrastructure can be expected with ever increasing economic losses, and, more importantly, a burgeoning threat to human health and safety, too.*" The effects of reduced recharge would be especially impacting to areas outside of the area serviced by the Central Arizona Project or Salt River Project, since there are no alternative sources for implementing groundwater recharge when local resources are in decline.

Changes in Development

Development and the population continue to grow in areas that are subjected to the risks of subsidence and fissure formation as old agricultural lands are converted to residential housing units. Increased water demand from new developments, combined with limited surface-water supplies, induce increased groundwater pumping that exacerbates subsidence and fissure formation conditions. Subsidence hazard specific changes in vulnerability to state CFI due to changes in development may increase due to lowering of ground surfaces caused by increased groundwater pumping at or near state CFI locations. Impacts could include roadway damages, drainage reversals, etc.

North Region

Except for a small portion of La Paz County, most of the North Region has very low to no risk from subsidence. Accordingly, development changes in the non-La Paz County areas of the North Region are not expected to be impacted by subsidence risk

The active Ranegras Plain and McMullen Valley subsidence areas in La Paz County are not anticipated to experience significant population growth over the next five years. Local agriculture relies solely on groundwater for meeting the irrigation needs of the local farms, so proposed changes to crop types or irrigation methods that increase the water demand may increase the groundwater declines and exacerbate the current subsidence rates.

Central Region

Areas within the Central Region have experienced significant subsidence and the region has the largest active subsidence footprint in currently published data for the state. Development of the Phoenix Metropolitan communities (both the west and east valley), and the San Tan Valley, are expected to continue, and will likely be impacted by ongoing subsidence rates. Impacts to drainage and gravity flow systems may require special design considerations in the areas of significant lowering. Conversion of agricultural lands to residential, commercial, and industrial developments may initially reduce the burden on groundwater sources as irrigated agriculture typically uses more water, allowing for wastewater streams to be treated and recharged. Expansion of development in the higher risk Casa Grande, Eloy, and Picacho areas is expected to be limited over the next five years.

South Region

The primary areas of active subsidence are located near the Tucson Metropolitan area and the Willcox, San Simon, Bowie, and Elfrida areas of Cochise County. Moderate growth of the Tucson Metropolitan area is anticipated and may be impacted by slight subsidence. Recent InSAR data indicate that the Tucson area subsidence rates are very low; however, these trends could reverse if extra burden is placed on the existing groundwater supplies to meet growth demands. Limited growth of the Cochise County areas is anticipated, and some of that growth may extend into the active subsidence areas.

VULNERABILITY ASSESSMENT

Most of the significant damages associated with subsidence are typically related to the secondary, causal effects of subsidence as it relates to altering surficial profiles and slopes, and fissure development. Directly attributable impacts and damages may include:

- Uneven or differential subsidence across large agricultural fields requiring expensive re-leveling efforts and irrigation system reconfiguration.
- Well damage and protruding well casings in both agricultural and urban areas.
- Replacement or remediation of large, regional, gravity-based drainage, irrigation and wastewater systems due to flow reversal or changes of slope.
- Loss of municipal benchmark network accuracy and the need to re-survey and re-establish vertical bench mark elevations

The estimation of potential exposure to the identified high subsidence hazard zones was accomplished using GIS tools to intersect the human and state-owned regular and critical facilities and infrastructure (CFI) data with the subsidence hazard limits depicted on profile maps. Except for fissure generation, subsidence activity generally does not create direct losses to structures and buildings; therefore, no quantitative losses to state-owned facilities are made, and only exposure quantities will be reported for state-owned assets. Exposure estimates of the various population sectors to high subsidence hazard zones are also made.

There are only two counties (Maricopa and Pinal) that included subsidence as a significant hazard in their local county risk assessments.

North Region

Apart from the portion of the McMullen Valley in eastern La Paz County, North Region vulnerabilities to subsidence are very low. The North Region, show in Map 49, is the least vulnerable region of the state, primarily due to the lack of identified subsidence zones, and very few assets and population at risk.

State-Owned CFI Exposure and Loss Estimates

A total of 19 state-owned CFI, or 1.7% of the statewide exposure, are located within a high hazard area. The exposed facilities represent a total replacement value of $2.64 million. No losses are estimated.

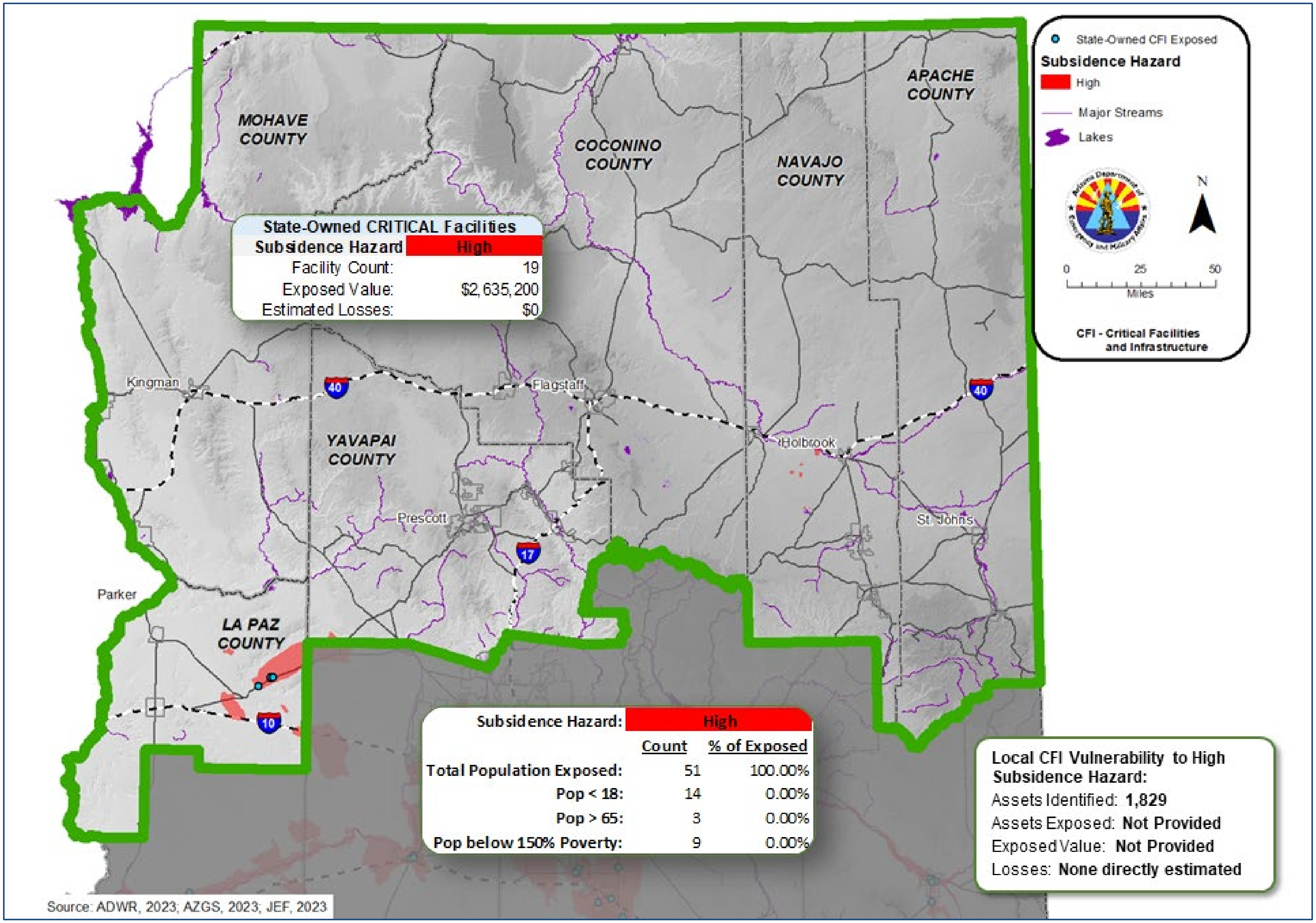
Additional state-owned facilities vulnerable to subsidence are the ADOT operated and maintained roads that pass through the known subsidence hazard areas, and particularly their drainage facilites. For example, US Hwy 60 parallels and then crosses Centennial Wash near Wenden. Subsidence in the McMullen Valley area is believed to exacerbate flooding in Centennial Wash due to lowering of the wash and flattening of the watercourse slopes. The bridge crossing at Hwy 60 may be downgraded in hydraulic safety considerations due to continued lowering and may require replacement to maintain design standards. Costs would likely be in the millions of dollars.

Vulnerable Population Groups

The 2022 estimated total population for the North Region is 801,655 people. Less than 0.01% of the total population, or 51 persons, are located within the high subsidence hazard areas. Exposure estimates for at-risk population groups like persons under 18-years of age, over 65-years of age, and those living at or below 150% poverty level are included on Map 49

SVUC Impact Assessment

Subsidence high hazard impacts to North Region SVUC are summarized by CDC SVI themes and percentile rankings in Table 33. The highest percentages of regional exposure are highlighted using bold text. The strongest majority of exposure is to areas with index ranking centered around the 0.50 to 0.75 range with the Theme 2 majority in the 0.90 to 1.00 (flaggable) range. This would suggest a moderately high SVUC vulnerability in South Region communities.



Map 49. Subsidence vulnerability for the North region

Local Jurisdiction Vulnerability

None of the local jurisdictions in the North Region included subsidence in their risk assessments. Accordingly, there are no estimated quantitative subsidence related losses for locally identified critical and non-critical facilities.

Table 33. Subsidence high hazard SVUC exposure for North Region

Region	CDC-SVI Assigned Percentile Rank	Percent of Impacted Area by SVI Percentile Rank Range				
		THEME 1 Socio-Economic Status	THEME 2 Household Characteristics	THEME 3 Racial and Ethnic Minority Status	THEME 4 Housing Type/ Transportation	THEMES (ALL) Overall Ranking
North	NO DATA	0.00%	0.00%	0.00%	0.00%	0.00%
North	0-0.25	13.85%	13.85%	31.34%	0.00%	13.85%
North	0.25-0.50	11.96%	0.00%	0.00%	19.38%	11.96%
North	0.50-0.75	**74.19%**	5.52%	**68.66%**	**76.73%**	5.52%
North	0.75-0.90	0.00%	15.86%	0.00%	3.90%	**68.66%**
North	0.90-1.00	0.00%	**64.77%**	0.00%	0.00%	0.00%

Specific Areas of Concern

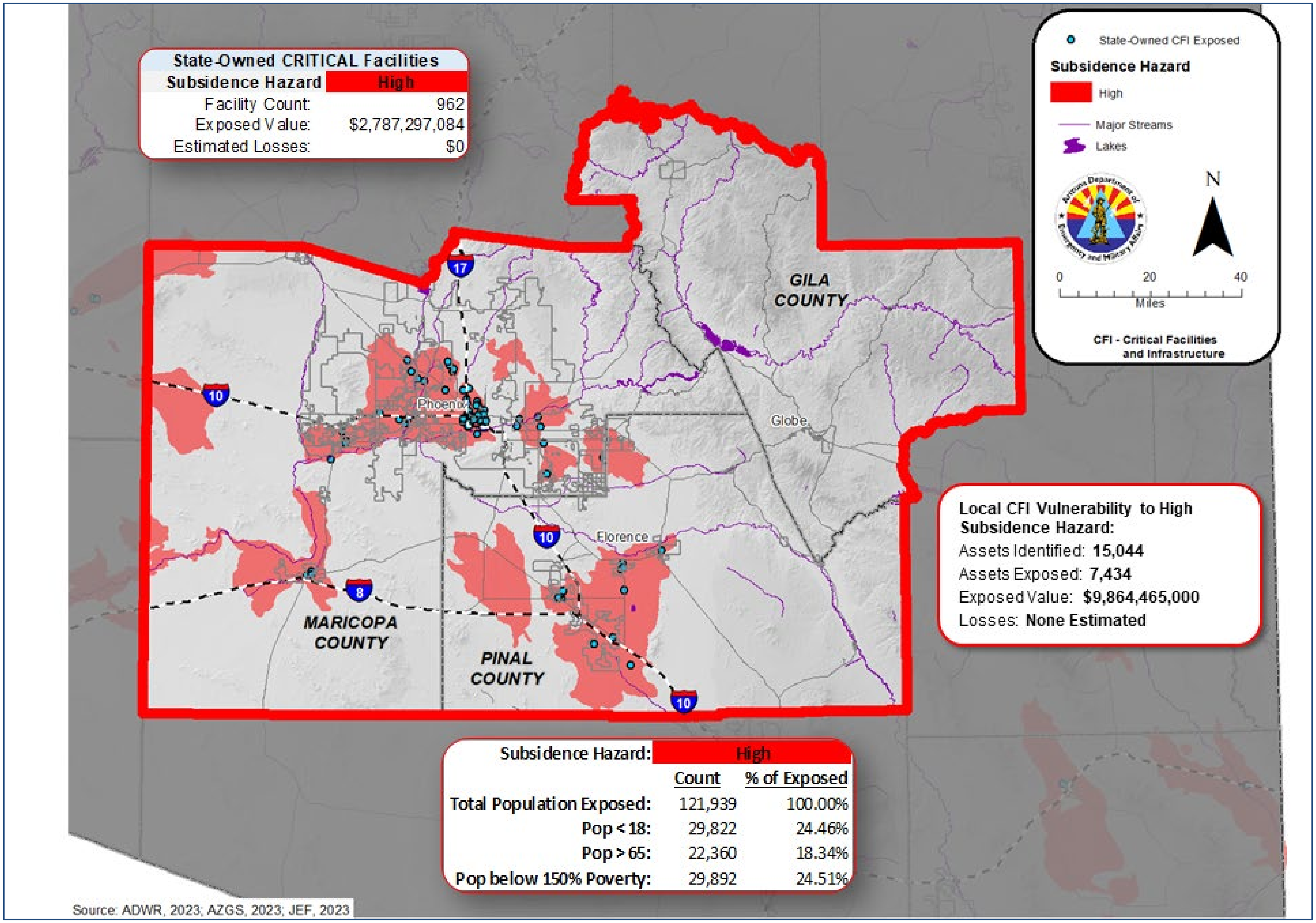
Subsidence in the McMullen Valley Area is directly correlated with the pumping of irrigation water for agricultural purposes. According to ADWR (2009), the total groundwater drawn from the McMullen Valley aquifer is approximately 77 times the annual recharge capacity, which is unsustainable. In 2019, AZGS mapped new earth fissures (Conway, 2019) developing due to groundwater withdrawals and subsidence. Continued use of the valley's groundwater at a rate that exceeds the recharge capacity, will result in continued subsidence.

Central Region

Central Region vulnerabilities to subsidence are moderately high. The Central Region, shown in Map 50, is considered the most vulnerable region in the state, due to the largest number and size of identified active subsidence areas, significant population and infrastructure within the hazard areas, and exposure of population and state-owned facilities. From a benefit perspective, the availability of water via the CAP and SRP systems decrease the Central Region's reliance upon groundwater and hence, the rates of subsidence in several areas.

State-Owned CFI Exposure and Loss Estimates

A total of 962 state-owned CFI, or 87.2% of the statewide exposure, are located within a high hazard area. The exposed facilities represent total replacement values of $2.79 billion. No losses are estimated.



Map 50. Subsidence vulnerability for the Central region

Additional state-owned facilities vulnerable to subsidence are the ADOT operated and maintained freeways, highways, and state routes that pass through the known subsidence hazard areas, and especially the associated drainage facilities. Alterations of ground elevations and slopes may have adverse consequences on drainage systems and cause unexpected flooding or ponding.

Vulnerable Population Groups

The 2022 estimated population for the Central Region is 4,604,414 people. Approximately 2.65% of the total population, or 121,939 persons, are located within the high subsidence hazard areas. Exposure estimates for at-risk population groups like persons under 18-years of age, over 65-years of age, and those living at or below 150% poverty level are included on Map 50.

SVUC Impact Assessment

Subsidence high hazard impacts to Central Region SVUC are summarized by CDC SVI themes and percentile rankings in Table 34. The highest percentages of regional exposure are highlighted using bold text. The strongest majority of exposure is generally centered around the 0.50 - 0.75 index range. which would suggest a moderate SVUC vulnerability in Central Region communities.

Table 34. Subsidence high hazard SVUC exposure for Central Region

Region	CDC-SVI Assigned Percentile Rank	Percent of Impacted Area by SVI Percentile Rank Range				
		THEME 1 Socio-Economic Status	THEME 2 Household Characteristics	THEME 3 Racial and Ethnic Minority Status	THEME 4 Housing Type/ Transportation	THEMES (ALL) Overall Ranking
Central	NO DATA	0.66%	0.66%	0.57%	0.66%	0.66%
Central	0-0.25	10.18%	17.24%	14.87%	11.03%	8.90%
Central	0.25-0.50	21.12%	8.80%	25.31%	30.69%	21.03%
Central	0.50-0.75	**45.86%**	**36.39%**	**27.81%**	**33.89%**	**41.33%**
Central	0.75-0.90	17.10%	23.59%	27.71%	9.44%	14.84%
Central	0.90-1.00	5.08%	13.31%	3.74%	13.93%	13.24%

Local Jurisdiction Vulnerability

Maricopa and Pinal Counties included subsidence in their risk assessments and used a similar approach to define subsidence hazard zones. Between the two plans, a total of 7,434 assets with a total replacement value of $9.86 billion have been identified to be located within a high hazard area. No losses to local CFI were estimated.

Specific Areas of Concern

For many areas of the Central Region, subsidence rates have significantly reduced in the last 30 years due to alternative water supplies provided by the CAP and regulation of groundwater pumping through the Arizona Groundwater Management Act of 1980 creation of the Phoenix and Pinal Active Management Areas. Should CAP allocations be reduced due to shortages in the Colorado River, groundwater would become the only available replacement to meet the demands and the threat of water level declines would be elevated, re-activating pre-CAP rates of subsidence. It is also noted that subsidence continues to this day, and agencies and municipalities must continue to monitor and evaluate the rates of decline when considering development of large, regional, gravity-flow based infrastructure.

South Region

South Region vulnerabilities to high subsidence hazards are moderate. The South region, shown in Map 51, is the second-most vulnerable region in the state, largely due to the number and size of the active subsidence areas, the growing history of damages, and the smaller amount of population and facility exposure when compared to the Central Region.

State-Owned CFI Exposure and Loss Estimates

A total of 122 state-owned CFI, or 11.1% of the statewide exposure, are located within a high hazard area. The exposed facilities represent total replacement values of $147.2 million. No losses are estimated.

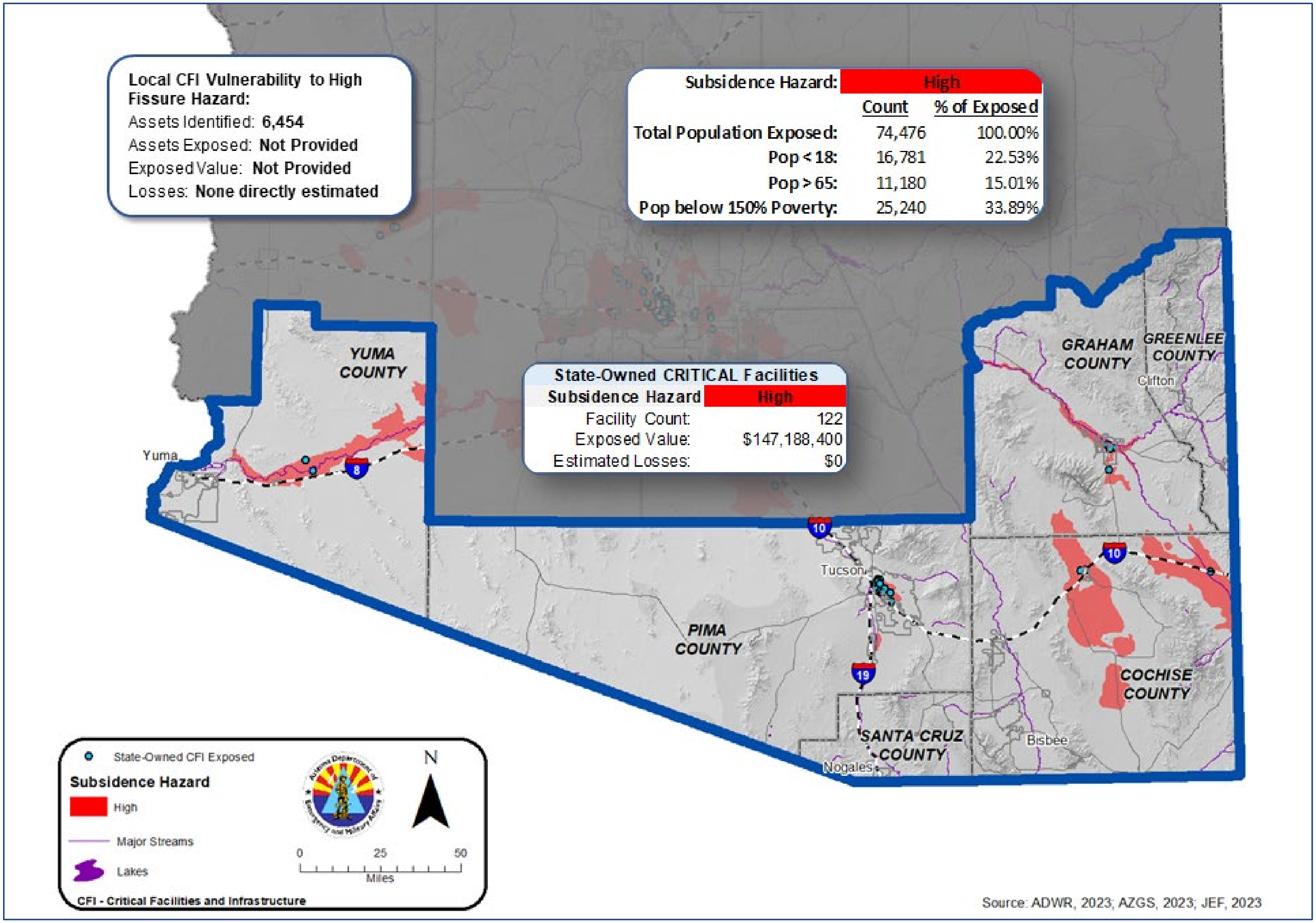
Additional state-owned facilities vulnerable to subsidence are the ADOT operated and maintained freeways, highways, and state routes that pass through the known subsidence hazard areas, and especially their drainage facilities. Alterations of ground elevations and slopes may have adverse consequences on drainage systems and cause unexpected flooding or ponding.

Vulnerable Population Groups

The 2022 estimated total population for the South Region is 1,487,942 people. Approximately 5.96% of the total population, or 74,476 persons, are located within the high subsidence hazard areas. Exposure estimates for at-risk population groups like persons under 18-years of age, over 65-years of age, and those living at or below 150% poverty level are included on Map 51.

SVUC Impact Assessment

Subsidence high hazard impacts to South Region SVUC are summarized by CDC SVI themes and percentile rankings in Table 35 The highest percentages of regional exposure are highlighted using bold text. The strongest majority of exposure is to areas with index ranking centered around the 0.50 to 0.75 range with the Theme 2 majority in the 0.90 to 1.00 (flaggable) range. This would suggest a moderately high SVUC vulnerability in South Region communities.



Map 51. Subsidence vulnerability for the South region

Table 35. Subsidence high hazard SVUC exposure for South Region

Region	CDC-SVI Assigned Percentile Rank	Percent of Impacted Area by SVI Percentile Rank Range				
		THEME 1 Socio-Economic Status	THEME 2 Household Characteristics	THEME 3 Racial and Ethnic Minority Status	THEME 4 Housing Type/ Transportation	THEMES (ALL) Overall Ranking
South	NO DATA	0.69%	0.69%	0.69%	0.69%	0.69%
South	0-0.25	0.03%	3.91%	19.37%	21.99%	0.15%
South	0.25-0.50	36.64%	12.97%	17.87%	26.43%	15.31%
South	0.50-0.75	**52.48%**	**31.91%**	**59.17%**	21.32%	**78.07%**
South	0.75-0.90	9.59%	25.42%	1.00%	**26.88%**	2.85%
South	0.90-1.00	0.57%	25.10%	1.89%	2.69%	2.92%

Local Jurisdiction Vulnerability

None of the local jurisdictions in the South Region included subsidence in their risk assessments. Accordingly, there are no estimated quantitative subsidence related losses for locally identified critical facilities or infrastructure.

Specific Areas of Concern

Alternative water sources for recharging groundwater in the active subsidence areas in Cochise and southern Pima Counties do not exist and groundwater basins in those areas are dependent on watershed generated surface water. There is also no aquifer management area authority to mitigate the In most cases, the groundwater withdrawal outpaces the recharge by a factor of 50-100 times, and ultimately is unsustainable.

RESOURCES

Sources

AZ Dept of Water Resources, Hydrology Division, Geophysics / Surveying Unit, https://www.azwater.gov/hydrology/field-services/groundwater-and-land-subsidence-info

AZ Geological Survey, Hazards Viewer, https://uagis.maps.arcgis.com/apps/webappviewer/index.html?id=98729f76e4644f1093d1c2cd6dabb584

References

AZ Dept of Water Resources, 2009, Arizona Water Atlas, Vol. 7, Lower Colorado River Planning Area.

AZ Dept of Water Resources, 2010, Arizona Water Atlas, Vol. 1, Executive Summary.

AZ Dept of Water Resources, 2010, Arizona Water Atlas, Vol. 8, Active Management Area Planning Area.

AZ Dept of Water Resources, 2017, Land Subsidence Monitoring Report No. 3.

AZ Land Subsidence Group, 2017, Land Subsidence and Earth Fissures in Arizona, Research and Information Needs for Effective Risk Management., AZGS Contributed Report CR-07-C.

Central Arizona Project, 2007, Executive Summary of Critical Issues Topic – Subsidence.

Conway, Brian D., 2013, *Land Subsidence Monitoring Report No. 1*. AZ Dept of Water Resources.

Conway, Brian D., 2014, *Land Subsidence Monitoring Report No. 2*. AZ Dept of Water Resources.

Conway, Brian D., 2019, *Land Subsidence Monitoring Report No. 4*. AZ Dept of Water Resources. https://new.azwater.gov/sites/default/files/ADWR%20Land%20Subsidence%20Monitoring%20Report_Number4_Final.pdf

Cook, J.P., 2013, Revisiting earth fissures near Luke Air Force Base, central Maricopa County, Geological Survey Open File Report, OFR-13-15, 10 p.

Gelt, J., 1992, *Land Subsidence, Earth Subsidence change Arizona's Landscape*. University of Arizona's Water Resources Research Center, Arroyo, Vol. 6, No. 2.

Harmon, D.B., 1982, *Subsidence in Northeast Phoenix: A New Problem for Engineers.* AZ Bureau of Geology and Mineral Technology, Field notes, Vol. 12, No. 3, Sept 1982, pp10-11.

Rucker, M., 2010, Ground Subsidence: Infrastructure Impact, Investigations, Solutions and Monitoring. 2010 NACE Western Region County Engineers Symposium.

Schumann, H.H., L.S. Cripe, 1986, *Land Subsidence and Earth Fissures Caused by Groundwater Depletion in Southern Arizona, USA* International Symposium on Land Subsidence, 3rd, Venice, 1984, [Proceedings, Johnson, A.I., Carbognin Laura, and Ubertini, L., eds.], International Association of Scientific Hydrology Publication 151, p. 841–851.

Schumann, H.H., 1995, *Land subsidence and earth subsidence hazards near Luke Air Force Base, Arizona*: in Prince, K.R., Galloway, D.L., and Leake, S.A., eds., US Geological Survey subsidence interest group conference, Edwards Air Force Base, CA, Nov 18–19, 1992—abstracts and summary: US Geological Open-File Report 94-532, p. 18-21.

Schumann, H.H. and O'Day, C.M., 1995, Investigation of Hydrology, Land Subsidence, and Earth Fissures, Luke Air Force Base, AZ. US Geological Survey Admin Report, 62p. Schumann, H.H. and O'Day, C.M., 1995, Investigation of Hydrology, Land Subsidence, and Earth Fissures, Luke Air Force Base, Arizona. US Geological Survey Admin Report, 62p.

Slaff, Steven, 1993, *Land Subsidence and Earth Fissures in Arizona*. AZ Geological Survey, Down-to-Earth Series 3.

TERRORISM

DESCRIPTION

The term "terrorism" refers to intentional, criminal, malicious acts, but the functional definition of terrorism can be interpreted in many ways. Officially, terrorism is defined in the Code of Federal Regulations as "…the unlawful use of force and violence against persons or property to intimidate or coerce a government, the civilian population, or any segment thereof, in furtherance of political or social objectives" (28 CFR §0.85). Terrorists use threats to create fear, in an attempt to convince citizens of the powerlessness of their government, and to get publicity for their cause.

Terrorist attacks can take many forms, including agroterrorism, arson/incendiary attack, armed attack, assassination, biological agent, chemical agent, cyberterrorism, conventional bomb, hijackings, intentional hazardous material release, kidnapping, nuclear bomb, and radiological agent (FEMA April 2009). Terrorists can utilize almost anything to carry out an attack, including less complex methods such as firearms, small homemade explosive devises, and vehicles to strike crowds of people. There are many avenues terrorist actors can use to cause harm, but the most concerning for Arizona are chemical, biological, radiological, nuclear, or cyber attacks.

Chemical

Chemical weapons utilize an agent that causes toxicity: that is, their chemical reaction can cause death, permanent harm, or temporary incapacity. Chemical weapons come in many forms, including cyanides, mustard agents, nerve agents, and toxic industrial chemicals.

Biological

Biological weapons infect people with disease-causing microorganisms and pathogens like viruses, bacteria, and fungi. Biological agents have the ability to multiply in hosts over time. Key characteristics of an ideal biological agent are infectivity, virulence, lethality, pathogenicity, incubation period, contagiousness, and stability; all resulting in widespread infection, illness, and death. Some of the most concerning biological agents are anthrax, botulinum toxin, and ricin. Biological agents do not just affect people, but can have severe adverse effects on livestock and crops. Some biological agents cannot be easily detected and may take time to develop. Therefore, it can be difficult to know that a biological attack has occurred until victims display symptoms. In other cases, the effects are immediate.

Radiological

Radiological weapons expose the population to radioactive material. This can be accomplished through the use of a "dirty bomb" or radiological dispersal device (RDD), radiological exposure device (RED), or by sabotaging a nuclear power plant. Radiological attacks are not likely to cause catastrophic death and injury but may cause both short and long-term health problems for those exposed.

Nuclear

Nuclear weapons that may be utilized by terrorists are often characterized as improvised nuclear devises (IND). An IND gives off four types of energy: blast wave, intense light, heat, and radiation.

Nuclear fallout develops as dust-like particles from the explosion drop to the earth and contaminate all surfaces with radioactive material.

Cyber

Cyberterrorism has become a large threat in recent years. Cyberterrorism is defined as activities intended to damage or disrupt vital computer systems. These acts can range from taking control of a host website to using networked resources to directly cause destruction and harm. Cyber terrorists can be difficult to identify because the internet provides a meeting place for individuals from various parts of the world. Individuals or groups planning a cyber-attack are not organized traditionally, as they can effectively communicate over long distances without delay. The largest threat to institutions from cyber terrorism comes from any processes that are networked and controlled via computer.

International Terrorism

International terrorism is perpetrated by individuals and/or groups inspired by or associated with designated foreign terrorist organizations or nations. The Islamic State of Iraq and ash-Sham (ISIS) is the most potent international terrorist threat, but Al-Qaeda and Hezbollah continue to threaten the US homeland. Recruitment of violent extremists through social media is central to ISIS's terrorist campaign.

Domestic Terrorism

Domestic terrorism is perpetrated by individuals and/or groups inspired by or associated with primarily U.S.-based movements that espouse extremist ideologies of a political, religious, social, racial, or environmental nature.

HISTORY

On the day following the September 11, 2001 attacks, the state declared its first and only terrorism emergency. Prior to and since that time, there have not been any major terrorism attacks in Arizona. National and international events are examples of terrorist attacks that may occur in Arizona. The following major attacks represent national and international examples that have occurred or were narrowly avoided in the last 10-years:

- El Paso Walmart Shooting, 2019 – Patrick Crusius of Allen, Texas, attacked a Walmart store in El Paso, Texas, shooting and killing 23 people and injuring 23 others. Crusius was reportedly inspired by the Christchurch mosque shooting and beliefs in the Great Replacement conspiracy theory.
- Congressional Baseball Shooting, 2017 – James Hodgkinson, a Bernie Sanders supporter and registered Democrat, opened fire during a practice session for a charity congressional baseball game where 24 Republican members of Congress were present. He shot and injured 6 people. The Virginia Attorney General determined this to be an act of terrorism that was "fueled by rage against Republican legislators."
- New York and New Jersey Bombings, 2016 – Four bombings or bombing attempts occurred in the New York metropolitan area. Thirty-one civilians were injured in or of the bombings. Ahmad Kan Rahimi was identified as a suspect in all of the incidents and was

apprehended on September 19th in Linden, New Jersey. According to authorities, Rahimi was not part of a terrorist cell, but was motivated and inspired by the extremist Islamic ideology of al Qaeda leaders.

- Orlando Pulse Nightclub Shooting, 2016 – Omar Mir Seddique Mateen, 29, armed with a rifle and a handgun, began shooting patrons inside Pulse nightclub in Orlando, Florida. Law enforcement officers entered the nightclub and engaged the shooter, the shooter then barricaded himself inside a bathroom with hostages for approximately three hours. Forty-nine people were killed; 53 were wounded. The shooter was killed in an exchange of gunfire with law enforcement officers after they breached the building. The FBI asserted his possible link to radical Islam.

- Boston Marathon Bombing, 2013 – At least three were killed and over 170 injured when two bombs sent shrapnel into the crowd and runners' paths. Pieces of metal flew out at leg level, leading to a number of severe leg injuries.

Recent notable cyber terrorism incidents include:

- U.S. Marshalls Service Ransomware Attack, 2023 – A major ransomware attack on the US Marshalls Service compromised some of its most sensitive information, including law enforcement materials and personal information of employees and potential targets of federal investigations. The investigation into this incident is on-going.
- Colonial Oil Pipeline, 2021 – On May 7th the Colonial Oil Pipeline was hit with the most devastating targeted ransomware attack in recent memory. This pipeline is the largest overall pipeline in the U.S. and supplies 45% of gas, diesel and jet fuel to the East Coast. As a result of the attack, the networks and operations were completely shut down. While the system was able to be restored to full function, by May 18th almost 11,000 gas stations were still without gas. Colonial paid $5 million in cryptocurrency to the hacker group DarkSide in order to regain control of the system, which had the result of raising the average cost of gas per gallon in the US to the highest level in over six years.
- The World’s First Ransomworm: WannaCry, 2017 – The world’s first “ransomworm,” WannaCry affected 230,000 Windows-operated computers in 150 countries. It spread through the exploit called EternalBlue, which was made by the NSA. The perpetrators demanded payments of $300 in Bitcoin cryptocurrency in exchange for unlocking files which had been encrypted by WannaCry.
- Shadow Brokers Leaks NSA Hacking Tools, 2017 – An anonymous group known as the Shadow Brokers stole and leaked hacking tools from the National Security Agency (NSA). Microsoft provided a patch to protect computers running Windows, which were affected but many users did not install the patch and were compromised. The leaked tools led to other incidents, including NotPetya and WannaCry.
- Ferizi US Military Identity Hack, 2015 – In June 2015, Ardit Ferizi, operating as part of the hacking crew known as the Kosova Hacker’s Security, hacked into a server used by an un-named Illinois-based online retail company and accessed data on about 100,000 people.

Ferizi chose his target with the specific intent to gather information on US military personnel. He parsed the stolen data, discovering personal information of about 1,351 military and other government personnel, and provided the information to ISIS/ISIL in the form of a "kill list". Ferizi was captured by US authorities and is the first terrorist hacker to be convicted in the US – serving a 20-year sentence.[25]

- Media Attack by Syrian Electronic Army, 2013 – In August 2013, media companies including the New York Times, Twitter, and the Huffington Post lost control of some of their websites after hackers supporting the Syrian government breached the Australian internet company that manages many major site addresses. The Syrian Electronic Army, a hacker group that has previously attacked media organizations that it considers hostile to the regime of Syrian president Bashar al-Assad, claimed credit for the Twitter and Huffington Post hacks in a series of Twitter messages. Electronic records showed that NYTimes.com, the only site with an hours-long outage, redirected visitors to a server controlled by the Syrian group before it went dark.

PROBABILITY/EXTENT

Terrorism is a threat everywhere, but there are some important considerations in evaluating terrorism hazards, such as the existence of facilities, landmarks, or other buildings of international, national, or regional importance. High-risk targets for acts of terrorism include military and civilian government facilities, international airports, large cities, and high-profile landmarks. Terrorists might also target large public gatherings, water and food supplies, utilities, and corporate centers. Furthermore, terrorists are capable of spreading fear by sending explosives or chemical and biological agents through the mail. Nonetheless, terrorism can take many forms and terrorists have a wide range of personal, political, or cultural agendas. Therefore, there is no location that is not a potential terrorist target.

The impacts of terrorism can vary in severity from nominal to catastrophic and are contingent upon the method of the attack, the volume of force applied, and the population density of the attack site. There may be significant, widespread loss of life as well as structural and economic losses.

The proliferation of digital systems and information, and electronic access to that information and those systems, puts cyber terrorism on the world stage. Hackers can access systems from anywhere in the world, with the potential to cause significant damage. Essentially any system connected to the internet or operating digitally is a potential target for cyber terrorists.

WARNING TIME

The initiation of an act of terrorism comes without warning. However, large scale coordinated attacks may require weeks or years of planning, which if detected by authorities, can provide warning of an impending attack.

[25]Infosec Institute – online at: http://resources.infosecinstitute.com/the-ferizi-case-the-first-man-charged-with-cyber-terrorism/

FUTURE CONDITIONS

Climate Considerations

Changes to the climate do not have a direct impact on terrorism.

Changes in Development

Many things need to be considered when evaluating future hazard conditions. Increases in population and/or population densities and the expansion of infrastructure may result in increased exposure and vulnerability, but growth and development aspects for terrorism hazards are not confined solely to the physical built environment and changes in population. Further globalization and advancements in technology must be evaluated in order to gain an understanding of the potential future conditions. Globalization is macro-level changes around the world, including movements of cultures, values, and people (Moghaddam, Heckenlaible, Blackman et al., 2016). In the short term, increasing the integration of culture, economics, technology, science, and social and political systems around the world can make information easily accessible, expand the technical knowhow of rogue organizations, and expand terrorism networks. Additionally, cultural appropriation and/or the expansion of western culture around the world can fuel terrorism by increasing animosity towards western societies. Globalization in the 21st century is driven by technological advancements that not only enable terrorist organizations with the ability to easily expand, communicate, and transfer resources around the world, but also may create new opportunities/ways terrorists can conduct attacks. Globalization, technological advancements, and society's increasing technological reliance may increase both the future probability and magnitude of terrorist attacks, but the future environment is widely uncertain.

VULNERABILITY ASSESSMENT

Communities where potential targets are located should be considered more vulnerable. Larger cities like Phoenix, Mesa, Glendale and Tucson are the most vulnerable to terrorist attacks due to the sheer size of these urban areas, density of the population, multiple large sporting and entertainment venues, and concentrations of local, state, and federal critical infrastructure. Arizona has a sizeable tourism economy in regards to large sporting events, concerts, and conventions. Arizona has been known to host the NCAA Final Four tournament, the NFL Superbowl, large events like the Phoenix Comicon, the Ironman Triathlon, and various concerts. Terrorists have a documented history of targeting large gatherings of people in order to spread fear and inflict as much damage as possible. All events with large gatherings of people may be the most vulnerable to terrorist attacks. Additionally, because of its status as the state capital, Phoenix has an elevated vulnerability.

Of particular concern to Arizona are the many critical facilities in the state. Critical life-line infrastructure, such as bridges, tunnels, power and gas distribution facilities, and public water supply lines, may be potential terrorist targets. Damage to these facilities and infrastructure could cripple transportation routes and utilities, and their associated commerce. Additionally, there are many Title III facilities as well as transportation routes vital to the entire nation traversing Arizona, making intentional hazardous material releases a potential threat to citizens and the environment.

Vulnerability to cyber-terrorism exists with any system connected to the internet or even internal non-connected operating systems. Vulnerabilities include informational databases, operational systems, communications networks, and more. Government and private entities are vulnerable alike.

One example of a worst-case scenario for a terrorism event in Arizona would be if a “dirty bomb” combining radioactive material with conventional explosives were to be detonated in Phoenix at lunchtime on a weekday. At that time of day and location, a significant number of individuals would be exposed to the bomb’s radiation both at the time of detonation and after the fact as the radiation spread. The explosive device could damage or even topple buildings, spark utility outages citywide, and/or ignite large-scale urban fires. Prediction of terrorist attacks is almost impossible because terrorism is a result of human factors. As long as fringe groups maintain radically different ideas than that of the government or general population, terrorism is a possibility.

State Facility Loss Estimation

All state facilities are vulnerable to terrorism in some way, with variable levels of risk. Since the probability of terrorism occurring cannot be quantified in the same way as many natural hazards, it is not possible to assess vulnerability in terms of likelihood of occurrence. Instead, vulnerability is assessed in terms of specific assets. FEMA’s Integrating Manmade Hazards into Mitigation Planning (2003) encourages site-specific assessments that are based on the relative importance of a particular site to the surrounding community or population, threats that are known to exist, and vulnerabilities including:

Inherent Vulnerability

- Visibility – How aware is the public of the existence of the facility?
- Utility – How valuable might the place be in meeting the objectives of a potential terrorist?
- Accessibility – How accessible is the place to the public?
- Asset mobility – is the asset’s location fixed or mobile?
- Presence of hazardous materials – Are flammable, explosive, biological, chemical and/or radiological materials present on site? If so, are they well secured?
- Potential for collateral damage – What are the potential consequences for the surrounding area if the asset is attacked or damaged?
- Occupancy – What is the potential for mass casualties based on the maximum number of individuals on site at a given time?

Tactical Vulnerability

- Site Perimeter
    - Site Planning and Landscape Design – Is the facility designed with security in mind – both site-specific and with regard to adjacent land uses?
    - Parking Security – Are vehicle access and parking managed in a way that separates vehicles and structures?
- Building Envelope
    - Structural Engineering – Is the building’s envelope designed to be blast-resistant? Does it provide collective protection against chemical, biological and radiological contaminants?
- Facility Interior

- Architectural and Interior Space Planning – Does security screening cover all public and private areas?
- Mechanical Engineering – Are utilities and HVAC systems protected and/or backed up with redundant systems?
- Electrical Engineering – Are emergency power and telecommunications available? Are alarm systems operational? Is lightning sufficient?
- Fire Protection Engineering – Are the building's water supply and fire suppression systems adequate, code-compliant and protected? Are on-site personnel trained appropriately? Are local first responders aware of the nature of the operations at the facility?
- Electronic and Organized Security – Are systems and personnel in place to monitor and protect the facility?

Vulnerable Population Groups

The entire population is considered vulnerable to terrorist attacks, but certain population groups may be more vulnerable depending on the method used to carry out an attack. The entire population is dependent on technology and any cyber attack on the electrical grid would pose a threat to all. Additionally, children below the age of 18, especially below the age of five, the elderly, the immunosuppressed, and those living in poverty may be more vulnerable to chemical, biological, and radiological attacks as they all have biological effects. Those living in poverty and the homeless may be more vulnerable to attacks based on the fact they may reside in high population density areas, and may have inadequate/insufficient housing to shelter in place. Additionally, police and military personnel may be specifically targeted by terrorist organizations.

Jurisdictional Losses

Jurisdictional loss estimates can vary greatly in a terrorism event based on the magnitude and type of terrorist action. Catastrophic terrorism events will have proportionally catastrophic losses for the jurisdiction in question. For example, losses may be greater in an event that results in the complete destruction of a high-rise building; in that scenario, losses will stem from loss of life, the actual destruction of the building, and business interruptions. For comparison's sake, the total losses incurred by New York City in the September 11, 2001 attacks are estimated at $83-95 billion. This loss estimate includes lost tax revenue for the city, the cost of response and recovery, business interruptions, deaths, building damage, and infrastructure damage. While Arizona's cities are smaller than New York, losses could still be severe.

RESOURCES

Sources

AZ Counter Terrorism Information Center, http://www.azactic.gov/

Ready.gov, https://www.ready.gov/be-informed

US Dept of Homeland Security – Terrorism Prevention, Preventing Terrorism | Homeland Security (dhs.gov)

References

US Dept of Justice, FBI, 2016, Active Shooter Incidents in the USA from 2000-2016.

WILDFIRE

DESCRIPTION

A wildfire is an uncontrolled fire spreading through wildland vegetative fuels and/or urban interface areas where fuels may include structures. Wildfires often begin unnoticed, spread quickly, and are usually signaled by dense smoke that may fill the area for miles around. Wildfires can be human-caused through acts such as arson or campfires, or can be caused by natural events such as lightning. If not promptly controlled, wildfires may grow into an emergency or disaster, especially when burning in areas where people and infrastructure are located. Even small fires can threaten lives, resources, and properties.

HISTORY

Wildfires burn thousands of acres in Arizona every year. According to the Ecological Restoration Institute and Southwest Fire Science Consortium (Saiz, et.al., 2023), the 10-year period ending with the 2022 wildfire season for Arizona had an annual average burn area of 341,744 acres. Unplanned human ignitions accounted for 78% of wildfire acres burned in the Southwest in 2022.

Following are a few of the most significant wildfires in the past 10-years of Arizona history:

- April-June 2022 – Two fires in the same general vicinity burned northeast of Flagstaff, AZ, in and around the 2011 Schultz Fire scar. The Tunnel Fire burned first and was reported to start on the Coconino National Forest on April 17, 2022. The fire burned 19,105-acres, some of which was within the 2011 Schultz Fire burn perimeter, and the cause of the fire is still under investigation. The fire threatened over 2,600 residents with partial evacuations, and would go on to burn 54 structures with total destruction of 30 homes. The fire was fully contained on May 20. Fire management costs were estimated at $5.1 million and losses estimated at $2.5 million.

  Tunnel Fire burning in neighborhood.
  Source: Reuters/CNN, 2022

  The Pipeline Fire ignited shortly after the Tunnel Fire was contained and was located along the southern perimeter of the Schultz burn scar. The cause of this 26,532-acre fire was listed undetermined, though court documents suggest it was caused by a man burning toilet paper. The Pipeline Fire threatened over 3,100 homes and caused the evacuation of 2,100 residents. One home was destroyed and no civilian injuries or fatalities were reported. The fire was contained July 27, 2022. Fire management costs were reported at $2.33 million and lossest were estimated at $250,000. (Saiz, et.al., 2023;GACC, 2023; NCDC, 2023)

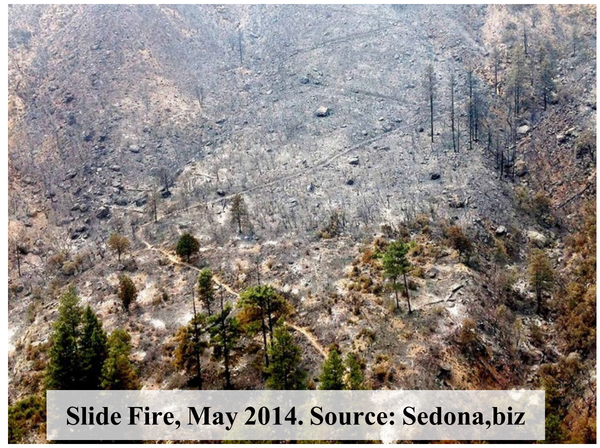
- June 2021 – The Telegraph Fire was a human-caused wildfire that started in the Tonto National Forest near Superior, Arizona. The fire started on June 4, 2021 and burned more than 180,000 acres before it was fully contained on July 3, 2021. This was the largest fire in Arizona during the 2021 season and the sixth-largest wildfire in Arizona history. Fire management costs were estimated at $40 million. The fire forced multiple extended road closures, including Highway 177 between Superior and Winkelman, Highway 77 between Globe and Winkelman, and Highway 60 between Superior and Top-Of-The-World. Evacuation orders were issued for multiple communities, including Superior, Top-Of-The-World, El Capitan, and portions of Miami and Globe. No civilian injuries or fatalities were reported, but 52 structures were reported to have burned with 22 of those structures reported to have burned in El Capitan. Total losses were estimated to exceed $8 million. (Lynch, et.al., 2022; GACC, 2023; NCDC, 2023)

- June 2020 – The Bush Fire was a human-caused wildfire that started in the Tonto National Forest northeast of Phoenix, Arizona. The fire started on June 13, 2020 near the intersection of Bush Highway and SR 87 and burned 193,455 acres before it was fully contained on July 6, 2020. This was the largest fire in Arizona during the 2020 season and the fifth-largest wildfire in Arizona history. Fire management costs were estimated at $11.6 million. Fortunately, no homes or structures were destroyed and no one was injured or killed, however, nearly 2,000 civilians were evacuated. The fire did damage portions of Hwy-87 and Hwy-188 according to the Arizona Department of Transportation (ADOT), including guardrails, fencing, signage, and other infrastructure. ADOT estimated repair, cleanup, labor, and other miscellaneous costs at around $6 million for highway repairs and received $2 million in emergency grant funds from the Federal Highway Administration (FHWA). (Lynch, et.al., 2021; ADOT, 2020; NCDC, 2023)

Damaged guardrail along SR 87 from Bush Fire. Source: ADOT, 2020

- April 2018 – The Tinder Fire burned for 27 days covering 16,309 acres. Investigators determined that the fire originated in the East Clear Creek drainage approximately 1 mile downstream from Forest Road 95 near C.C. Cragin (Blue Ridge) Reservoir. The cause of the fire was an abandoned illegal campfire. Fire management cost was $7.5 million and the fire threatened more than 1,700 residencies, destroying 33 along with 63 minor structures. There were no reported injuries, but 300 civilians were evacuated in response to the fire Losses were estimated at $15 million. (Lynch & Evans, 2019; NCDC, 2023)
- June 2015 – Whitetail Fire burned for 30 days covering 33,633 acres of Grassland and woodland in the central part of the San Carlos Apache Reservation. Fire management cost was $2.8 million dollars and was the most significant fire monitored in the southwest for 2015 (Evans, 2016).

- June 2014 – San Juan Fire was a human-caused fire ignited on the Fort Apache Indian Reservation. The fire burned approximately 7,004 acres west of Springerville. The fire was declared controlled on July 8, 2014, with over $5.8 million in fire suppression costs expended (Evans, 2014; AZCentral.com, 2014).



Slide Fire, May 2014. Source: Sedona,biz

- May 2014 – Slide Fire began as a human-caused wildfire north of the Slide Rock State Park. The fire burned over 22,000 acres and had a firefighting cost of over $7 million (NCDC, 2017).
- June-July 2013 – Yarnell Hill Fire, 8,400 acres. A lightning-caused fire that originated 3.5 miles west of the community of Yarnell. On Sunday, June 28th, the fire rapidly grew in size and intensity. Strong, erratic winds pushed the fire in several directions at the same time. Nineteen members of the Granite Mountain Hotshot Crew lost their lives battling this fire on June 30, 2013. Residents of the communities of Yarnell and Peeples Valley were forced to evacuate. The Yarnell Hill Fire destroyed 108 homes in Yarnell and damaged an additional 25 others.
- June-July 2013 – Dean Peak Fire, approximately 5,400 acres. A lightning-caused fire in the Hualapai Mountains, 10 miles southeast of Kingman. This fire led to the communities of Pine Lake and Pinion Pine Estates being evacuated. No structures were lost.

PROBABILITY/EXTENT

Based on history, the probability of wildfire occurring in the state is 100%. The magnitude and severity of wildfire incidents can be very high and 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. The primary dataset used to depict the threat of wildfire in Arizona was recently developed as a part of the West Wide Wildfire Risk Assessment[26] (WWWRA) for the western US, and hosted by the Arizona Department of Forestry and Fire Management on its website[27]. Work is underway to update this data set, but as of the writing of this Plan, it is still best available.

The wildfire hazard areas used in this update are derived from the Fire Threat Index (FTI) data distributed with the WWWRA. The FTI reflects the likelihood of one acre burning if a fire started at a specific grid location. The calculation process integrates the probability of an acre igniting and

26 Sanborn Map Company, 2013, *West Wide Wildfire Risk Assessment, Final Report,* prepared for the Oregon Department of Forestry in cooperation with the Western Forestry Leadership Coalition and Council of Western State Foresters.

27 Arizona Wildfire Risk Assessment Portal (AZWRAP), accessed at: https://arizonawildfirerisk.com/

the expected final fire size into a single measure of wildland fire susceptibility. The assessed fire size is based on the rate of spread in four weather percentile categories.

The key inputs used in the wildfire model to produce the FTI wildfire hazard layer are:

- Probability of fire occurrence, derived from:
  - Historic fire locations and fire occurrence areas;
  - Weather influence zones (historic weather observations);
- Fire behavior (rate of spread) derived from:
  - Surface fuels;
  - Canopy closure;
  - Canopy characteristics;
  - Topography;
- Fire suppression effectiveness, derived from:
  - Historic fire sizes; and
  - Historic protection organization.

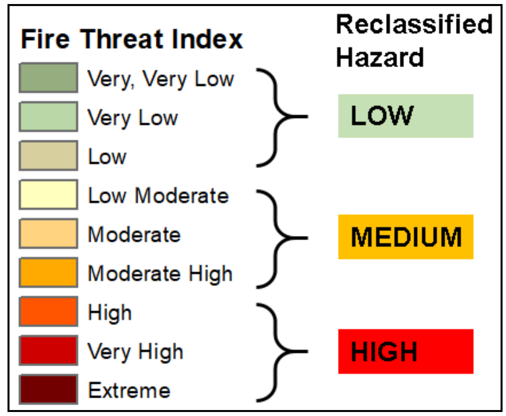


Figure 16. Fire Threat Index summary

For the purposes of this Plan, the nine FTI categories were reclassified into three generalized categories, Low, Medium and High wildfire hazard (see Figure 16 for hazard category assignments).

In addition to the hazard classifications discussed above, historic wilfire perimeters for fire years 2013 to 2021 were obtained from the National Interagency Fire Center Open Data Site (NIFC, 2023) to provide context of burn history over roughly the last 10 years.

Region specific wildire hazard profile maps are shown in Map 52, Map 53, and Map 54.

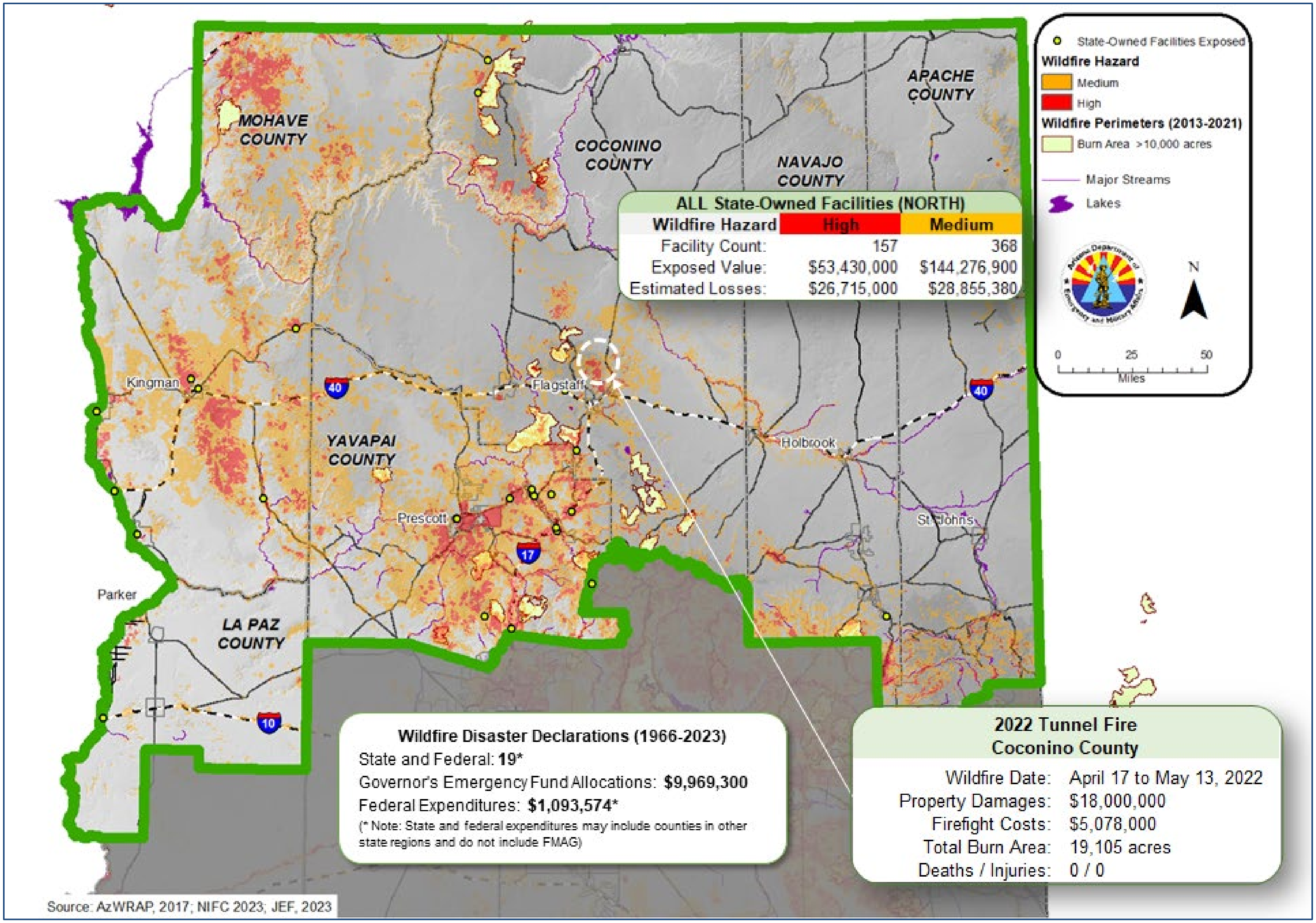
WARNING TIME

Warning time for wildfire incidents is multi-faceted. There is little to no warning time for the ignition of most fires. Once a fire has started and has been detected, a second level of warning comes in the form of the potential need for evacuations, which can be in hours or days, depending on the fire's location and proximity to populated areas. The state can monitor the size and growth of the fire in real time, which optimizes the ability to give responders time to evacuate at-risk homes and residents.

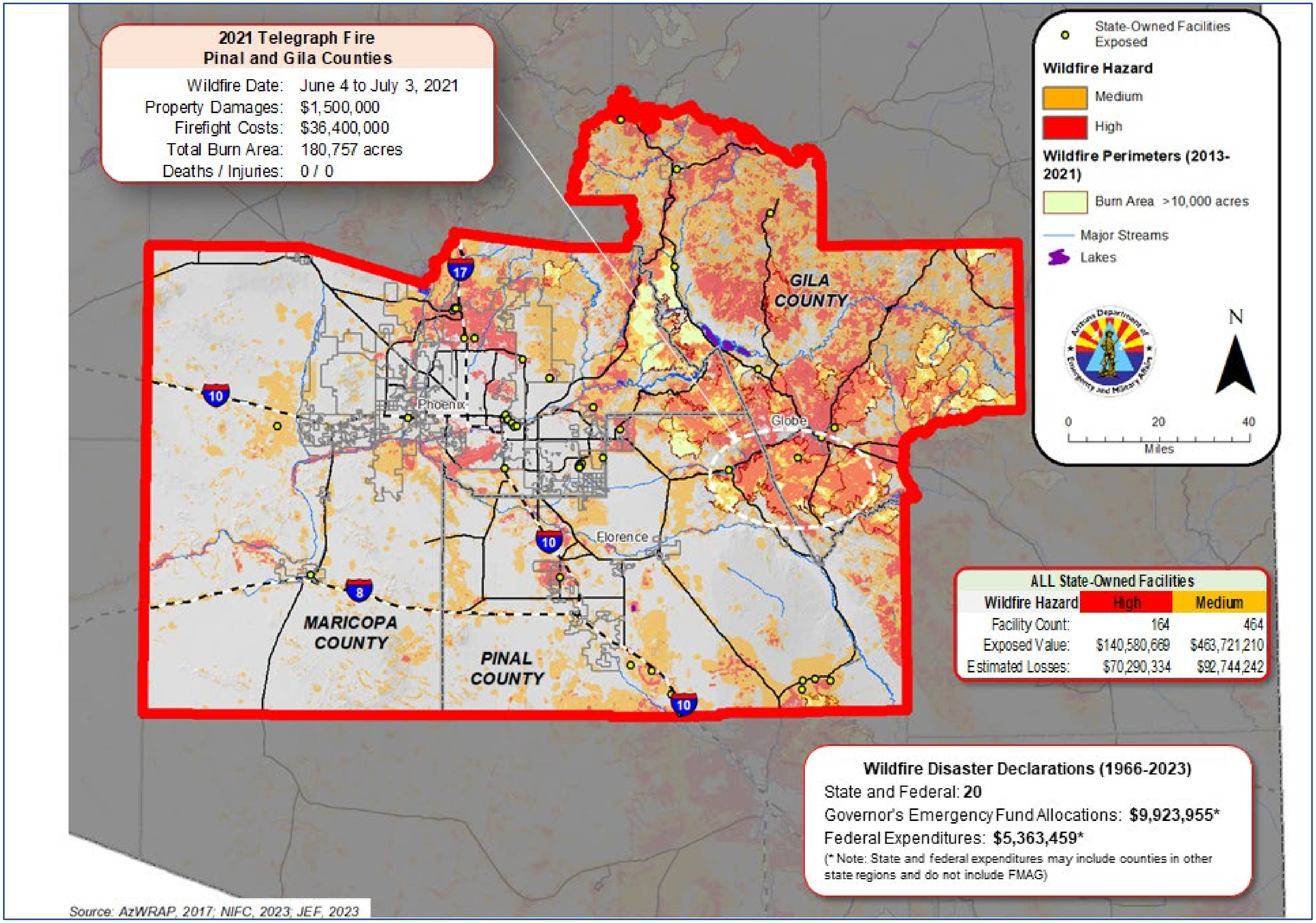
FUTURE CONDITIONS

Climate Considerations

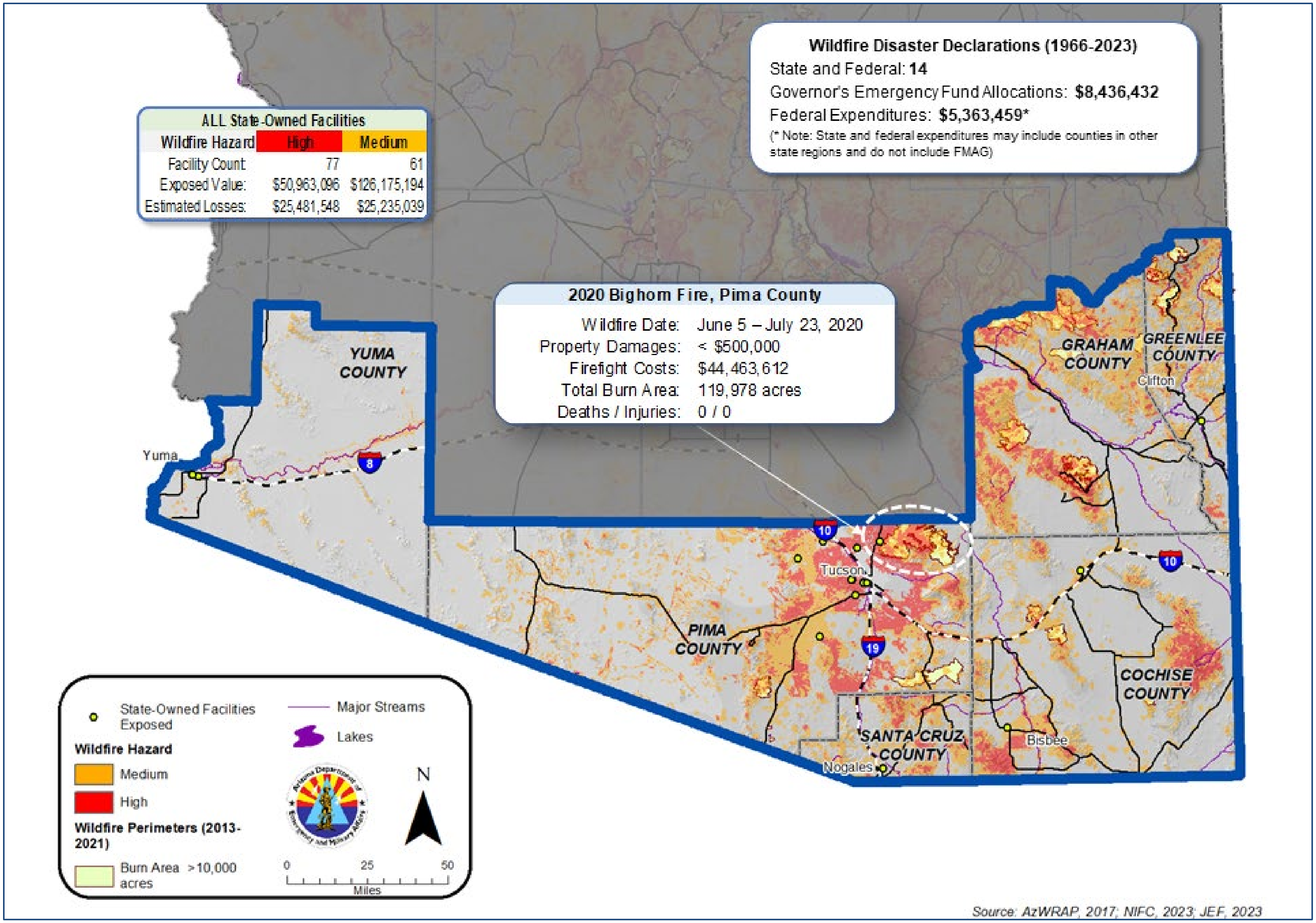
The NCA reports (Garfin, et.al., 2014 and Gonzales, et.al., 2018) note that one of the anticipated impacts of climate change for the Southwest is an increase in the frequency and magnitude of wildfires due to increased temperatures and seasonal reductions in snowpack and spring runoff. The NCA report also notes that drought conditions are expected to be more frequent and more intense. The Ecological Restoration Institute's (ERI) Working Paper No. 34 (Kent, 2015) concludes:



Map 52. Wildfire hazard for the North region



Map 53. Wildfire hazard for the Central region



Map 54. Wildfire hazard for the Soutth region

"Climate change may impact fire through three pathways: alteration of fuel moisture, alteration of fuel loading, and alteration of ignitions. Alteration of fuel moisture in the Southwest may happen through longer fire seasons, increased temperatures, decreased relative humidity, or changes in precipitation. Alteration of fuel loading has been predicted due to tree mortality and loss of vegetation cover, range shifts, changes in regeneration patterns, and disturbances themselves, such as insect outbreaks and severe fire. Lightning ignitions may increase, but ignitions are the least understood aspect of how climate change may influence fire.

Different ecosystems will respond to climate change differently. Ecosystems in which fires are generally limited by fuel moisture (wetter, more productive ecosystems which typically need a drought year to burn) will be most affected by changes to fuel moisture. Ecosystems in which fires tend to be limited by fuel availability (drier, less productive ecosystems in which fire may be limited by fuel continuity) will be most affected by changes to fuel loading. Any changes in ignitions will likely affect all ecosystem types. The impacts of climate change on fire regimes may change over time; fire risk may be high initially but decrease in the long term with changes in vegetation and fuels."

Changes in Development

Expansion of the wildland urban interface (WUI) due to development and population growth may increase the risk and exposure of structures and people to wildfire. Wildfire specific changes in vulnerability to state CFI due to changes in development are essentially limited to the WUI areas and the potential of added development creating a pathway for fire to a state CFI. Alternately, properly designed development of the WUI may reduce the state CFI vulnerability by creating an effective buffer.

North Region

Apache, La Paz, and Navajo Counties have experienced little to no growth over the past five years, nor is there any major growth or development of the WUI anticipated over the next five years. Moderate in-fill growth has occurred in Coconino, Mohave, and Yavapai Counties and the trends of the past five years are anticipated to continue with most of the growth being centered around existing population centers and limited in the WUI. Areas of anticipated significant growth that may extend into the WUI boundaries are identified in the Flagstaff and Tusayan (Coconino), Prescott Valley and Chino Valley (Yavapai), Kingman, Bullhead City and Lake Havasu City (Mohave), plus several populated areas within the unincorporated areas of Coconino, Mohave, and Yavapai Counties.

Central Region

Moderate growth has occurred in Maricopa and Pinal Counties over the past five years, and primarily in the build-out of previously planned residential, industrial and commercial areas. Some of that growth has occurred in the WUI. Growth in Gila County has been mostly limited to the Payson area and mostly in-fill. Planned growth in WUI areas is anticipated to be heaviest in Maricopa County and lesser in Pinal and Gila Counties.

South Region

Region-wide, most of the growth has been in-fill related with limited expansion of the WUI. Planned growth in WUI areas over the next five years is anticipated to be limited in Pima and Yuma Counties and insignificant in Cochise, Graham, Greenlee, and Santa Cruz Counties.

VULNERABILITY ASSESSMENT

The estimation of potential exposure to the identified high and medium wildfire hazards was accomplished by using GIS tools to intersect the human and state-owned critical facilities and infrastructure (CFI) data with the wildfire hazard limits depicted on the profile maps. The loss calculations assume that facilities located within high and medium hazard areas will be 50% and 20% damaged, respectively. The loss estimates presented are based on a single event and assume that the entire region is burning to the depicted hazard at the same time.

North Region

The North Region, shown in Map 55, has the greatest vulnerability to wildfire hazards when considering the available fuels, the number of historic declarations, and the number of people and structures located within the WUI.

State-Owned CFI Exposure and Loss Estimates

A total of 63 state-owned CFI, or 26.3% of the statewide exposure, are located within a high hazard area. The exposed facilities represent a total exposed replacement value of $28.9 million, with an estimated $14.4 million in potential losses. For the medium hazard, a total of 183 state-owned CFI, or 48.2% of the statewide exposure, are exposed and represent a total replacement value of $86.8 million, with an estimated $17.4 million in potential losses.

Vulnerable Population Groups

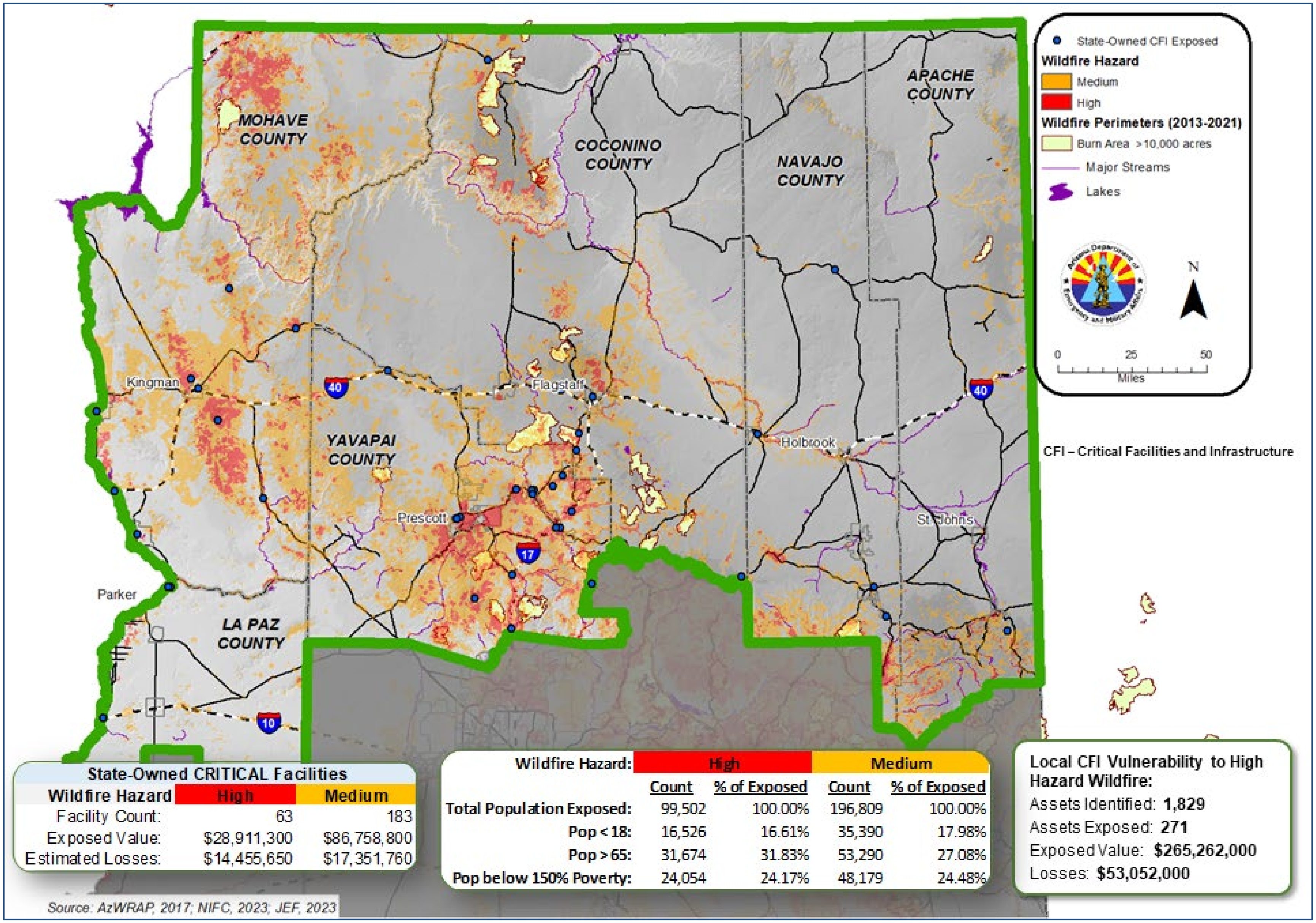
The 2022 estimated total population for the North Region is 801,655 people. Approximately 12.4% and 24.6% of the total population, or 99,502 and 196,809 persons, are exposed to high and medium wildfire hazards. Exposure estimates for at-risk population groups like persons under 18-years of age, over 65-years of age, and those living at or below 150% poverty level are included on Map 55.

SVUC Impact Assessment

Wildifire high hazard impacts to North Region SVUC are summarized by CDC SVI themes and percentile rankings in Table 36. The highest percentages of regional exposure are highlighted using bold text. The strongest majority of exposure is to areas with index ranking centered around the 0.50 to 0.75 range suggesting a moderate SVUC vulnerability in South Region communities.

Local Jurisdiction Vulnerability

Local hazard mitigation plans for the North Region identified a total of 271 assets with a total replacement value of $265.3 million. Total potential losses to local CFI were estimated at $53 million.



State-Owned CRITICAL Facilities

Wildfire Hazard	High	Medium
Facility Count:	63	183
Exposed Value:	$28,911,300	$86,758,800
Estimated Losses:	$14,455,650	$17,351,760

Wildfire Hazard:	High		Medium	
	Count	% of Exposed	Count	% of Exposed
Total Population Exposed:	99,502	100.00%	196,809	100.00%
Pop < 18:	16,526	16.61%	35,390	17.98%
Pop > 65:	31,674	31.83%	53,290	27.08%
Pop below 150% Poverty:	24,054	24.17%	48,179	24.48%

Local CFI Vulnerability to High Hazard Wildfire:
Assets Identified: **1,829**
Assets Exposed: **271**
Exposed Value: **$265,262,000**
Losses: **$53,052,000**

Map 55. Wildfire vulnerability for the North region

Table 36. Wildfire high hazard SVUC exposure for North Region

Region	CDC-SVI Assigned Percentile Rank	Percent of Impacted Area by SVI Percentile Rank Range THEME 1 Socio-Economic Status	THEME 2 Household Characteristics	THEME 3 Racial and Ethnic Minority Status	THEME 4 Housing Type/ Transportation	THEMES (ALL) Overall Ranking
North	NO DATA	0.01%	0.01%	0.01%	4.04%	4.04%
North	0-0.25	9.13%	23.56%	**47.25%**	9.26%	10.35%
North	0.25-0.50	29.80%	**25.44%**	20.09%	32.16%	26.18%
North	0.50-0.75	**53.44%**	22.06%	25.28%	**43.10%**	**48.47%**
North	0.75-0.90	6.21%	7.59%	0.89%	5.76%	8.71%
North	0.90-1.00	1.41%	21.35%	6.49%	5.41%	2.24%

Specific Areas of Concern

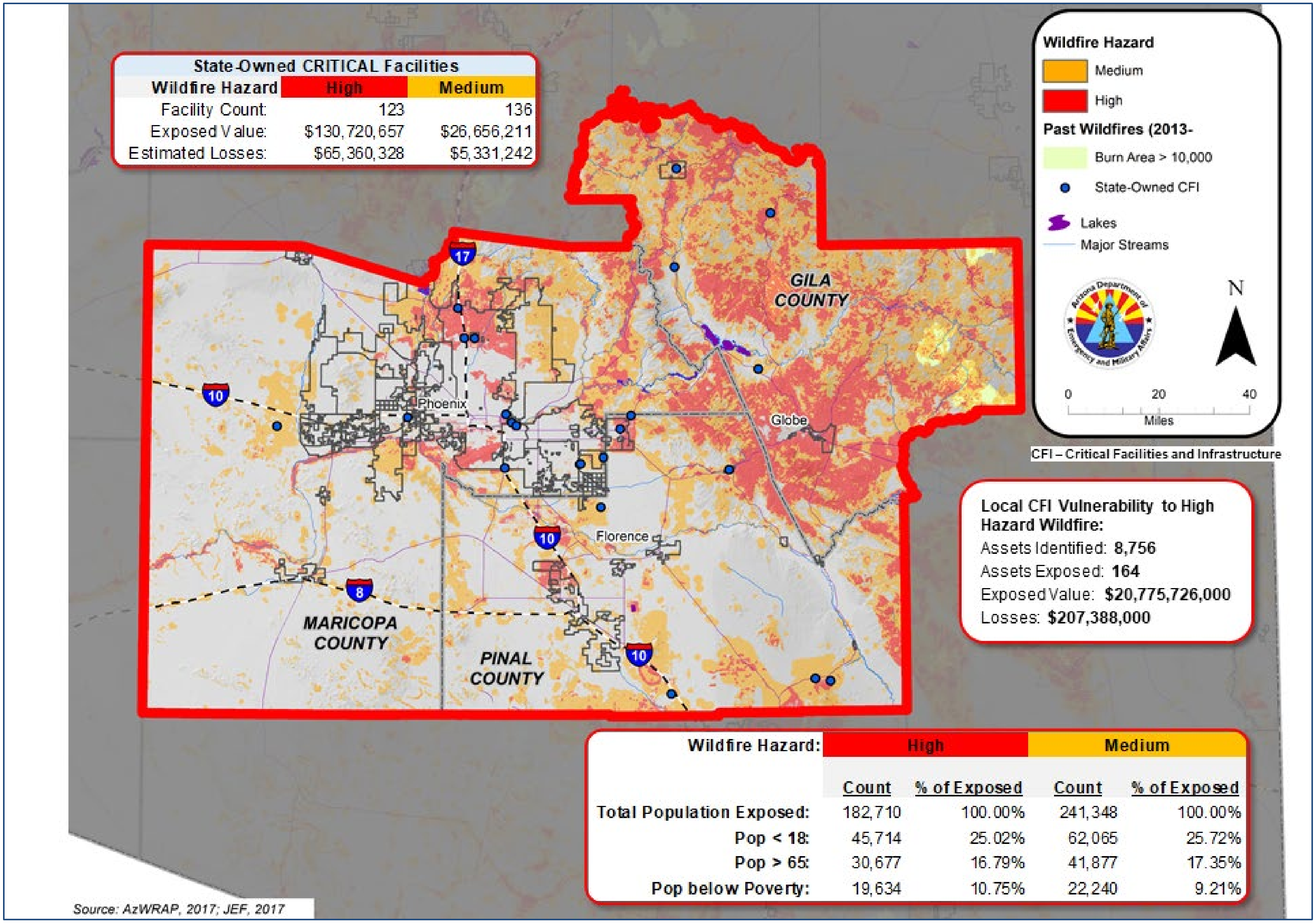
The North Region has large swaths of publicly accessible lands that serve as recreation areas for a wide population of the state. Those same areas are exposed to human-caused wildfire ignition potential through campfires, cooking equipment, and vehicles. In Mohave County, the northern Hualapai Mountains have substantial high hazard areas with limited road access and several small communities. There are also significant areas of high hazard surrounding Flagstaff, Williams, Prescott, and Sedona, which all have a large population of residents and structures located within the WUI. According to the Arizona Department of Forestry and Fire Management (AzDFFM) in a 2019 analysis, Pine Lake and Pinon Pine in Mohave County, and Highland Pines and Ponderosa Park in Yavapai County are included in the top 20 list of at risk communities for wildfire.

Central Region

Among the three state regions, the Central Region, shown in Map 56 is considered equally vulnerable to wildfires as the South Region and less vulnerable than the North. Maricopa and Pinal Counties have the largest WUI populations, but least significant exposure to high and medium hazard risks. Gila County has significant high and medium exposure risk to WUI communities, many of which have experienced major wildfire events in the last couple of years.

State-Owned CFI Exposure and Loss Estimates

A total of 155 state-owned CFI, or 64.6% of the statewide exposure, are located within a high hazard area. The exposed facilities represent a total exposed replacement value of $361.5 million, with an estimated $180.7 million in potential losses. For the medium hazard, a total of 151 state-owned CFI, or 39.7% of the statewide exposure, are exposed and represent a total replacement value of $216.7 million, with an estimated $43.3 million in potential losses.



Map 56. Wildfire vulnerability for the Central region

Vulnerable Population Groups

The 2022 estimated total population for the Central Region is 5,069,600 people. Approximately 6.7% and 7.2% of the total population, or 340,172 and 368,480 persons, are exposed to high and medium wildfire hazards. Exposure estimates for at-risk population groups like persons under 18-years of age, over 65-years of age, and those living at or below 150% poverty level are included on Map 56,

SVUC Impact Assessment

Wildfire high hazard impacts to Central Region SVUC are summarized by CDC SVI themes and percentile rankings in Table 37. The highest percentages of regional exposure are highlighted using bold text. The strongest majority of exposure is generally centered around the 0.50 - 0.75 index range. which would suggest a moderate SVUC vulnerability in Central Region communities.

Table 37. Wildfire high hazard SVUC exposure for Central Region

Region	CDC-SVI Assigned Percentile Rank	Percent of Impacted Area by SVI Percentile Rank Range				
		THEME 1 Socio-Economic Status	THEME 2 Household Characteristics	THEME 3 Racial and Ethnic Minority Status	THEME 4 Housing Type/ Transportation	THEMES (ALL) Overall Ranking
Central	NO DATA	0.88%	0.04%	0.04%	0.05%	0.89%
Central	0-0.25	16.89%	19.43%	**43.11%**	20.74%	21.63%
Central	0.25-0.50	15.82%	23.82%	6.06%	20.07%	10.96%
Central	0.50-0.75	**43.49%**	**36.26%**	20.30%	**35.27%**	**40.32%**
Central	0.75-0.90	22.29%	9.31%	8.25%	7.40%	24.52%
Central	0.90-1.00	0.63%	11.15%	21.41%	16.26%	1.68%

Local Jurisdiction Vulnerability

Local hazard mitigation plans for the Central Region identified a total of 534 assets with a total replacement value of $1.78 billion. Total potential losses to local CFI were estimated at $354.4 million.

Specific Areas of Concern

Maricopa and Pinal County portions of the Central Region have less fuel loading as compared to the North Region. However, there remain significant areas along the WUI perimeter that are vulnerable to wildfire and especially in the northern communities. The exception to this are the northern higher elevation areas of Gila County (Payson, Globe, Strawberry, and Pine), which have significant fuels and intermixed people and structures. Many of the river beds and regional watercourses have dense stands of overgrown salt cedar, which when ignited, can burn very hot and threaten nearby structures. According to the AzDFFM 2019 analysis, ten Gila Counties (Bear Flat, Six Shooter Canyon, R-C Camp, Kohls Ranch, Rose Creek, Ice House Kellner, Little Green Valley, Hunter Creek, Bonita

Creek Estates, and Ellison Creek Summer Homes are included in the top 20 list of at risk communities for wildfire.

South Region

Among the three state regions, the South Region, shown in Map 57 is considered equally vulnerable with the Central Region and less vulnerable than the North.

State-Owned CFI Exposure and Loss Estimates

A total of 22 state-owned CFI, or 9.2% of the statewide exposure, are located within a high hazard area. The exposed facilities represent a total exposed replacement value of $22.6 million, with an estimated $11.3 million in potential losses. For the medium hazard, a total of 46 state-owned CFI, or 12.1% of the statewide exposure, are exposed and represent a total replacement value of $58.2 million, with an estimated $11.6 million in potential losses.

Vulnerable Population Groups

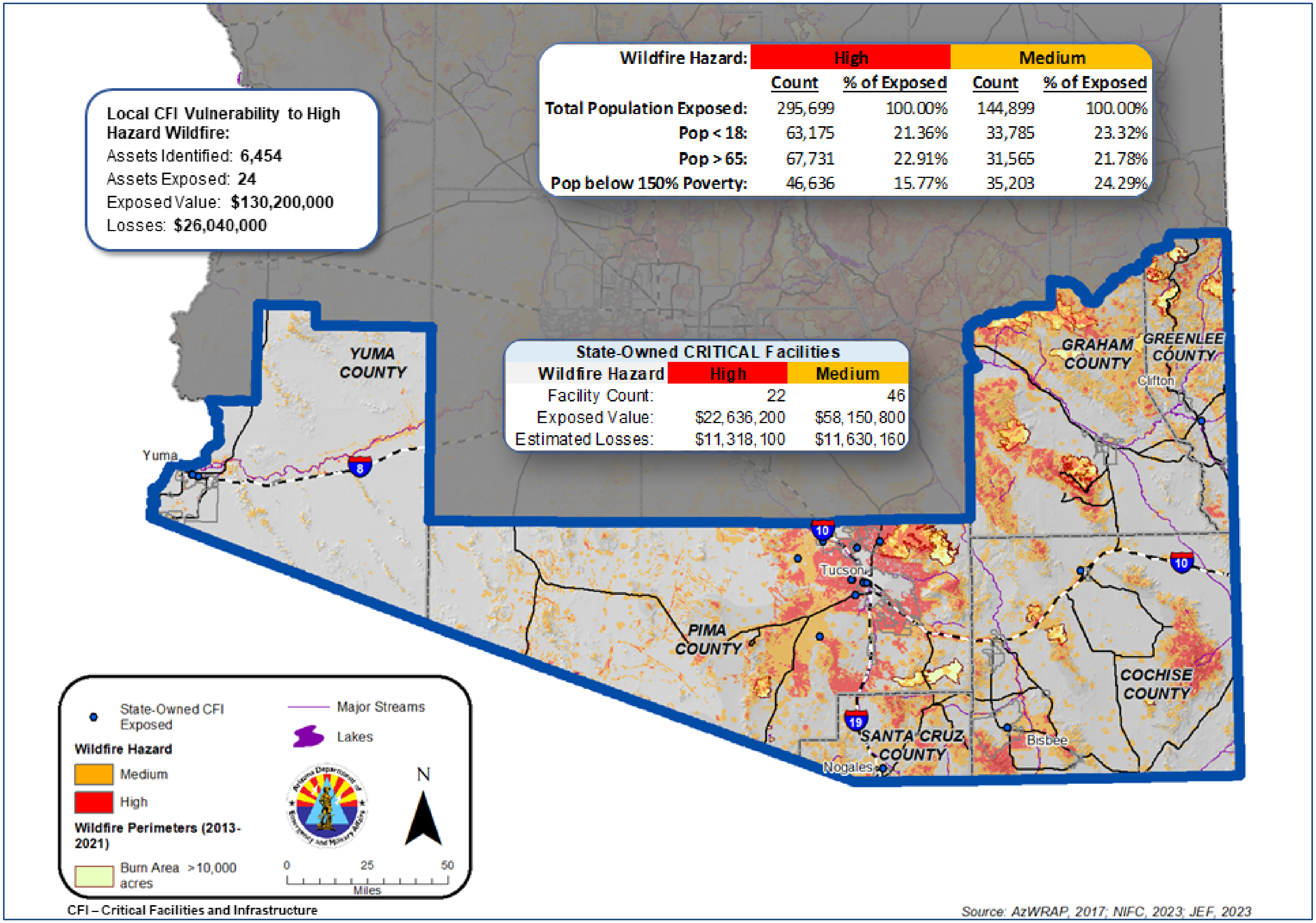
The 2022 estimated total population for the South Region is 1,487,942 people. Approximately 19.9% and 7.28% of the total population, or 295,699 and 144,899 persons, are exposed to high and medium wildfire hazards. Exposure estimates for at-risk population groups like persons under 18-years of age, over 65-years of age, and those living at or below 150% poverty level are included on Map 57

SVUC Impact Assessment

Wildfire high hazard impacts to South Region SVUC are summarized by CDC SVI themes and percentile rankings in **Error! Reference source not found.** The highest percentages of regional exposure are highlighted using bold text. The strongest majority of exposure is to areas with index ranking centered around the 0.50 index ranging between 0.25 and 0.9. This would suggest a moderate SVUC vulnerability in South Region communities.

Table 38. Wildire high hazard SVUC exposure for South Region

Region	CDC-SVI Assigned Percentile Rank	Percent of Impacted Area by SVI Percentile Rank Range				
		THEME 1 Socio-Economic Status	THEME 2 Household Characteristics	THEME 3 Racial and Ethnic Minority Status	THEME 4 Housing Type/ Transportation	THEMES (ALL) Overall Ranking
South	NO DATA	0.46%	0.46%	0.41%	0.46%	0.46%
South	0-0.25	16.92%	18.90%	25.89%	20.24%	18.32%
South	0.25-0.50	**37.10%**	**45.74%**	20.32%	20.41%	**34.74%**
South	0.50-0.75	22.93%	19.45%	**32.71%**	24.30%	18.71%
South	0.75-0.90	21.34%	12.97%	4.22%	**25.69%**	23.69%
South	0.90-1.00	1.21%	2.48%	16.45%	8.87%	4.04%



Map 57. Wildfire vulnerability for the South region

Local Jurisdiction Vulnerability

Local hazard mitigation plans for the South Region identified a total of 24 assets with a total replacement value of $130.2 million. Total potential losses to local CFI were estimated at $26.1 million.

Specific Areas of Concern

The foothills surrounding the Tucson Metropolitan area are predominantly indicated to have a high wildfire hazard, with a significant number of people and structures exposed. The mountainous areas in the eastern and northern portions of the region have a higher wildfire potential, but limited population and structure exposure. In other areas of the South region, WUI exposure is limited and scattered. As with the Central Region, many of the river beds and regional watercourses have dense areas of overgrown salt cedar, which, when ignited, can burn very hot and threaten nearby structures. According to the AzDFFM 2019 analysis, Ramsey Canyon (Cochise County), Top of the World (Pinal County), Summerhaven, Catalina, Catalina Foothills, and Arivaca Junction (Pima County) are included in the top 20 list of at-risk communities for wildfire.

RESOURCES

Sources

AZ Emergency Information Network, http://www.azein.gov/

AZ Geological Survey, AZGS | Geosciences serving Arizona since 1887

AZ State Land Dept, Division of Forestry, http://www.azsf.az.gov/

AZ Wildfire Risk Assessment Portal, https://arizonawildfirerisk.com/

InciWeb Incident Information System, https://inciweb.nwcg.gov/

Southwest Coordination Center, http://gacc.nifc.gov/swcc/

US Forest Service, Fire and Aviation Management, Fire and Aviation Management | US Forest Service (usda.gov)

US Dept of Interior, Bureau of Land Management, Fire and Aviation, Fire | Bureau of Land Management (blm.gov)

Western Forestry Leadership Coalition: Wildland Fire and the Wildland-urban Interface | Western Forestry Leadership Coalition (thewflc.org)

References

AZCentral.com, http://www.azcentral.com/story/news/arizona/2014/06/26/san-juan-fire-burning-abrk/11425023/

Arizona Department of Forestry and Fire Management, 2019, Ranked List of Highest Risk Communities in Arizona. Authour unknown.

AZRepublic, June 30, 2003, *Past Wildfires at a Glance*

AZRepublic, June 20, 2003, *Largest Wildfires in Arizona History*.

Dale, L., 2010, *The True Cost of Wildfire in the Western U.S.*, Western Forestry Leadership Coalition, https://www.blm.gov/or/districts/roseburg/plans/collab_forestry/files/TrueCostOfWilfire.pdf

Evans, A., 2015, *2014 Wildfire Season: An Overview, Southwestern U.S.*, Ecological Restoration Institute and Southwest Fire Science Consortium, Northern Arizona University. 20 p.

Evans, A. 2017, *2016 Wildfire Season: An Overview, Southwestern U.S*. Technical Report. Ecological Restoration Institute and Southwest Fire Science Consortium, Northern Arizona University. 12 p.

FEMA. August 2001. How-To Guide #2: Understanding Your Risks – Identifying Hazards and Estimating Loss Potential (FEMA 386-2).

FEMA, Interagency/Intergovernmental Watershed Task Force. Sept 2002, *Rodeo-Chediski Fire Watershed Recovery Report, FEMA-DR-1422-AZ*.

Federal Register. Aug 17, 2001. *Urban Wildland Interface Communities within the Vicinity of Federal Lands That Area at High Risk from Wildfire*; Notice. Vol. 66, No. 160.

Garfin, G., G. Franco, H. Blanco, A. Comrie, P. Gonzalez, T. Piechota, R. Smyth, and R. Waskom, 2014, *Ch. 20: Southwest. Climate Change Impacts in the United States: The Third National Climate Assessment*, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., US Global Change Research Program, 462-486. doi:10.7930/J08G8HMN

Gonzalez, P., G.M. Garfin, D.D. Breshears, K.M. Brooks, H.E. Brown, E.H. Elias, A. Gunasekara, N. Huntly, J.K., Maldonado, N.J. Mantua, H.G. Margolis, S. McAfee, B.R. Middleton, and B.H. Udall, 2018: *Southwest. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 1101–1184. doi: 10.7930/NCA4.2018.CH25. On the Web: https://nca2018.globalchange.gov/chapter/southwest

International Fire Code Institute, 2000, *Urban-Wildland Interface Code*.

Kent, L.Y., 2015, *Climate Change and Fire in the Southwest*. ERI Working Paper No. 34. Ecological Restoration Institute and Southwest Fire Science Consortium, Northern Arizona University, Flagstaff. 6 p.

Lynch, M., and A. Evans. 2018, *2017 Wildfire Season: An Overview, Southwestern U.S. Special Report*. Ecological Restoration Institute and Southwest Fire Science Consortium, Northern Arizona University. 20 p.

Lynch, M., and A. Evans. 2019, *2018 Wildfire Season: An Overview, Southwestern US. Special Report*. Ecological Restoration Institute and Southwest Fire Science Consortium, Northern Arizona University. 19 p.

Lynch, M., and A. Evans, 2020. *2019 Wildfire Season: An Overview, Southwestern US. Special Report*. Ecological Restoration Institute and Southwest Fire Science Consortium, Northern Arizona University. 20 p.

Lynch, M., and A. Evans, 2021. *2020 Wildfire Season: An Overview, Southwestern US. Special Report*. Ecological Restoration Institute and Southwest Fire Science Consortium, Northern Arizona University. 18 p.

Lynch, M., L. Wood Miller, and A. Evans. 2022, *2021 Wildfire Season: An Overview, Southwestern US. Special Report.* Ecological Restoration Institute and Southwest Fire Science Consortium, Northern Arizona University. 22 p.

National Interagency Fire Center, 2023, Open Data Site accessed at: https://data-nifc.opendata.arcgis.com/

Saiz, C., L. Wood Miller, and A. Evans. Draft 2023, *2022 Wildfire Season: An Overview, Southwestern US. Special Report*. Ecological Restoration Institute and Southwest Fire Science Consortium, Northern Arizona University.

Southwest Coordination Center, 2017, *Southwest Area Fires & Acres by State.*

WINTER STORM

DESCRIPTION

Winter storms in Arizona can include heavy snowfall, freezing rain, and sleet. Heavy precipitation associated with winter storms has the potential to collapse roofs, topple trees and power poles, and cause road closures due to the rapid accumulation of snow or ice. Winter highway conditions can turn injurious or even deadly, with slippery or icy roads causing multi-vehicle accidents, hypothermic exposure to cold and wet conditions, and impassable roads stranding travelers, isolating residents, and preventing emergency response.

ADOT snow plow clearing snow on SR260 east of Payson, AZ
Source: (azfamily.com, 2011)

HISTORY

Since 1966, Arizona has had a total of 11 state declarations related to winter storm events that included some blending of higher altitude snow accumulation and lower altitude rainfall and flooding, plus wind and extreme temperatures, and a total of Governor's Emergency Fund allocations of $7,118,504. One of those events received a presidential disaster declaration, with $5,563,626 in federal funds expended. Since 2017, there have been 13 winter storms incidents reporting a loss, injury or fatality. The total of losses reported is $310,000 with one fatality. (NCDC Storm Event Database, 2023).

The following represent some of the more significant winter storms in the past 15- years of Arizona's history:

- January 26-27, 2021 – Rain and snow showers created slippery roads in parts of eastern Pima County, which led to numerous, mainly minor, traffic accidents along Interstate 19 near Green Valley and Sahuarita and along Interstate 10 in the northwest Tucson Metro area. One accident on I-10 near the Cochise County line resulted in a rollover, which caused one east bound lane to be closed for an hour. No injuries were reported and losses were estimated at $100,000. (NCDC Storm Event Database, 2023).
- February 21-22, 2019 – A relatively strong and cold weather system impacted southeast Arizona resulting in heavy snow across area mountain ranges with locations above 5000 feet receiving one to two and a half feet of snow. Snow levels dropped to 2000 feet during the morning of the 22nd with snow reports ranging from 2 to 10 inches on the valley floors. Numerous accidents and road closures resulted with losses estimated to exceed $120,000. (NCDC Storm Event Database, 2023)
- January 1-3, 2019 – A winter storm over the southern portion of the state dumped heavy snow with depths ranging from 2 to 7 inches. Numerous accidents and road closures resulted with losses estimated to exceed $100,000 and fatality. (NCDC Storm Event Database, 2023)

- January 20-21, 2017 – A winter storm caused heavy snow and damaging winds on the Santa Catalina, Chiricahua, Galiuro, Pinaleno, Dragoon, and Rincon Mountains. Power was lost to Mount Lemmon for 48 hours and communication towers were inoperable for several hours. Roads were blocked from snow and rain triggered rock slides that also damaged guard rails. Storm-wide damages were estimated to exceed $177,000 (NCEI, 2017).

- January 18-23, 2010 – A series of strong Pacific winter storms produced lower altitude rain and heavy mountain snow to fall over a significant portion the north half of the state. Heavy snow closed roadways and caused numerous traffic problems and stranded vehicles. Strong winds accompanying the storms also created blizzard conditions for several hours. DPS responded to over 150 requests for help, 14 non-injury collisions, and four injury collisions. There was one fatal crash about six miles east of Flagstaff. In Flagstaff, 10-15 buildings either suffered from collapsed roofs or developed structural problems because of the weight of over 25 inches of snow that fell during the week of storms. The City of Flagstaff issued an emergency order requiring all buildings with flat roofs to be cleared of snow and ice On February 16, 2010, the Governor requested a major disaster declaration due to a severe winter storm/snowstorm emergency during the period of January 18-22, 2010, and then amended the request on February 24, 2010, to include flooding and high winds and to clarify that the request was for a severe winter storm, snowstorm, flooding, and high wind event. A presidential disaster declaration was received on March 18, 2010 (DEMA/EM, AZ Central, NCEI Storm Event Database).

Roof damage from January 2010 snow storm in Flagstaff, AZ
Source: Betsy Bruner, AZ Daily Sun

- November 28, 2009 – The early stages of an approaching winter storm caused a bridge to ice up on I-17 near Munds Park. A semi-truck slid on the ice, crossed a median and struck an officer investigating a van rollover. The officer was pinned under a third vehicle; other drivers were able to lift the vehicle off the officer, free him, and call for help. He was taken to a local hospital where he was in critical but stable condition. Property damages were estimated to exceed $100,000 (NCEI Storm Event Database).

- October 28, 2009 – A departing low-pressure center brought snow showers and cold conditions to the Flagstaff area during the afternoon and early evening which lead to icy roads and a few dozen car wrecks. The Department of Public Safety reported 11 collisions, Coconino Co Sheriff's Office reported seven traffic accidents with injuries, and the Flagstaff Police Dept. reported 14 traffic accidents. A parked DPS patrol car was hit and totaled by a truck that slid on the ice on I-40 just west of Flagstaff. The officer was out of his vehicle investigating a single vehicle roll over and was not hurt. Property damages were estimated to exceed $400,000 (NCEI Storm Event Database).

- December 2008 – A three-day winter storm in northern Arizona dropped 24 inches of snow at 7,000 ft, and nearly 48 inches at 9,000 ft. resulting in hazardous road conditions with the Department of Public Safety reported 188 cars slid off the highway in northern Arizona, and 65 collisions, 12 with injuries (NCEI Storm Event Database).
- March 2008 – An intense winter snow storm reduced visibility to zero on I-40 near Flagstaff, leading to a 139-vehicle pile-up covering four miles on both sides of the highway. Eastbound lanes were closed for 14 hours, westbound for 16 hours. Two deaths were reported, along with 10 people hospitalized with serious injuries and another 35 people treated and released (NCEI Storm Event Database).

The table below summarizes snowfall related historic records for Arizona.

Table 39. Snowfall record depths in Arizona

Event	Amount (Inches)	Date	Location
Record Max Yearly	400.9	1972-73	Sunrise Mountain
Record Max 1-Day	42.0	Jan 21, 2010	Flagstaff 1.4 W
Record Max 3-Day	95.0	Jan 22, 2010	Flagstaff 1.4 W
Source: NCEI at https://www.ncei.noaa.gov/access/monitoring/snowfall-extremes/AZ			

PROBABILITY/EXTENT

The probability of a winter storm with significant snow accumulation is high for most of the North Region, and small areas within the Central and South Regions that are located above 5,000 feet in elevation. The Planning Team chose to use two data sets to depict the probability and extent of the snow hazard. The first is a nationwide snow climatology statistics data set compiled by the then National Climatic Data Center[28] using 1948-1996 records from weather stations across the country[29]. From this data, the NCDC developed one-, two-, and three-day, 10-, 25-, 50- and 100-year recurrence interval snow depth estimates for each of the statistically eligible[30] stations. The second source of data is maintained by the NCEI and reports the maximum one-day, two-day, and three-day duration snow depths for weather stations across the nation, through June 30, 2021. The NCEI data was processed by the Planning Team using GIS tools, to develop zones of maximum snowfall depth for each of the one, two, and three-day durations. Bordering gage stations in California, Nevada, Utah, Colorado, and New Mexico were used to ensure that no boundary effects were created at the Arizona borders. The max 3-day zonal generation results, along with the NCDC 100-year recurrence interval probabilities for the three-day durations are shown in Map 58.

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[28] The NCDC is now the National Centers for Environmental Information, and is a part of the USDepartment of Commerce, National Oceanic and Atmospheric Administration.

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

[30] Those stations with sufficient continuous data.

WARNING TIME

The National Weather Service is able to provide warning for an impending winter storm that is typically 24-48 hours or more in advance of the storm. The National Weather Service in Flagstaff uses the following criteria for issuing warnings about winter storm weather:

Blizzard Warning: Sustained winds or frequent gusts of 35 mph or more, AND visibility frequently below 1/4 mile in considerable snow and/or blowing snow, AND above conditions are expected to persist for three hours or longer.

Winter Storm Warning: Issued when more than one winter hazard is involved producing life-threatening conditions, such as a combination of heavy snow, strong winds producing widespread blowing and drifting snow, freezing rain, or wind chill. Table 40 and Table 41 provide heavy snow warning and snow advisory criteria.

Table 40. Heavy snow warning criteria

Elevation	Inches / 12 Hr	Inches / 24 Hr
Above 8,500 ft	12 inches/12 hrs	18 inches/24 hrs
7,000 to 8,500 ft	8 inches/12 hrs*	12 inches/24 hrs*
5,000 to 7,000 ft	6 inches/12 hrs	10 inches/24 hrs
Below 5,000 ft	2 inches/12 hrs	4 inches/24 hrs

*(Flagstaff is located in these elevation criteria)

Table 41. Snow advisory criteria

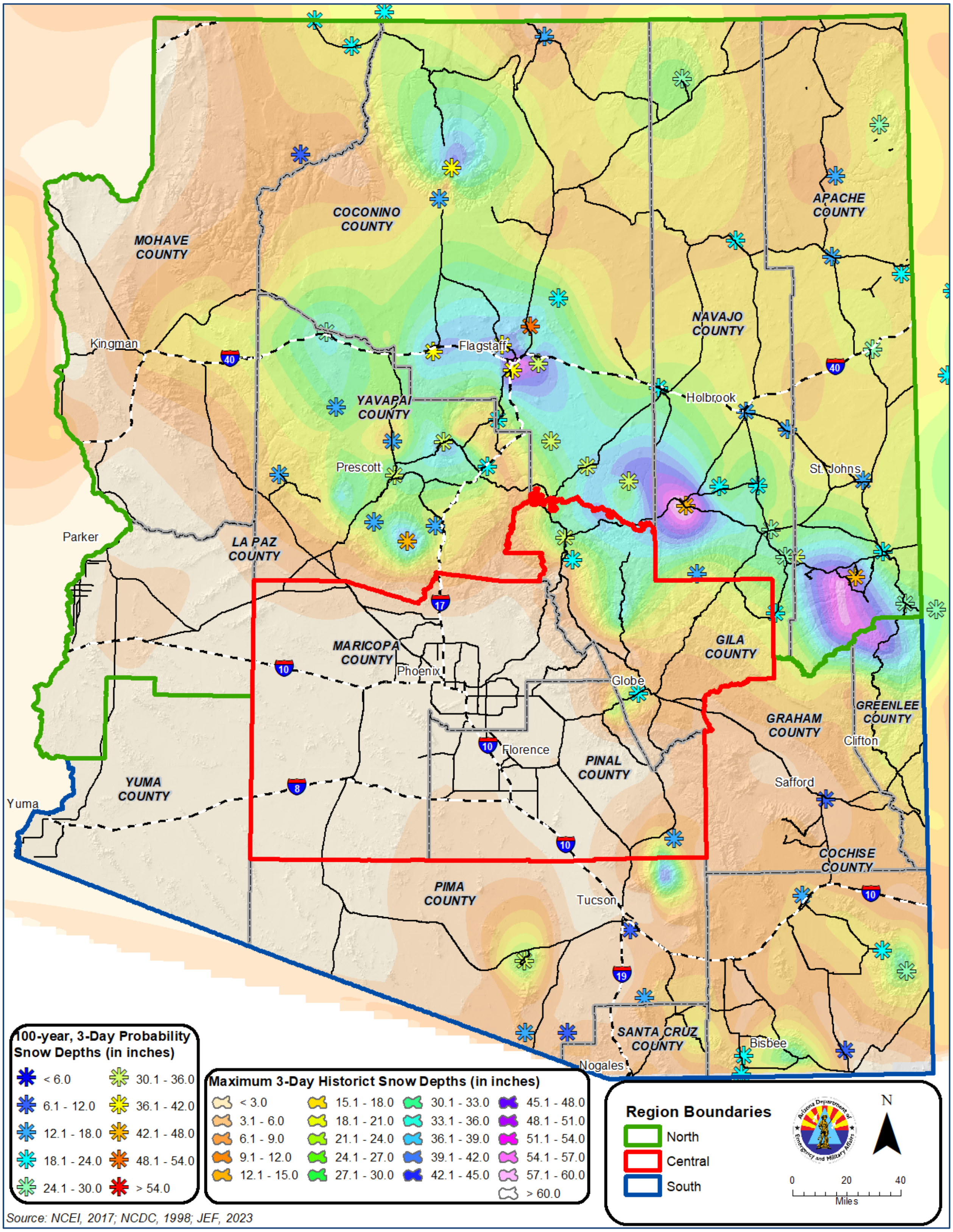
Elevation	Inches / 12 Hr	Inches / 24 Hr
Above 8,500 ft	6 to 12 inches/12 hrs	12 to 18 inches/24 hrs
7,000 to 8,500 ft	4 to 8 inches/12 hrs*	8 to 12 inches/24 hrs*
5,000-7,000 ft	3 to 6 inches/12 hrs	6 to 10 inches/24 hrs
Below 5,000 ft	1 to 2 inches/12 hrs	2 inches/24 hrs**

*(Flagstaff is located in this elevation criteria) **or snow accumulation in any location where it is a rare event.

Blowing Snow Advisory Criteria: Issued when visibility frequently at or below 1/4 mile.

Wind Chill: Issued when there is a wind chill factor of minus 20°F or colder.

Freezing Rain/Drizzle or Sleet: Issued when there is widespread, dangerous, and damaging accumulations of ice or sleet.



Map 58. Maximum 3-day snowfall depths vs 100-year, 3-day probable snow depths

Frost or Freeze Warning: Issued when temperatures are critical for crops and sensitive plants. Criteria is season dependent, but usually, a freeze warning is appropriate when temperatures are expected to fall below freezing for at least two hours.

FUTURE CONDITIONS

Climate Considerations

The NCA reports (Garfin, et al., 2014 and Gonzales, et.al., 2018) anticipate that over the duration of the 21st century, changes in the Southwest climate may result in up to a 50% decrease in April 1 snowpack due to warmer temperatures. The study also anticipates an exchange of snow producing winter storm events with more rain based storms, and there are also mentions of winter storm events increasing in intensity when the events do occur. It is anticipated that, regarding the single event based accumulations, the past may be an adequate indicator of future risks.

Changes in Development

Winter Storm specific changes in vulnerability to state CFI due to changes in development are essentially neutral. Region specific impacts are discussed below.

North Region

Low to moderate development of areas around established cities that are generally located north of the Mogollon Rim such as Flagstaff and Show Low, is expected over the next five years. Increases to traffic and population numbers being exposed to winter storm effects will increase the overall risk in these areas.

Central Region

Anticipated development and growth associated with most of the Central Region areas is not expected to be significantly impacted by the risk of winter storm, primarily due to the low elevations, lack of history and low probability of damaging storm events. The only exceptions to this may be areas around Payson and Globe in Gila County. The increased risk is low however, as both areas are not anticipated to experience significant growth over the next five years and the snow related hazard is moderately low.

South Region

Similar to the Central Region, snow related risks to anticipated growth in the South Region are minimal as most of the anticipated growth areas (Tucson Metropolitan area) are not at risk to snow storms. The exceptions include any expansion of development into the Santa Catalina, Pinaleño, and Dragoon Mountain areas, which is expected to be minimal if any.

VULNERABILITY ASSESSMENT

From a historical perspective, both human and infrastructure losses could be expected with a major winter storm event, and especially regarding traffic accidents, structural loading, and human exposure. Vulnerability of state-owned buildings and infrastructure exists in the form of potential roof collapse or other damages associated with excessive snow-loads; however, estimation of potential losses to state-owned structures and buildings is difficult and would require detail analysis of the load-bearing capacities and design standards used when the buildings were constructed. Instead, a more generalized approach will be used to estimate the number of potentially vulnerable structures and their exposed value.

Freestone (2006) conducted research on the climatology of snow loads for Arizona and the use of ground snow load estimates in the structural design of buildings located in areas where snow loading can be a factor. One product of the research was a statistical analysis of snow data to produce 30-year and 50-year (3.33% and 2.0% annual chance of exceedance) probability estimates of extreme event ground snow loads for gage locations throughout Arizona. These recurrence intervals are specified for use by modern building standards.

Freestone also noted that ground snow loads that are less than 12 pounds per square foot (or approximately 18-inches of normal snow depth) are considered negligible for buildings constructed using modern building codes. Accordingly, only state-owned facilities exposed to 50-year ground snow depths of greater than 18-inches will be considered as vulnerable, and no attempt to estimate losses will be made. It is noted that through inspection of the 50-year depths map, the majority of the Central and South Regions are not expected to produce winter storm snow depths greater than the 18-inch threshold.

For this Plan, all the state's population is considered exposed to some form of winter storm event and is reported as such in the following discussions. It is recognized, however, that winter storms in the region areas generally above 5,000 feet in elevation pose the most significant threat, with the North Region having the highest exposure.

Map 59 depicts the vulnerability for state-owned CFI for all three regions on a single map.

North Region

The North Region has the greatest vulnerability to winter storm due to the overall history of deeper snow depths, and exposure of population and state-owned buildings. It is noted, that nearly all the historic winter storm related traffic deaths and injuries have occurred in the North Region stretches of I-17 and I-40, and other major highways that pass through the region.

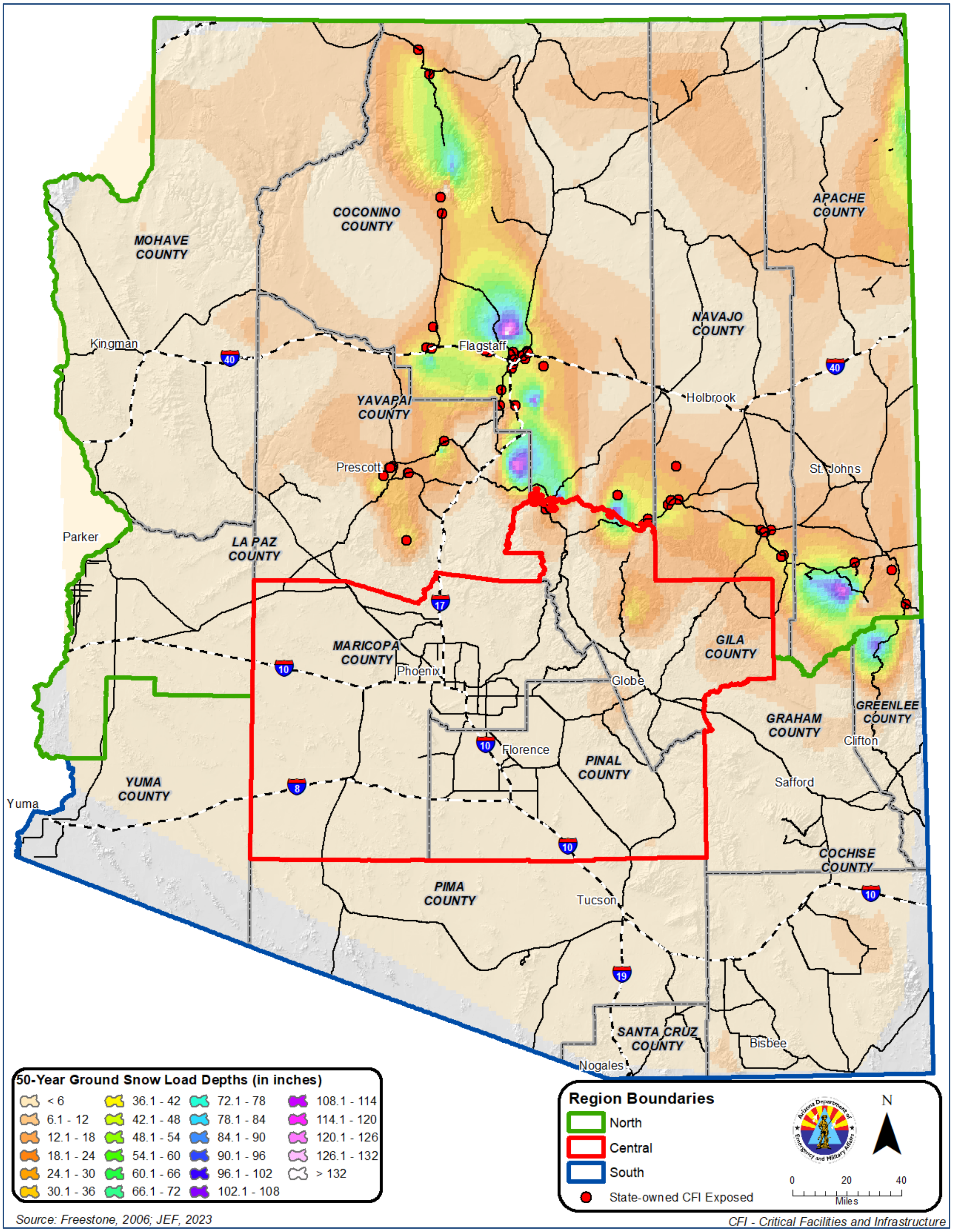
State-Owned CFI Exposure and Loss Estimates

A total of 860 state-owned CFI, or 1 structure short of 100% of the statewide exposure, are located within an area with a projected 50-year ground snow load depth of 18 inches or more. The exposed facilities represent $2.66 billion in replacement value. No losses are estimated.

Vulnerable Population Groups

The entire 2022 estimated population of 801,655 people are considered to be exposed to winter storm events, with the population groups located above 5,000 feet in elevation being most vulnerable.

Map 59



Map 59. Vulnerability to 50-year ground snow loading

SVUC Impact Assessment

Winter Storm impacts to North Region SVUC are summarized by CDC SVI themes and percentile rankings in **Error! Not a valid bookmark self-reference.**. The highest percentages of regional exposure are highlighted using bold text. The strongest majority of exposure is to areas with index ranking centered around the 0.50 to 0.75 range with a Theme 3 majority in a flaggable range, suggesting a moderately high SVUC vulnerability in North Region communities.

Table 42. Winter Storm SVUC exposure for North Region

Region	CDC-SVI Assigned Percentile Rank	Percent of Impacted Area by SVI Percentile Rank Range				
		THEME 1 Socio-Economic Status	THEME 2 Household Characteristics	THEME 3 Racial and Ethnic Minority Status	THEME 4 Housing Type/ Transportation	THEMES (ALL) Overall Ranking
North	NO DATA	1.00%	1.00%	0.93%	2.51%	2.51%
North	0-0.25	11.66%	17.85%	29.90%	5.13%	7.82%
North	0.25-0.50	25.83%	17.57%	15.75%	23.55%	22.51%
North	0.50-0.75	**34.42%**	**24.63%**	21.96%	**38.82%**	**30.84%**
North	0.75-0.90	26.44%	19.87%	0.86%	18.29%	28.64%
North	0.90-1.00	0.66%	19.08%	**30.59%**	11.70%	7.68%

Local Jurisdiction Vulnerability

Apache, Coconino, Navajo, and Yavapai Counties address winter storm in each of their mitigation plan's risk assessment. Conclusions of the vulnerability analysis are similar to what is presented in this Plan and no specific losses or critical facility exposures are made. The Coconino Plan estimated a general annual loss of $500,000 could be expected, at least one fatality and multiple injuries could result. The other plans all noted that past events were likely to be indicative of potential future losses in terms of infrastructure and human safety.

Specific Areas of Concern

Interstates 17 and 40 are major transportation corridors that receive year-around heavy use by the traveling public and commercial long-haul truckers. Snow and ice associated with winter events has been the leading cause of deaths and injuries related to winter storms and continues to be a significant concern. Another concern is the number of remote populations that can easily become isolated and stranded for weeks by heavy snow events, with a particular focus on the Hopi and Navajo Nations.

Central Region

The Central Region is considered the second most vulnerable to winter storm events, primarily due to the populations and infrastructure located in the upper elevations of Gila County, including Payson, Pine, Strawberry, Young, and the Miami-Globe area.

State-Owned CFI Exposure and Loss Estimates

One state-owned CFI located in the Central Region is exposed to 50-year snow depths exceeding 18 inches and represents $72,000 in replacement costs. No lossess are estimated.

Vulnerable Population Groups

The entire 2022 estimated population of 5,069,600 people are considered to be exposed to some level of winter storm hazard, with the highest risk areas being those parts of the region within Gila County that are generally located above 5,000 feet in elevation.

SVUC Impact Assessment

Winter Storm impacts to Central Region SVUC are summarized by CDC SVI themes and percentile rankings in Table 43. The highest percentages of regional exposure are highlighted using bold text. The strongest majority of exposure is generally centered around the 0.50 - 0.75 index range with Theme 3 being nearer the bottom quartile. which would suggest a moderate SVUC vulnerability in Central Region communities.

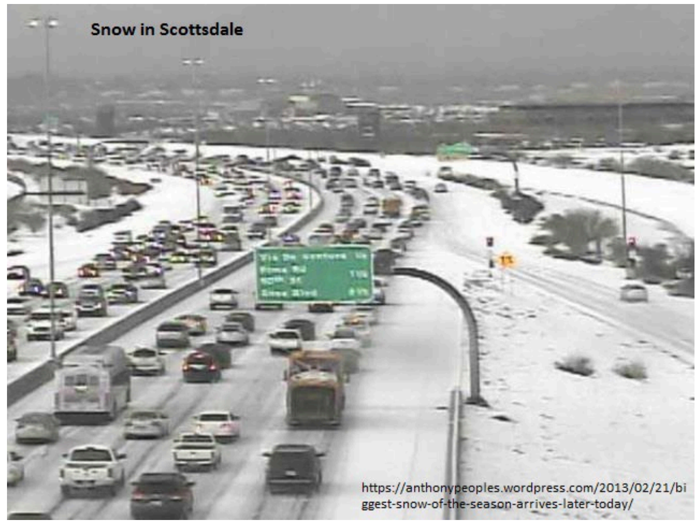
Table 43. Winter Storm SVUC exposure for Central Region

Region	CDC-SVI Assigned Percentile Rank	Percent of Impacted Area by SVI Percentile Rank Range				
		THEME 1 Socio-Economic Status	THEME 2 Household Characteristics	THEME 3 Racial and Ethnic Minority Status	THEME 4 Housing Type/ Transportation	THEMES (ALL) Overall Ranking
Central	NO DATA	6.15%	6.02%	6.01%	6.03%	6.16%
Central	0-0.25	13.03%	23.17%	**32.99%**	15.15%	14.84%
Central	0.25-0.50	17.02%	14.54%	12.75%	27.98%	20.04%
Central	0.50-0.75	**46.43%**	**35.53%**	21.66%	**36.57%**	**38.29%**
Central	0.75-0.90	16.21%	13.67%	12.71%	3.67%	16.32%
Central	0.90-1.00	1.17%	7.06%	13.88%	10.58%	4.34%

Local Jurisdiction Vulnerability

Gila County is the only Central Region county to address winter storm in their mitigation plan risk assessment. Conclusions of the Gila County vulnerability analysis are similar to what is presented in this Plan and no specific losses or critical facility exposures are made. The Gila Plan noted that past events were likely to be indicative of potential future losses in terms of infrastructure and human safety.

Specific Areas of Concern



The most notable areas of concern for the Central Region include the remote populations and developments located along the Mogollon Rim area in Gila County becoming isolated or cut-off for significant periods of time due to heavy snow. It is also notable that although rare, small amounts of snow and ice in the urbanized Phoenix Metropolitan Area can cause businesses and schools to shut down due to lack of equipment or capacity to deal with snow covered streets and roadways, and a general public that is unfamiliar with winter driving conditions and hazards.

South Region

The South Region is considered the least vulnerable to winter storm due to the lowest historic snow amounts and exposed population and facilities. The only notable exceptions include the higher elevation portions of Graham and Greenlee Counties, the small community of Summerhaven at the top of Mount Lemmon, and areas near the Dragoon Mountains in Cochise County.

State-Owned CFI Exposure and Loss Estimates

None of the state-owned CFI within the South Region are exposed to 50-year ground snow loads of 18-inches or more, and no losses are estimated.

Vulnerable Population Groups

The entire 2022 estimated population of 1,487,942 people are considered to be exposed to winter storm events, and especially those residing in areas generally above the 5,000 foot level.

SVUC Impact Assessment

Winter Storm impacts to South Region SVUC are summarized by CDC SVI themes and percentile rankings in Table 44 The highest percentages of regional exposure are highlighted using bold text. The strongest majority of exposure is to areas with index ranking centered around the 0.75 index ranging between 0.25 and 0.9. This would suggest a moderately high SVUC vulnerability in South Region communities.

Table 44. Winter Storm SVUC exposure for South Region

Region	CDC-SVI Assigned Percentile Rank	Percent of Impacted Area by SVI Percentile Rank Range				
		THEME 1 Socio-Economic Status	THEME 2 Household Characteristics	THEME 3 Racial and Ethnic Minority Status	THEME 4 Housing Type/ Transportation	THEMES (ALL) Overall Ranking
South	NO DATA	7.93%	7.93%	7.85%	7.93%	7.93%
South	0-0.25	5.22%	7.46%	15.40%	10.74%	5.32%
South	0.25-0.50	**36.64%**	24.95%	14.32%	10.81%	21.34%
South	0.50-0.75	26.20%	24.97%	**38.82%**	24.94%	**34.01%**
South	0.75-0.90	23.55%	**29.48%**	3.70%	**27.38%**	23.95%
South	0.90-1.00	0.46%	5.20%	19.91%	18.21%	7.44%

Local Jurisdiction Vulnerability

None of the South Region counties included winter storm in their risk assessments.

Specific Areas of Concern

The community of Summerhaven can quickly become isolated if the Catalina Highway becomes impassable due to heavy snow and ice, or by snow triggered mudslides and debris flows. It is also notable that although rare, small amounts of snow and ice in the urbanized Tucson Metropolitan Area can cause schools and businesses to shut down due to lack of equipment or capacity to deal with snow covered streets and roadways, and a general public that is unfamiliar with winter driving conditions and hazards.

RESOURCES

Sources

NOAA National Centers for Environmental Information, Snowfall Extremes, https://www.ncei.noaa.gov/access/monitoring/snowfall-extremes/AZ

NWS, Flagstaff Warning and Forecast Office, http://w2.weather.gov/climate/index.php?wfo=fgz

References

FEMA, 1997, Multi-Hazard Identification & Risk Assessment – A Cornerstone of the Nat'l Mitigation Strategy. Part 1, Map 7-1, p 79.

Freestone, Scott Brent, 2006, A Review of Climatological Data for Ground Snow Loads in Arizona.

Garfin, G., G. Franco, H. Blanco, A. Comrie, P. Gonzalez, T. Piechota, R. Smyth, and R. Waskom, 2014, *Ch. 20: Southwest. Climate Change Impacts in the United States: The Third National Climate Assessment*, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., US Global Change Research Program, 462-486. doi:10.7930/J08G8HMN

Gonzalez, P., G.M. Garfin, D.D. Breshears, K.M. Brooks, H.E. Brown, E.H. Elias, A. Gunasekara, N. Huntly, J.K., Maldonado, N.J. Mantua, H.G. Margolis, S. McAfee, B.R. Middleton, and B.H. Udall, 2018: *Southwest. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 1101–1184. doi: 10.7930/NCA4.2018.CH25. On the Web: https://nca2018.globalchange.gov/chapter/southwest

National Oceanic and Atmospheric Administration, National Climatic Data Center, 1998, *United States Snow Climatology*, TD-9641.

SECTION 5: MITIGATION STRATEGY

SECTION CHANGES

The goals and objectives section has been revised to reflect new FEMA requirements and to refine the objectives.

MITIGATION GOALS AND OBJECTIVES

The mitigation goal and objectives were reviewed to ensure they continue to represent the statewide mission and responsibilities related to hazard mitigation. They were revised to reflect the State of Arizona's dedication to building awareness, capabilities, and resilience, recognizing the needs of socially vulnerable and underserved communities, and actively engaging with local and tribal governments to empower them to reduce vulnerability for all people and property. The goal and objectives are as follows:

Hazard Mitigation Goal

Increase resilience throughout the State of Arizona by reducing the vulnerability of people and property to natural and human-caused hazards.

Objectives

1. Increase state, tribal, and local government awareness regarding Arizona's hazards and risks.
2. Promote hazard mitigation throughout Arizona.
3. Ensure the well-being of Arizona's residents, businesses, and visitors by lessening the impact of hazards and empowering them to reduce vulnerability through increased public awareness.
4. Reduce the vulnerability of critical facilities and infrastructure to natural and human-caused hazards.
5. Identify and pursue funding sources for hazard mitigation projects.
6. Identify and reduce the number of repetitive loss and severe repetitive loss properties.
7. Identify and reduce vulnerabilities to and from high hazard potential dams and potential consequences associated with dam incidents.

MITIGATION MEASURES

The mitigation measures outlined in this Plan are large-scale overarching measures that support the communities of Arizona. The hazards identified in the risk assessment are inclusive of all major hazards, and therefore, encompass the major risks and vulnerabilities of local, county, and tribal jurisdictions. The State of Arizona, in partnership with local, county, and tribal governments, utilizes a holistic, decentralized approach for hazard mitigation in an attempt to attain the common goal of reducing and/or eliminating the impact of hazards, resulting in increased resilience.

The 2018 Plan's Mitigation Strategy was evaluated to determine the status and disposition of the mitigation measures. The possible dispositions were to delete, revise, and remain in the Plan. A summary of the 2018 Plan mitigation measures and actions with status and disposition and supporting information are located in Annex B. Each 2018 Plan measure or action carried forward is noted in the Plan list of measures and actions as "Continued from Prior Plan" and includes a brief summary of the assessment. New measures and actions are noted as such.

The mitigation measures included in this Plan update were prioritized using a model that allowed lead agencies to prioritize the mitigation measures they are responsible for implementing. Agencies and departments have varying levels of staff and finances, and may have different leadership priorities. All measures and actions within the mitigation strategy were categorized by the lead agency with either a high, medium, or low designation. Selection of the ranking designation was based on an objective evaluation of the measure/action regarding the success in satisfying the following categories of effectiveness:

- Direct impact on life;
- Direct impact on property;
- Long-term solution;
- Benefit vs. cost;
- Environmentally & technically sound;
- Repetitive & severe repetitive loss properties;
- Availability of funds;
- Availability of staff; and
- Agency leadership priorities.

In general, each mitigation action/measure (A/M) that positively affirms effectiveness for most to all of the above categories is assigned a high ranking. If at least half of the bullets are affirmed, the A/M is assigned at least a medium ranking. If less than half of the bullets can be affirmed, the A/M is assigned a low priority.

Lead Agency: Department of Emergency and Military Affairs Division of Emergency Management (DEMA/EM)

1.0 CONTINUED FROM PRIOR PLAN

Hazard Addressed: All climatic hazards

Action/Measure: Share and educate local, tribal, and state agency partners on climate-hazards resiliency efforts and information during annual hazard mitigation workshops to enable all parties to adapt to emergent threats and potential future conditions of the state.

Priority: High

Estimated Completion: 2027

Potential Funding Source: Existing Staff/Budget: EMPG

Assessment of 2018 Plan Action/Measure: Action/measure is an ongoing effort and is being modified with this Plan update, so it is time-bound, as there was no metric in place with the prior action. The proposed modifications will also align the A/M with EMPG.

Objective Satisfied: 1-4, & 6

1.1 NEW MITIGATION ACTION/MEASURE

Hazard Addressed: Earthquake

Action/Measure: The Great Arizona ShakeOut is an annual hazard mitigation event occurring every October 20th, involving public and private sector organizations, as well as local, regional, state, and federal agencies. The earthquake awareness and preparedness drill is conducted annually to raise awareness about earthquake risks and to promote preparedness measures in partnership with the Arizona Geological Survey and the American Red Cross. By engaging participants in earthquake drills and education, the event aims to reduce the impact of potential earthquakes and enhance the resilience of communities against seismic hazards.

Priority: Medium

Estimated Completion: 2026

Potential Funding Source: Existing Staff/Budget: EMPG

Objective Satisfied: 1-4

1.2 NEW MITIGATION ACTION/MEASURE

Hazard Addressed: Terrorism

Action/Measure: Reduce the likelihood and severity of cyber incidents that could damage critical infrastructure or public and private sector computer networks through state agency collaboration.

The DEMA/EM Cybersecurity Task Force is a statewide hazard mitigation initiative, bringing together key stakeholders, subject matter experts, and cybersecurity professionals from Arizona's public sector, private industry, academia, and law enforcement. Its primary mission is to implement measures to reduce the likelihood and severity of cyber incidents that threaten the state’s economy, infrastructure, and computer networks, thereby enhancing resilience and preparedness against cyber hazards.

Priority: Medium

Estimated Completion: 2027

Potential Funding Source: Existing Staff/Budget: EMPG

Objective Satisfied: 1, 4 & 6

1.3 NEW MITIGATION ACTION/MEASURE

Hazard Addressed: Extreme Heat

Action/Measure: Provide technical assistance and support to local partners as they submit projects to assess the vulnerability of state assets to extreme heat and develop adaptation strategies. By conducting thorough vulnerability assessments and formulating effective adaptation plans, we aim to mitigate the potential impacts of extreme heat on critical infrastructure and assets.

Priority: Medium

Estimated Completion: 2028

Potential Funding Source: Mitigation Management Costs/PDM/HMGP/BRIC/FMA

Objective Satisfied: 1-6

1.4 NEW MITIGATION ACTION/MEASURE

Hazard Addressed: Extreme Heat

Action/Measure: Facilitate and provide technical assistance to local partners in Arizona as they submit projects to study and assess the urban heat island phenomenon, aiming to quantify its extent and severity. The goal is to better understand and mitigate the potential impacts of extreme heat on the community and its infrastructure.

Priority: Medium

Estimated Completion: 2028

Potential Funding Source: General Fund

Objective Satisfied: 1-6

1.5 NEW MITIGATION ACTION/MEASURE

Hazard Addressed: All

Action/Measure: Develop resource materials to assist local and tribal governments in achieving consistency with other hazard mitigation and land use plans and comply with state legislative requirements.

Priority: Medium

Estimated Completion: 2028

Potential Funding Source: EMPG

Objective Satisfied: 1-4

Lead Agency: Arizona Department of Water Resources (ADWR)

2.0 CONTINUED FROM PRIOR PLAN

Hazard Addressed: Flooding

Action/Measure: Assist local jurisdictions in acquiring, or otherwise mitigating, property located in the 100-year floodplain, beginning with repetitive loss properties.

Priority: High

Estimated Completion: Ongoing/Annually

Funding Source: Existing Staff/Budget

Assessment of 2018 Plan Action/Measure: ADWR continues to serve as a liaison between local jurisdictions and FEMA. In this role, ADWR audits floodplain management programs for compliance with State and Federal requirements, provides technical assistance to communities that seek assistance, and coordinates with the DEMA/EM SHMO to review applications for HMA and other FEMA grants. Staff assisted FEMA with multiple Discoveries in Arizona, including Gila and Navajo Counties. Staff assisted in FEMA's Risk MAP kick offs for Pima County, La Paz County and Apache Junction.

ADWR assisted the Town of Superior with a CTP Grant from FEMA to establish a Flood Risk Report. The Flood Risk Report (FRR) provides non-regulatory information to help local or tribal officials, floodplain managers, planners, emergency managers, and others better understand their flood risk, take steps to mitigate those risks, and communicate those risks to their citizens and local businesses for the Town of Superior.

The intent of Risk MAP is to encourage partnerships and innovative uses of flood hazard and fisk assessment data in order to reduce flood and other hazard risk. Risk MAP prioritizes areas of mapping needs based on evaluations of risk, need, availability of data, regional knowledge of issues vulnerable communities and other local input. The FEMA Map Service Center is also a tool to enable a community of mapping needs in their areas of need and communities' interest in developing more detailed maps by incorporating local geospatial data and Base Level Engineering into flood hazard maps.

Objective Satisfied: 1, 2, & 6

2.1 CONTINUED FROM PRIOR PLAN

Hazard Addressed: Dam Failure

Action/Measure: Provide information to county and local emergency management and floodplain management officials regarding the status, potential hazards, and risks associated with deficient dams to ensure they make better informed decisions regarding planning and development.

Priority: Medium

Estimated Completion: Ongoing/Annually

Potential Funding Source: Existing Staff/Budget

Assessment of 2018 Plan Action/Measure. ADWR continues to inspect jurisdictional dams on a set schedule. Special attention is paid to high hazard potential dams where failure of the dam could result in loss of life. The findings of these inspections and safety deficiencies (if any) are conveyed to the dam owner. ADWR continues to review EAPs for high and significant hazard potential dams, and where possible, provides assistance to dam owners for development of EAPs where none exist or require updating.

Objective Satisfied: 1, 2, 3, 5, & 7

2.2 CONTINUED FROM PRIOR PLAN

Hazard Addressed: Dam Failure

Action/Measure: Identify adequate funding sources within the dam repair program, which is designed to assist the state and the dam owners in the protection of life and property. Report to the Director of ADWR.

Priority: High

Estimated Completion: Ongoing/Annually

Potential Funding Source: Existing Staff/Budget

Assessment of 2018 Plan Action/Measure: ADWR has applied for and received funding from the HHPD Grants to assist the owners of Black Canyon Dam and Jaques Dam hire engineering consultants to evaluate the existing conditions at these high hazard, unsafe dams. The non-Federal cost share for these grants is being paid from the Dam Repair Fund maintained by ADWR.

Objective Satisfied: 1,2, 5, & 7

2.3 CONTINUED FROM PRIOR PLAN

Hazard Addressed: Flooding

Action/Measure: Continue to encourage and educate local officials and renters who live in areas that are flood prone to acquire flood insurance through the NFIP.

Priority: Medium

Estimated Completion: Ongoing

Potential Funding Source: Existing Staff/Budget

Assessment of 2018 Plan Action/Measure: ADWR continues to serve as a liaison between FEMA and local jurisdictions. As such, ADWR provides communities with education, training, and technical assistance related to floodplain management, floodplain mapping needs, general NFIP flood insurance information and flood risks associated with wildland fires.

Objective Satisfied: 1, 2, 3, & 6

2.4 CONTINUED FROM PRIOR PLAN

Hazard Addressed: Flooding

Action/Measure: Encourage communities to begin or continue participation in the Community Rating System (CRS) program. The program offers credit for various activities that potentially reduce flood damage and assist property owners in receiving reduced insurance premiums from flood policies purchased through the National Flood Insurance Program.

Priority: Low

Estimated Completion: Ongoing

Potential Funding Source: Existing Staff/Budget

Assessment of 2018 Plan Action/Measure: ADWR continues to encourage communities to adopt higher floodplain management regulatory standards through participating in the CRS program. ADWR staff also actively participate in the Arizona CRS Users Group meetings to keep abreast with the requirements of CRS as well as to be informed of the communities' concerns and needs. As of April 1, 2023, residents of 27 communities take advantage of discounted NFIP flood insurance premiums because these communities have earned enough CRS credits.

Objective Satisfied: 1, 2, 3, & 4

2.5 CONTINUED FROM PRIOR PLAN

Hazard Addressed: Dam Failure

Action/Measure: Coordinate with county/community emergency management and floodplain management officials to provide information regarding the locations and potential hazards of existing dams so communities can make better informed development decisions.

Priority: Low

Estimated Completion: Ongoing/Annual

Potential Funding Source: Existing Staff/Budget

Assessment of 2018 Plan Action/Measure: ADWR continues to coordinate with dam owners and local Emergency Managers to increase awareness of potential hazards posted by dam. ADWR also reviews EAPs submitted by dam owners.

Objective Satisfied: 1, 2, 3, 4, 5, & 7

Lead Agency: Arizona Geological Survey (AZGS)

3.0 CONTINUED FROM PRIOR PLAN

Hazard Addressed: Flooding

Action/Measure: Conduct assessments to identify areas with the potential for debris flows and flooding in the post-fire environment & identify high-risk areas for incorporation into mitigation plans and to target areas for mitigation activities.

Priority: High

Estimated Completion: Ongoing/Multi-year project

Potential Funding Source: FEMA PDM, HMGP, and BRIC programs

Assessment of 2018 Plan Action/Measure: AZGS has several projects around the state that are either ongoing or are slated to begin in the fall. AZGS collects data from burned areas to help improve hazard assessment models, and we work with local county flood control districts to identify areas that could be prone to post-fire flooding so mitigation efforts can begin prior to the occurrence of a wildfire. Coconino County was previously studied, Yavapai County is being studied now, and FEMA HMGP funds have been allocated for Gila County.

Objective Satisfied: 1, 2, 3, 4, & 5

3.1 CONTINUED FROM PRIOR PLAN

Hazard Addressed: Flooding

Action/Measure: Conduct surficial geologic mapping to evaluate piedmont areas that may be prone to flooding. Make the resulting map products available on the AZGS document repository for use in planning efforts at the local, county, and tribal levels.

Priority: Medium

Estimated Completion: Ongoing

Potential Funding Source: Existing Staff/Budget, Statemap Program

Assessment of 2018 Plan Action/Measure: This work is conducted through the USGS Statemap Program. New mapping areas around the state are selected by an advisory committee.

Objective Satisfied: 1, 2, & 4

3.2 CONTINUED FROM PRIOR PLAN

Hazard Addressed: Fissures

Action/Measure: Identify and map known fissures across the state. Publish the maps and make them available at AZGS's Hazard Viewer at: https://uagis.maps.arcgis.com/apps/webappviewer/index.html?id=98729f76e4644f1093d1c2cd6dabb584 . This information can aid the local, county, and tribal entities in their planning and mitigation efforts. AZGS will also conduct earth fissure planning map briefings for state and local agencies whose responsibilities are affected by fissures.

Priority: Medium

Estimated Completion: Ongoing

Potential Funding Source: Existing Staff/Budget,

Assessment of 2018 Plan Action/Measure: The work of fissure identification, mapping, and planning briefings continued throughout the past plan cycle. AZGS also supports ADWR's efforts in addressing Subsidence by providing new and updated data as it is collected. Prior plan action/measures 3.2 and 3.7 have been combined into one.

Objective Satisfied: 1, 2, 3, & 4

3.3 CONTINUED FROM PRIOR PLAN

Hazard Addressed: Earthquake, Fissures, Flooding, and Landslides

Action/Measure: Perform geohazards outreach to deliver awareness of Arizona geologic hazards including earthquakes, earth fissures, landslides (including post-wildfire debris flows), and flash floods via workshops, online resources, media, and other outreach avenues through AZGS Geologic Extension Service.

Priority: Medium

Estimated Completion: Ongoing

Potential Funding Source: Existing Staff/Budget, FEMA NEHRP Program

Assessment of 2018 Plan Action/Measure: AZGS continues to leverage online resources and in-person outreach events as needs are identified and funding is available. Fissure outreach is conducted via email to affected counties at the beginning of monsoon to bring awareness during the time of year that fissures are most active. Fissure and post-fire hazards outreach are also conducted via presentations as requested. The most active outreach area addresses earthquake hazards, funded through a recurring FEMA NEHRP Grant. AZGS is continuing its outreach efforts with the ShakeOut Event every fall and working directly with county and Tribal Emergency Managers through the Arizona Council for Earthquake Safety (ACES). AZGS has also presented research on unreinforced masonry buildings and AZ earthquakes at the National Earthquake Program Managers meetings. Funding for other outreach initiatives continues to be an issue. Prior plan action/measures 3.3 and 3.4 have been combined into one comprehensive outreach action/measure for AZGS.

Objective Satisfied: 1, 2, & 3

3.4 CONTINUED FROM PRIOR PLAN

Hazard Addressed: Earthquake

Action/Measure: Investigate quaternary (young) faults to estimate the time since the most recent event, average recurrence intervals or slip rates and to estimate paleoearthquake magnitudes. This information can be used for seismic hazard assessments, including probabilistic earthquake hazard maps, which in turn can be used to plan mitigation projects.

Priority: Medium

Estimated Completion: Ongoing

Potential Funding Source: US Geological Survey, StateMap Program, ADOT, Bureau of Reclamation

Assessment of 2018 Plan Action/Measure: AZGS has studied several active faults in the state, such as the Mead Slope fault near Hoover Dam, Lake Mary fault in Flagstaff, and the Carefree fault in Scottsdale Arizona. Fault studies such as these provide earthquake recurrence and size information that is used in the National Seismic Hazard Map to be released in 2025.

Objective Satisfied: 1, 2, 3, & 4

3.5 CONTINUED FROM PRIOR PLAN

Hazard Addressed: Post-wildfire debris flows

Action/Measure: Coordinate research priorities to develop a predictive understanding of post-fire debris flows & triggering rainfall intensities. Make the resulting information available to federal, local, county and tribal entities to aid in issuing warnings, and in planning and mitigation efforts.

Priority: Medium

Estimated Completion: Ongoing

Potential Funding Source: FEMA HMGP

Assessment of 2018 Plan Action/Measure: Efforts to continue with identification of debris flow potential within the context of post wildfire conditions has been the primary focus of AZGS over the last plan cycle.

Objective Satisfied: 1, 2, 3, & 4

3.6 NEW MITIGATION ACTION/MEASURE

Hazard Addressed: Landslides

Action/Measure: Identify and map existing landslide features along selected highway corridors in Arizona.

Priority: Medium

Estimated Completion: Ongoing

Potential Funding Source: FEMA BRIC Program

Objective Satisfied: AZGS has successfully completed landslide mapping along I-17 from Phoenix to Flagstaff. The extents of known landslides were refined and newly identified landslides were mapped. These data were supplied to ADOT for the expansion efforts of I-17. AZGS is currently conducting landslide mapping along State Highway 87 from Phoenix to Payson, and has planned mapping along a portion of State Highway 60.

3.7 CONTINUED FROM PRIOR PLAN

Hazard Addressed: All natural hazards

Action/Measure: Add the GIS layers from 2018 state hazard mitigation plan risk assessment maps to the natural hazards viewer.

Priority: Low

Estimated Completion: Ongoing

Potential Funding Source: Existing Staff/Budget

Assessment of 2018 Plan Action/Measure: Activity by AZGS continues with a recent update of the Natural Hazards Viewer.

Objective Satisfied: 1, 2, & 3

Lead Agency: Arizona Department of Environmental Quality (ADEQ)

4.0 CONTINUED FROM PRIOR PLAN

Hazard Addressed: Hazardous Materials

Action/Measure: Manage an online database for Hazardous Materials and Extremely Hazardous Chemicals in which facilities in Arizona upload Tier II information for viewing by Fire Departments and Local Emergency Planning Committees for response and planning activities to mitigate against HazMat incidents.

Priority: High

Estimated Completion: Ongoing/Annually

Potential Funding Source: ADEQ

Assessment of 2018 Plan Action/Measure: The Emergency Response Unit (ERU) within ADEQ manages the Tier II reporting site and communicates with all LEPCs and participating FDs.

Objective Satisfied: 1, 2, & 4

4.1 CONTINUED FROM PRIOR PLAN

Hazard Addressed: Hazardous Materials

Action/Measure: Distribute funds to the Local Emergency Planning Committees (LEPCs) to support HazMat planning, training, and equipment. The LEPCs have Response Plans in the event of a HazMat incident. The HazMat training is for first responders and the equipment enhances the County HazMat Teams.

Priority: High

Estimated Completion: Ongoing

Potential Funding Source: HMEP program

Assessment of 2018 Plan Action/Measure: On average ADEQ has $500k annual in funding available for participating FDs and LEPCs to utilize for hazardous materials equipment and/or training. The funding comes from 2 sources, the federal HMEP grant, and state appropriated funds from Tier II reporting fees.

Objective Satisfied: 1, 2, & 5

4.2 CONTINUED FROM PRIOR PLAN

Hazard Addressed: Hazardous Materials

Action/Measure: Provide consultative services, conduct and participate in workshops, and coordinate development and review of plans and programs for 15 LEPCs.

Priority: Medium

Estimated Completion: Ongoing

Potential Funding Source: ADEQ

Assessment of 2018 Plan Action/Measure: ERU is designated by the State Emergency Response Commission as SERC staff to assist in plan development, LEPC assistance and compliance, and hosts semi-annual workshops.

Objective Satisfied: 1, 2, & 5

Lead Agency: Arizona Department of Forestry and Fire Management (AZDFFM)

5.0 CONTINUED FROM PRIOR PLAN

Hazard Addressed: Wildfire

Action/Measure: Ensure Arizona Firewise Communities program and fire prevention information is distributed statewide. It has been repeatedly demonstrated that education is a key component in convincing the public to endorse and adopt wildland fire prevention and Firewise principles and activities.

Priority: High

Estimated Completion: Ongoing

Potential Funding Source: Existing Staff/Budget

Assessment of 2018 Plan Action/Measure: DFFM continues outreach on a regular basis throughout the year to promote the adoption of Firewise principles. Arizona has 125 Firewise USA sites throughout the state which is over a 40% increase for plan cycle, with more communities and HOAs in the participation pipeline.

Objective Satisfied: 1, 2, 3, & 4

5.1 CONTINUED FROM PRIOR PLAN

Hazard Addressed: Wildfire

Action/Measure: Work with local communities to maintain a GIS wildfire incident and project database that is keyed to local CWPP planning areas to have the ability to parse and aggregate data for that CWPP area. This will benefit local jurisdictions and others that may use the data to identify areas at risk and prioritize project areas based on present fuels, threat to the public, and natural resources and to track the location and progress of ongoing projects.

Priority: High

Estimated Completion: Ongoing / Still Under Development

Potential Funding Source: Existing Staff/Budget

Assessment of 2018 Plan Action/Measure: Currently there are many agencies that maintain fire data however, this information is not readily shared. The action/measure is modified to a more CWPP metric to focus tracking of fire data and projects at the local community level so it is a one stop shop for this information for that CWPP area.

Objective Satisfied: 1 & 2

5.2 CONTINUED FROM PRIOR PLAN

Hazard Addressed: Wildfire

Action/Measure: Encourage cities, communities, and other municipalities to specify landscaping requirements based upon Firewise principles. This is necessary for those living in or owning property in the WUI or Communities at Risk to manage the fuels on their properties to reduce their risk from wildland fires.

Priority: High

Estimated Completion: Ongoing

Potential Funding Source: Existing Staff/Budget

Assessment of 2018 Plan Action/Measure: Outreach continues through the state's five districts - Northern in Flagstaff, Northeastern in Pinetop, Southeastern in Tucson, Central in Phoenix, and Northwestern in Chino Valley.

Objective Satisfied: 1, 2, 3, & 4

5.3 NEW MITIGATION ACTION/MEASURE

Hazard Addressed: Wildfire

Action/Measure: Work with local agencies and entities to leverage FMAG mitigation grant funds to perform eligible wildfire risk reduction strategies such as thinning, perimeter development, and post-fire debris flow protection.

Priority: High

Estimated Completion: Ongoing and tied to wildfire incidents

Potential Funding Source: FMAG, HMGP Post-Fire

Objective Satisfied: 2, 3, 4, & 5

5.4 NEW MITIGATION ACTION/MEASURE

Hazard Addressed: Wildfire

Action/Measure: Work with state agencies to identify and mitigate wildfire risk to state owned facilities and infrastructure. Actions may include vegetation maintenance and thinning, perimeter development, and post-fire debris flow protection..

Priority: High

Estimated Completion: Next 5-year Plan Cycle

Potential Funding Source: FMAG, HMGP Post-Fire, Staff Time

Objective Satisfied: 2, 3, 4, & 5

Lead Agency: State Climate Office & Arizona State University (ASU)

6.0 CONTINUED FROM PRIOR PLAN

Hazard Addressed: All Natural Hazards

Action/Measure: The State Climate Office will maintain and update the Natural Hazards webpage that describes Arizona's weather/climate related natural hazards and explains measures the public can take before, during and after the events to keep themselves and their property safe. Will also maintain and update links to resources for assistance before and after extreme weather events. The linkage to Arizona State University's web pages will be maintained and updated, as many of the students at the University are from other states and may be unaware of Arizona's weather/climate hazards.

Priority: High

Estimated Completion: Ongoing

Potential Funding Source: Existing Staff/Budget

Assessment of 2018 Plan Action/Measure: The webpage and links have been completed and can be accessed at https://azclimate.asu.edu/weather/weather-safety

Objective Satisfied: 1, 2, & 3

6.1 CONTINUED FROM PRIOR PLAN

Hazard Addressed: All Natural Hazards

Action/Measure: The State Climate Office, in conjunction with Arizona State University, will create a University-wide weather webpage showing current weather conditions across the four campuses and include NWS alerts, special weather statements, watches and warnings for the area and the state. The scope will include development of a mesonet (weather station network) to portray weather conditions on each of the four individual ASU campus locations in real time. This page will link to the Natural Hazards page.

Priority: High

Estimated Completion: Ongoing

Potential Funding Source: Existing Staff/Budget

Assessment of 2018 Plan Action/Measure: The website (https://azclimate.asu.edu/weather/) shows current weather conditions, hazard alerts, forecasts, and satellite imagery for the Phoenix area and across the state. Additionally, in 2023, two ASU campuses (ASUTempe and ASUWest) now have weather instruments installed so that near real-time weather conditions can be accessed by the public through the State Climate Office website ((https://azclimate.asu.edu/weather/). Plans continue to install near real-time weather instruments at the ASU PolyTechnic and ASU Downtown locations within the next year.

Objective Satisfied: 1, 2, & 3

6.2 NEW MITIGATION ACTION/MEASURE

Hazard Addressed: All Natural Hazards

Action/Measure: The State Climate Office, in conjunction with Arizona State University, will create a monthly public webinar to educate residents and visitors of the state about weather, climate, water, and natural hazards in Arizona. The monthly educational and informational webinars are available to the public live on Zoom, or recorded and available to the public at any time after the webinar on the State Climate Office website (https://azclimate.asu.edu/webinars/).

Priority: High

Estimated Completion: Ongoing

Potential Funding Source: Existing Staff/Budget

Objective Satisfied: 1, 2, & 3

6.3 NEW MITIGATION ACTION/MEASURE

Hazard Addressed: Extreme Heat

Action/Measure: The State Climate Office, in conjunction with Arizona State University, will map individual urban heat islands across the state, identifying areas of these cities or towns where members of the public may be at risk from heat-related illnesses. Upon completion, the urban heat island maps will be published on the State Climate Office website.

Priority: High

Estimated Completion: In the next five years

Potential Funding Source: Existing Staff/Budget

Objective Satisfied: 1, 2, & 3

6.4 NEW MITIGATION ACTION/MEASURE

Hazard Addressed: Drought

Action/Measure: The State Climate Office, in conjunction with Arizona State University, will provide public access to Arizona's current short-term drought conditions and seasonal drought outlook on the State Climate Office website (https://azclimate.asu.edu/drought/). Additionally, the State Climate Office will evaluate and then publish current statewide long-term drought conditions on the State Climate Office website.

Priority: High

Estimated Completion: Ongoing

Potential Funding Source: Existing Staff/Budget

Objective Satisfied: 1, 2, & 3

Lead Agency: Arizona Department of Agriculture (AZDA)

7.0 CONTINUED FROM PRIOR PLAN

Hazard Addressed: All Hazards

Action/Measure: The AZ Department of Agriculture will publish the Arizona Secure Food Plan to increase awareness of food safety for producers while reducing the vulnerability of agricultural producers to natural and human-caused hazards. The Secure Food Plan will consist of three major components: secure beef, dairy, and egg plans. The goals of these plans will be to assure a continuous food supply to consumers and maintain business continuity for producers during both disease outbreaks and other emergencies that can affect agricultural products. These plans will provide for efficient and effective emergency response to maximize the movement of safe and healthy products to the market and consumer. We will provide these plans to agriculture stakeholders so that they can begin adoption of these plans to be better prepared for future emergencies.

Priority: High

Estimated Completion: Ongoing

Potential Funding Source: Existing Staff/Budget

Assessment of 2018 Plan Action/Measure: Secure food plans continue to be drafted and modified at regular intervals according to stakeholder input, which is in a continuous stage of change.

Objective Satisfied: 1, 2, & 3

Lead Agency: Arizona Counter Terrorism Information Center (ACTIC)

8.0 CONTINUED FROM PRIOR PLAN

Hazard Addressed: Cyber Terrorism

Action/Measure: Conduct community outreach to improve cyber resilience by educating residents, businesses, organizations, and government entities on cyber hygiene and best practices. This capability includes creating a public-facing website for cybersecurity, building a library of cybersecurity products, such as unclassified threat/incident alerting and notification products, FAQs, newsletters, and presentations, and facilitating events and presentations. Because the internet is one connected network, improving the security practices of one individual can help protect Arizona and the world.

Priority: High

Estimated Completion: Ongoing

Potential Funding Source: Urban Areas Security Initiative grant program

Assessment of 2018 Plan Action/Measure: Work on the outreach continued through the last plan cycle and not significant changes are anticipated over the next 5-year period.

Objective Satisfied: 1, 2, & 3

8.1 CONTINUED FROM PRIOR PLAN

Hazard Addressed: Cyber Terrorism

Action/Measure: Improve and expand the cyber threat/incident alerting and notification capability. This will provide timely alerts/notices of in-process and/or potential cyber threats and incidents. This will also include possible measures to prevent, detect, and respond to the threats, to residents, companies, community partners, organizations, state, local, tribal, law enforcement, military, and other entities. This will enable the State of Arizona to potentially prevent and minimize the impact of cyber incidents.

Priority: High

Estimated Completion: 2023

Potential Funding Source: Urban Areas Security Initiative grant program

Assessment of 2018 Plan Action/Measure: Work on the cyber threat/incident alerting and notification capabilities continued through the last plan cycle and not significant changes are anticipated over the next 5-year period.

Objective Satisfied: 1, 2, & 3

Lead Agency: Arizona Department of Administration (ADOA)

9.0 CONTINUED FROM PRIOR PLAN

Hazard Addressed: All Hazards

Action/Measure: The Arizona Department of Administration - Risk Management Division (State Risk Management) will continue working with state agencies that have developed a Safety Management System (SMS) to raise SMS scores in targeted areas. State Risk Management will also expand outreach to assist additional state agencies, boards, and commissions with SMS implementation as appropriate.

Priority: High

Estimated Completion: Ongoing

Potential Funding Source: ADOA

Assessment of 2018 Plan Action/Measure: Over the past five years, State Risk Management collaborated with multiple state agencies to establish a baseline SMS score and raise it in a sustainable manner. Many of the larger agencies have implemented the SMS in some form, which has generally been correlated with a reduction in injuries and property damage.

Objective Satisfied: 1, 2, 3, & 4

Lead Agency: Arizona Department of Health Services (ADHS)

10.0 CONTINUED FROM PRIOR PLAN

Hazards Addressed: Infectious Disease

Action/Measure: ADHS will enhance and modify the states Medical Electronic Disease Surveillance System (MEDSIS) in at minimum quarterly increments. This will ensure more rapidly generated reports, searching for or pulling data from medical cases or patients, and integrating surveillance data from local, tribal, federal, and disease monitoring systems among international public health partners along the Mexico border. This will allow for timely and effective epidemiological investigations to minimize risk to the public.

Priority: High

Estimated Completion: Ongoing

Potential Funding Source: Public Health Emergency Preparedness grant

Assessment of 2018 Plan Action/Measure: Only 2 MEDSIS production updates were released so far due to the HIV MEDSIS integration. The 2 production updates included two new standardized lab and drug tables to streamline overdose reporting and surveillance, added a duplicate check to the Batch Case Creation function, implemented Batch contact record creation to reduce contact record entry burden, and updated Hep A, Hep C, and COVID DSO to align with MMGs in prepare for case notification implementation. Multiple system enhancements were pushed into production to improve overall system performance and user experiences.

Objective Satisfied: 1, 2, & 3

10.1 CONTINUED FROM PRIOR PLAN

Hazard Addressed: Infectious Disease

Action/Measure: Update and enhance emergency Medical Counter Measure plans, and conduct drills and exercises to ensure medical counter measure capabilities are integrated with local and tribal public health and health care coalitions. This will create capacity to cope with demands on the healthcare infrastructure and rapidly communicate risks to the public.

Priority: Medium

Estimated Completion: Ongoing

Potential Funding Source: Public Health Emergency Preparedness grant

Assessment of 2018 Plan Action/Measure: In October 2022, ADHS-BPHEP MCM Coordinator updated the MCM Operational Plan and conducted a workshop highlighting changes/updates to the plan in November 2022. Some key update considerations: plan maintenance section, language and process updates from COVID-19 and addition of warehouse operations outlined. Additional training and/or workshops will be conducted with partners in the future.

Objective Satisfied: 1, 2, & 3

Lead Agency: Arizona Department of Homeland Security (AZDOHS)

11.0 CONTINUED FROM PRIOR PLAN

Hazard Addressed: Terrorism - Cyber

Action/Measure: Building a Cybersecurity Workforce Economic Development

The State of Arizona, through the Arizona Department of Homeland Security and Arizona Department of Administration, will drive cybersecurity and IT related workforce economic development and education. This will be a collaborative effort that will include representatives from public, private, and education sectors.

Priority: High

Estimated Completion: Ongoing

Assessment of 2018 Plan Action/Measure: This action/measure originated with ADOA and has been assigned to the Arizona Department of Homeland Security (AZDOHS) as the primary lead.

Potential Funding Source: Existing Staff/Budget

Objective Satisfied: 1, 2, & 3

11.1 NEW MITIGATION ACTION/MEASURE

Hazard Addressed: Terrorism - Cyber

Action/Measure: Cyber Readiness Program for Local Governments. The State of Arizona, through the Arizona Department of Homeland Security (AZDOHS) will work with local governments throughout the state to ensure their readiness to defend against and mitigate cyberattacks. This is accomplished by providing best-in-class cyber protections, support, and training to all local government entities at no additional cost to them

Priority: High

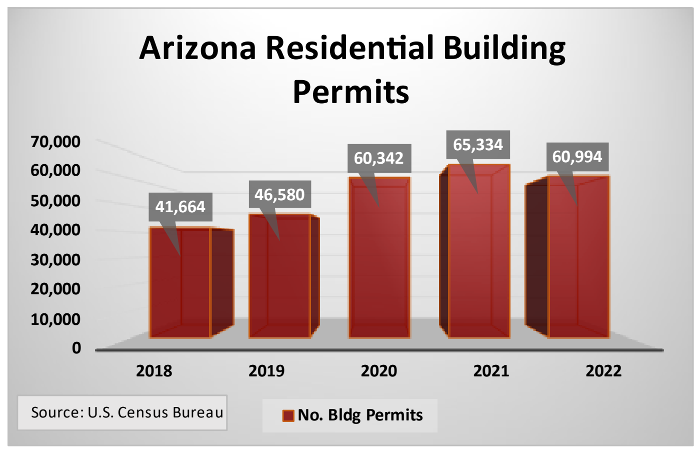
Estimated Completion: Ongoing

Potential Funding Source: General Fund/Existing Budget

Objective Satisfied: 1, 2, & 3

Changes in Development and Priorities & Mitigation Efforts

The state has experienced steady population and job growth with low unemployment rates. As of Q1 2023, Arizona is outpacing the national average GDP growth by 0.7 percentage points (2.7% vs. 2.0% nationally)[31]. As of June 2023, Arizona unemployment is slightly less than the national average (3.5% versus 3.6% nationally)[32] and Arizona's per capita personal income ranked 39th in the nation during 2022. Arizona personal income rose by 7.9% (seasonally-adjusted annual rate) over the quarter in the fourth quarter of 2022, outpacing the national average of 7.4%. State income growth ranked 8th in the nation, and on a per capita basis, the Bureau of Economic Analysis (BEA) reported that Arizona's income rose by 1.3% in 2022, faster than the national average of 0.4%[33].



According to the U.S. Census Bureau[34], residential building permits have shown significant growth over the 2018 to 2022 period. Continued pullback in the number of permits is expected for 2023 based on data as of June 2023, indicating a potential decline.

Over the past 5-years and projecting into the next 5-years, Arizona growth is expected to occur most prominently in five major industries: 1) Technology and Innovations, 2) Aerospace and Defense, 3) Healthcare and Biotechnology, 4) Tourism and Hospitality, and 5) Renewable Energy[35]. Each of these areas will impact land use, with a continued increase in industrial developments like the new Taiwan Semiconductor Manufacturing Company in North Phoenix, the numerous tilt-up warehouse facilities being constructed along major transportation corridors and hubs throughout the state, massive solar fields, and numerous other large-scale industrial and commercial development. The largest impacts are expected in each of the major urban centers (Phoenix, Tucson, Flagstaff).

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[31] Data from USA FACTS accessed at: https://usafacts.org/topics/economy/

[32] U.S. Bureau of Labor Statistics. Data accessed at: https://www.bls.gov/eag/eag.az.htm

[33] University of Arizona, Economic and Business Research Center, Arizona's Economy online magazine at: https://www.azeconomy.org/ .

[34] U.S. Census Bureau, Building Permits Survey, data accessed at: https://www.census.gov/construction/bps/current.html

[35] Arizona Big Media, 2023, 5 major industries booming in Arizona for 2023 - AZ Big Media

Although Arizona continues to grow, the priorities and focus of our hazard mitigation efforts and Plan have remained consistent. The mitigation measures from the previous Plan have been, for the most part, either completed or in progress. Most of the measures that are in progress have been carried forward into this Plan either for hopeful completion during the next plan cycle or continued service to the Arizona communities.

The focus of the mitigation measures has been and will likely continue to be predominantly related to education, awareness, and technical assistance-related activities. There are also several agencies that develop hazard and risk data used by multiple sources throughout the state. There is also a focus on providing information and resources to implement mitigation efforts statewide.

As with previous plan cycles, funding continues to be a barrier limiting the implementation of mitigation measures throughout the state. Local, tribal, and state agencies experience difficulty in committing funding toward large projects and measures on a schedule that can meet typical mitigation grant timelines. Most communities also have very limited resources to make effective applications for mitigation grant funds that will survive the grant selection process and provide the required matching funds.

Arizona continues to research and identify new funding sources, provide training and assistance for grant application preparation and programs, and work with communities to develop cost-effective and beneficial mitigation measures that can overcome existing barriers to mitigation implementation.

STATE CAPABILITIES

The State of Arizona utilizes a decentralized, whole-community approach to emergency management. The integrated emergency management program incorporates various agencies that play a role in mitigation efforts before and after a disaster. The state's primary responsibility is to support local counties and jurisdictions throughout all phases of emergency management.

According to Arizona Revised Statutes 26-305, DEMA/EM is responsible for preparing for and coordinating emergency management activities that may be required to reduce the impact of disasters on persons or property. Additionally, DEMA/EM shall coordinate the cooperative effort of all government agencies, including the federal government, this state, and its political subdivisions, to alleviate suffering and loss resulting from disasters.

By law, the State of Arizona, specifically DEMA/EM, is responsible for assisting and protecting the communities from disasters. DEMA/EM has built an intricate emergency management enterprise and has integrated vertically and horizontally throughout all levels of government and into the private and non-profit sectors. Many state agencies have been educated and empowered not only to understand but also to implement mitigation measures. Agencies that implement statewide mitigation measures include, but are not limited to, the Arizona Department of Water Resources (ADWR), the Arizona Department of Health (ADHS), the Arizona Department of Environmental Equality (ADEQ), the Arizona Geological Survey (AZGS), Arizona Department of Transportation (ADOT), Arizona Department of Forestry and Fire Management (DFFM), Arizona Department of Economic Security (DES), Arizona Department of Agriculture (AZDA), Arizona Department of Administration (ADOA), the University of Arizona (UA), Arizona State University (ASU), and the non-profit Team Rubicon.

Funding Sources

There are many sources of funding that can be utilized for hazard mitigation. The DEMA/EM State Hazard Mitigation Office is responsible for, and is efficient at, the administration and implementation of the Hazard Mitigation Assistance (HMA) Grants program, Public Assistance (PA) grants, and the Governor's Emergency Fund (GEF). The following is a list of current and potential funding sources that may be utilized for mitigation action implementation.

Hazard Mitigation Assistance (HMA) Program

The HMA program includes the Pre-Disaster Mitigation (PDM) grants, Building Resilient Infrastructure and Communities (BRIC) grants, Flood Mitigation Assistance (FMA) grants, the Hazard Mitigation Grant Program (HMGP), and the HMGP Post-Fire grants. All HMA programs are administered by the State Hazard Mitigation Officer (SHMO). These are FEMA grants that are used to fund various mitigation projects that reduce or eliminate the impact hazards have on communities. All HMA grants may be utilized to mitigate repetitive loss and severe repetitive loss properties.

Governor's Emergency Fund (GEF)

This fund receives four million dollars annually from the State's General Fund to assist government agencies respond to and recover from emergency and disaster events. Unused funds at the end of the state's fiscal year may be used as a funding source for the implementation of mitigation projects. The Governor's Emergency Fund may be utilized for mitigation projects statewide.

FEMA Public Assistance (PA)

PA funding is federal funding provided to eligible public agencies for the repair, restoration, and possible mitigation of damaged public structures within a declared disaster area.

FEMA Cooperting Technical Partners (CTP) Program

FEMA's CTP Program is an innovative approach to creating partnerships between FEMA and participating National Flood Insurance Program (NFIP) communities, regional agencies, state agencies, tribes and universities that have the interest and capability to become more active participants in the FEMA flood hazard mapping program. Currently, ADWR has a CTP agreement currently in place.

FEMA High Hazard Potential Dam (HHPD) Rehabilitation Program

The National Dam Safety Program Act (Pub. L. 92–367), as amended, 33 U.S.C. § 467f-2, authorizes FEMA to provide HHPD Rehabilitation Grant Program assistance to eligible states for pass through to non-Federal governmental organizations or nonprofit organizations for the rehabilitation of dams that fail to meet minimum dam safety standards and pose unacceptable risk to life and property.

Low Income Home Energy Assistance Program (LIHEAP)

LIHEAP is administered through the U.S. Department of Health & Human Services, Office of Community Services, and helps keep families safe and healthy through initiatives that assist families with energy costs by providing federally funded assistance to reduce the costs associated with home energy bills, energy crises, weatherization, and minor energy-related home repairs. LIHEAP can help people stay warm in the winter and cool in the summer through programs that reduce the risk of health and safety problems that arise from unsafe heating and cooling situations and practices.

Emergency Rental Assistance (ERA) Program

Two separate ERA programs, administered by the U.S. Department of Treasury, have been established: the ERA1 program was authorized by the Consolidated Appropriations Act, 2021 and provided $25 billion to assist eligible households with financial assistance and housing stability services. The ERA2 program was authorized by the American Rescue Plan Act of 2021 and provides $21.55 billion to assist eligible households with financial assistance, provide housing stability services, and as applicable, to cover the costs for other affordable rental housing and eviction prevention activities. ERA funds are provided directly to states, U.S. territories, local governments, and, in the case of ERA1, Indian Tribes or their Tribally Designated Housing Entities. Funds can be used extreme heat mitigation.

Other Sources

Various state agencies have an emergency management component, and, therefore, may be able to address the hazards that pose a threat to Arizona's communities. The ADOA also maintains a state level capital improvement plan for state-owned buildings and infrastructure not managed by other departments. Individual state agencies have technical expertise regarding certain hazards and those agencies may appropriate funds for the implementation of mitigation projects throughout the state. Agencies have a history of developing initiatives and programs that address future conditions and reduce or eliminate the impact hazards have on communities. Additionally, there are many federal funding sources that DEMA/EM does not administer or implement.

US Dept. of Housing & Urban Development (HUD)

Disaster recovery assistance is provided in the form of critical housing and community development to aid disaster recovery. HUD also provides funding to carry out community development activities focused economic development, revitalizing neighborhoods, and improving community facilities and services through the Community Development Block program.

US Dept. of Health and Human Services (HHS)

HHS, in coordination with the Center for Disease Control and Prevention provides funding through the Public Health Emergency Preparedness (PHEP) program. PHEP is utilized to upgrade the capacity of state and local public health jurisdictions' preparedness and response to bioterrorism, outbreaks, and other public health threats and emergencies.

US Army Corps of Engineers (USACE)

The Army Corps of Engineers has a rehabilitation program that is utilized to conduct emergency repair or rehabilitation of flood control works damaged by flood. Assistance does not extend to major improvements of flood control systems.

Natural Resource Conservation Service (NRCS)

The NRCS has the Emergency Watershed Protection Program that undertakes emergency measures, including the purchase of floodplain easements, for runoff retardation and soil erosion prevention in an attempt to safeguard lives and property from floods, drought, and the products of erosion. The NRCS offers services, including watershed surveys and planning program to assist state, local, and tribal governments protect watersheds from damage caused by erosion, floodwater, and sediment.

Small Business Administration (SBA)

The SBA offers low interest, fixed rate loans to small businesses for the purpose of implementing mitigation measures to protect their property from future disasters.

US Department of Homeland Security (USDHS)

The DHS uses the Homeland Security Grant Program to help enhance the protection of Arizona's residents and critical infrastructure from potential terrorist attacks and other significant hazards.

National Earthquake Hazard Reduction Program (NEHRP)

FEMA provides funding to the Arizona Geological Survey to conduct earthquake hazard awareness programs. This includes Arizona Shakeout, and the design and development of web-based and printed materials for informing and education the public.

US Department of Transportation (USDOT)

USDOT offers a Hazard Materials Emergency Preparedness Grant to provide guidance, and financial and technical assistance to enhance state, tribal, and local hazardous materials emergency planning and training.

State Programs

State departments have programs in place that work to mitigate the impact hazards have on state owned/operated facilities, and the entire community. These programs aim to protect property and infrastructure, save lives, and lessen the economic burden of hazards. Below are examples of state programs that work towards building a resilient state.

Arizona Dept of Administration (ADOA) Risk Management Section

The focus of the ADOA, Risk Management Section as it relates to mitigation is to protect the State's assets from loss. Risk Management was established to provide insurance coverage to state agencies and employees for property, liability and workers' compensation losses in accordance with the statutory provisions found in ARS Section 41-621 through Section 41-625.

Arizona Department of Forestry and Fire Management (AZDFFM)

AZDFFM is responsible for the prevention and suppression of wildfires on state and private lands, located outside incorporated municipalities, through the use of various cooperative agreements. They provide technical, educational, and financial assistance to rural communities and private land owners in the management of their forested lands.

Firewise Program

AZDFFM manages the Firewise Program which promotes fire-safe landscaping and construction practices to help reduce the loss of property from wildfire. The Firewise Program minimizes the negative effects of wildfire on public life, safety, and property by promoting fire-safe landscaping and construction practices to help reduce the loss of property from wildfire.

Community Wildfire Protection Plan (CWPP)

The AZDFFM works with communities in the state to analyze wildfire risk and develop CWPPs. CWPPs are a collaborative effort of local and state government representatives, in consultation with the federal government, to identify and prioritize areas for fuel reduction treatment and recommend mitigation measures that communities and homeowners can take to reduce their vulnerability to wildfires. CWPP information is often incorporated into the wildfire hazard profile section of local hazard mitigation plans as applicable. Communities with CWPPs are given priority for funding of hazardous fuels reduction projects under the Healthy Forests Restoration Act (HFRA).

All 15 counties in the State of Arizona utilize or have adopted CWPPs to varying degrees. Maricopa, Pinal, Pima, Mohave Graham, Greenlee, Cochise, Yavapai, and Yuma counties all have county wide CWPPs. Gila County has separate northern and southern CWPPs and La Paz county has separate Desert Communities and River Communities CWPPS. Apache, Navajo, Coconino, and Santa Cruz counties have CWPPs for a few more at-risk communities within their respective jurisdictions. DFFM is currently funding research through Northern Arizona University (NAU) to evaluate CWPPs in Arizona in order to develop recommendations for best practices.

Arizona Department of Water Resources (ADWR)

The Arizona Revised Statutes (A.R.S.) § 45-1201 assigns the responsibility for supervision of the safety of non-federal dams in the State of Arizona to the Director of the Arizona Department of Water Resources (ADWR). The ADWR Engineering Division is responsible for implementing the Flood Hazard Management Programs, which includes dam safety, flood warning, and floodplain management. An agency-critical mission of the Engineering Division is to protect the public against potential loss of life and property damage due to dam failure. This mission is achieved by the ADWR Dam Safety Program through periodic inspections of jurisdictional dams, reviewing and approving plans and specifications are required to construct new dams, as well as enlargements, repairs, alterations and removal of existing dams, monitoring critical construction activities to ensure compliance with the approved plans and specifications, requiring Emergency Action Plans for all high and significant hazard dams, and maintaining staff that includes professional engineers and technical specialists trained and experienced in the design, construction, operation and maintenance of dams.

The statutory authority for the above actions can be found in A.R.S. §§ 45-105 et seq. and 45-1201 et seq. Detailed rules for dam safety procedures are included in the Arizona Administrative Code, R12-15-1201 et seq., which was approved June 12, 2000. The ADWR Dam Safety Program as authorized by State legislation and administrative rules meets or exceeds the requirements to be eligible for assistance under the National Dam Safety Program (NDSP).

The Engineering Division includes two Units – Dam Safety, and Floodplain Management, and is led by the Chief Engineer.

Dam Safety Unit

The Dam Safety Unit includes five engineers and one inspector. All engineers in the Unit are registered professional engineers in the State of Arizona and have at least 10 years of professional experience. In addition, the Dam Safety Unit is assisted by one Administrative professional, and a full-time grants manager.

As noted above, ADWR is responsible for regulatory oversight of non-Federal dams in Arizona. As such, ADWR works continuously with local communities to increase awareness of risks posed by high-hazard potential dams (HHPDs), and to assist these communities with mitigating vulnerability and risk posed by these HHPDs. This risk mitigation is realized through the following policies, programs, and actions implemented by ADWR:

1. **Prioritization of HHPDs based on a Qualitative Risk Assessment**: In 2020, ADWR developed a plan to prioritize and address HHPDs in the State. The prioritization was based on a qualitative risk analysis using the safety condition (safe, safety deficiency, unsafe) and downstream persons at risk (PAR) as surrogates for likelihood of failure and consequences, respectively. Since that effort, two unsafe HHPDs were modified to reduce storage volume thereby reducing downstream risk. A third unsafe HHPD is currently under rehabilitation which when complete, will no longer be unsafe. The 2020 document is currently being updated to reflect current conditions at HHPDs across the State.
2. **Utilization of Federal Dam Safety Grants:** As the State agency responsible for providing regulatory oversight for jurisdictional dams in Arizona, ADWR has applied for and has been awarded HHPD Grants administered by FEMA and the NDSP. For these grants, ADWR is the primary applicant and serves as a pass-through of 100 percent of the funds awarded to dam owners. Funds from the HHPD

FY2019 Grant were used to fund hiring of a dam engineering consultant to assess and document the existing conditions at Black Canyon Dam in Navajo County which is currently classified as an unsafe HHPD. The findings of this study led the dam owner to reduce storage by 10-ft., thereby reducing downstream risk. ADWR has requested funding for an alternatives analysis as part of our application for the HHPD FY2022 Grant. Monies from the HHPD FY2020 grant were used to fund a hydrology and hydraulics analysis for Jaques Dam owned by the City of Show Low. ADWR will continue to seek Federal funding to help address HHPDs under State jurisdiction.

3. **State Dam Repair Fund**: In accordance with State statutes, ADWR has established, and maintains and manages a Dam Repair Fund. Monies from this fund have been used to address deficiencies at unsafe HHPDs in the State. For example – ADWR used monies from this fund to as a grant to the City of Safford to hire an engineering consultant to assess the hydrologic and hydraulic adequacy, and structural stability of Frye Mesa Dam in Graham County. Based on the results of these analyses, the dam is no longer classified as unsafe. ADWR has also used these funds as the non-Federal cost-share for the HHPD grants noted above. Through the Dam Repair Fund, ADWR provided financial assistance to Navajo County to stabilize the breach at Millet Swale Dam. ADWR continues to actively seek out opportunities to assist local communities and dam owners mitigate risk posed by their HHPDs.
4. **Coordination with DEMA**: ADWR and DEMA work closely to identify risk, and opportunities to mitigate risk posed by a variety of hazards, including HHPDs. For example – funds administered by DEMA were used to fund the services of an engineering consultant to develop an Emergency Action Plan for Fredonia Flood Retarding Structure in Coconino County. This is an unsafe HHPD, and the dam owner (Town of Fredonia) did not have the resources to update their EAP.
5. **Inspections & Outreach:** All HHPDs are inspected annually by ADWR Dam Safety staff. These inspections provide opportunity to engage dam owners in risk-communication and provide assistance and coordination on the development and maintenance of emergency action plans, stressing their importance to the dam owner. Direct observation of existing conditions at dams and opportunity to identify condition which may impair a dam's safe operation and require correction by the dam owner can also be identified.

In summary, ADWR recognizes the risk posed by HHPDs, especially against the backdrop of increasing urbanization and downstream hazard creep, and aging and deteriorating civil infrastructure including dams. ADWR also recognizes that dam repair/rehabilitation projects are expensive and often beyond the reach of dam owners and local communities. Therefore, in addition to meeting mandated responsibilities for regulatory oversight of non-Federal dams, ADWR actively seeks to identify opportunities to partner with dam owners and local communities to mitigate risk posed by HHPDs either through direct technical and/or financial assistance, or to leverage Federal funds via the grant process.

Floodplain Management Unit

ADWR administers the National Flood Insurance Program (NFIP). These programs protect the public against loss of life and property by reducing the likelihood of catastrophic failure of jurisdictional dams, and to assist communities, counties and local jurisdictions that participate in the NFIP. ADWR also administers the Community Assistance Program, and the RiskMAP program. These programs assist FEMA and the local jurisdictions with flood risk mapping needs and promote practices to reduce flood risk; establishes state model ordinances for floodplain management; and coordinates the planning, design, and construction of flood warning systems. The Department also coordinates resources and efforts with local, state, and federal entities during post-disaster flood and wildland fire emergencies. Additionally, the Department is responsible for statewide NFIP coordination specifically regarding repetitive loss (RL) and severe repetitive loss (SRL) properties. Coordination includes but is not limited to collection and distribution of the most current RL/SRL property list from FEMA. ADWR coordinates education for jurisdiction officials with RL & potential SRL properties during their scheduled Community Assistance Visits.

Arizona State Land Department (ASLD)

Arizona has more than 9 million surface acres of State Trust lands, interspersed throughout the state with federal and private lands. It represents approximately 13% of Arizona's total surface land ownership. The ASLD and the system by which State Trust lands were to be managed were established in 1915 by the State Land Code. With its authority vested from the Enabling Act of 1910 and the Article 10, Section 7 of the State Constitution, the State Land Code authorized the ASLD to manage and control all Trust lands and the natural products derived from them for the benefit of 13 entities primarily composed of Arizona shools and public institutions.

ASLD also administers several programs that support statewide planning and information databases that can serve the mitigation and emenrgency management communities. Programs include the Arizona Geographical Information Council, AZGEO Clearinghouse, and Natural Resource Conservation Districts (NRCDs)[36]

NRCDs serve a critical role in conserving natural resources on all land within the State of Arizona. They are the experts on conservation needs and practices in their regions and many operate education centers, which serve their respective communities. Additionally, the NRCDs are essential partners of ASLD, helping to steer federal, state, and non-profit grant funding to conservation projects on State Trust Lands, keeping the land productive

[36] Access to information for all 3 programs can be found at: https://land.az.gov/our-agency-mission/supported-programs

for grazing and agriculture. Further, they provide technical assistance to ASLD staff, assisting in land management planning, initiating educational outreach and consulting with ASLD staff on a wide variety of natural resource management issues. NRCDs are locally controlled and governed by elected Boards of Supervisors and are supported financially and administratively through the Arizona State Land Department.

ASLD prepares and annually update Stragic Plan that outlines various land management, disposition, and planning goals. ASLD regularly participates in local jurisdiction land use planning and zoning efforts and regularly evaluates State Trust Lands for mitigation opportunities and optimal land use planning to maximize the benefit to the 13 recipient entities.

State Policies

There are few state level policies that directly affect mitigation and emergency management throughout the state. Establishment of land use and zoning For the most part, local jurisdictions maintain autonomy in their ability to formulate and adopt policies that impact their communities. This is beneficial as all communities vary to a certain degree and require policies that best suit their circumstances. Additionally, research shows that the implementation of plans, policies, and procedures are most effective when the community is involved in the development and adoption process. Therefore, detailed policy information as to building and fire codes/standards and community development are available through local jurisdictions. The following are a few examples of state level mitigation policies.

The Growing Smarter and Growing Smarter Plus Acts

The Growing Smarter and Growing Smarter Plus Acts were created to assist communities in developing strategies for dealing with population growth and preserving open space. The legislation requires cities and towns to adopt a general plan that addresses land use and circulation. Depending on population size, some cities and towns must also include environmental planning, cost of development, and water resources. The water resources component of the general plan addresses available surface, ground, and effluent water supplies and requires cities and towns to address future water demands and how current and potential water sources will supply the future demand.

Executive Order 2015-13

The Governor of Arizona initiated the implementation of the Arizona Water Initiative through Executive Order 2015-13. Through the use of the Planning Area Process and the Governor’s Water Augmentation Council, the initiative identifies key priorities, timelines, and action items needed to maintain sustainable water supplies for Arizona’s future. The Planning Area Process involves ADWR working closely with 22 planning areas to identify issues that result in water demand and supply imbalances, and to develop strategies to address the issues. The Water Augmentation Council investigates augmentation strategies, explores water conservation opportunities, identifies infrastructure needs, and recommends policy direction or statutory changes that can help maintain sustainable water supplies for the future.

Executive Order 2015-13

The Governor of Arizona initiated the implementation of the Arizona Cybersecurity Team (ACT) through Executive Order 2015-13. Experts from state, local, and federal governments, the private sector, and higher education work together to mitigate cyber threats and increase statewide preparedness. The ACT works to increase collaboration, enhance cybersecurity workforce development and education, and increase public awareness on cybersecurity best practices.

Arizona Revised Statute (ARS) 26-308

State law under ARS 26-308 establishes that each county and incorporated city and town is charged with establishing and providing emergency management within their jurisdictions in accordance with state emergency plans and programs. State emergency plans shall be in effect within all subdivisions and jurisdictions within the state, and the governing bodies of each subdivision and jurisdiction may develop additional emergency plans in support of state emergency plans. This includes all response and recovery efforts outlined in the State Emergency Response and Recovery Plan (SERRP).

Arizona Revised Statute (ARS) 28-910

State law under ARS 28-910 charges that a driver who drives a vehicle on a public street or highway that is barricaded due to being temporarily covered by rise in water level from groundwater or overflow, is liable for the expenses of any emergency response that is required to remove any driver or any passenger in the vehicle should the vehicle become inoperable. This statute should serve as a deterrent to prevent vehicle operators from driving through flooded areas.

ADWR Substantive Policy Statements

ADWR Substantive Policy Statements are advisory only, and do not impose additional requirements or penalties on regulated parties. This includes the policy on the Development of Flood Control Plans, which was created to provide assistance to county flood control districts in investigating flooding problems and developing plans to control such problems. Another substantive policy is the Flood Control Loan Program, which was established to enable county flood control districts to proceed with timely implementation of flood control projects authorized for funding under the Alternative Flood Control Assistance Program.

Executive Order 2023-16 - Extreme Heat Planning and Preparedness

EO 2023-16 directs state agencies to build a comprehensive plan to approach extreme heat in future years. That plan will be submitted March 1, 2024 in advance of the 2024 heat season. The plan will: include centralized and formalized networks for cooling centers and heat relief coordination around the State; propose policy changes and legislative proposals that will make Arizona more prepared in future years; identify resource needs across the State, as well as potential sources of funds to address those resource needs; and, identify ways to ensure Arizona is receiving sufficient Low Income Home Energy Assistance

Program (LIHEAP) dollars, and that those dollars are being used efficiently and effectively.

Post-Disaster State Agency Coordination

In post-disaster scenarios, AZDEMA and various state agencies collaborate within the Arizona State Emergency Response and Recovery Plan framework. This plan serves as the foundation for their coordination efforts within the State Emergency Operations Center, where they manage resource deployment, information sharing, and disaster response. State agencies provide vital services, such as transportation, health and medical support, infrastructure maintenance, and legal guidance, all in accordance with the guidelines established in the plan. This partnership ensures an efficient disaster response and recovery process, emphasizing the importance of information sharing, resource allocation, and a unified approach to aid affected communities, as outlined in the Arizona State Emergency Response and Recovery Plan.

Obstacles/Challenges Summary

Obstacles and challenges noted by the planning team during the review and update of the state's capability assessment are limited to the following general issues:

- ***Staff Shortage/Retention/Continuity*** – Hiring and retaining adequate, qualified staff to implement many of the state's programs is complicated by challenges due to staff turnover, salary deficits, and the normal cycle of employment that results in lack of manpower and/or lost program familiarity. One example over the last plan cycle was a challenge to the State's ability to effectively administer and distribute wildfire mitigation funds due to lack of manpower or implementation capacity. Work continues to educate state elected leaders to prioritize some of these challenged programs.
- ***Governor's Emergency Fund (GEF)*** – The GEF currently does not specifically address mitigation as a line item. The DEMA/EM is working with the Governor's Office to change that accordingly.
- ***Statewide Adoption of Building Codes*** **–** as noted elsewhere, the state does not regulate or enforce building codes on a statewide basis. Instead, state officials work with local governments to encourage and educate local officials on the importance of adopting and regulating to modern building codes and keeping building codes current. The state does not currently have any plans to adopt statewide building codes.
- ***Funding Requirements for Federal Grants*** **–** For many of the smaller, less affluent Arizona communities, the ability to prepare applications and fund cost shares on effective mitigation projects is prohibitive. In many cases, the required funding and efforts far exceed a small community's capacity to meet. BCA's are often difficult to achieve and some hazards like Extreme Heat have not been traditionally eligible for grant funding at all. Continued discussions with federal funding program officers needs to continue.

State Support Strategies for Enhancing Local Mitigation Planning

In response to the identified barriers faced by local governments, such as limited funding and staffing for mitigation planning, the state is taking proactive measures to facilitate progress in this critical area:

- ***Increasing Funding Allocation*** – The state has increased its funding allocation, dedicating a more significant portion of the budget to mitigation projects and grants earmarked for local governments.
- ***Streamlined Grant Application Process*** – The state has streamlined the grant application process, making it more accessible and straightforward for local authorities. Technical assistance and expertise are readily available to support local governments in developing and updating their mitigation plans. Collaborative efforts with non-profit organizations, private sector entities, and educational institutions are being fostered to bring additional resources and knowledge.
- ***Capacity Building*** – Capacity-building initiatives have been implemented, including training programs for local government staff. Incentive programs and recognition awards have been established to encourage municipalities to prioritize mitigation planning. We are also actively working on policy and legislation to mandate a minimum allocation of resources for mitigation planning at the local level.
- ***Information Sharing and Awareness*** – DEMA/EM has established an information-sharing platform to bolster these efforts further through our website, allowing local governments to access valuable insight and best practices. Simultaneously, DEMA/EM has engaged in advocacy and awareness campaigns to underscore the importance of mitigation planning fostering a culture of resilience across our communities.

Through these comprehensive efforts, the state aims to empower and support local governments in their mitigation planning endeavors, enhancing community resilience.

SECTION 6: LOCAL MITIGATION CAPABILITIES

LOCAL MITIGATION POLICIES, PROGRAMS, AND CAPABILITIES

DEMA/EM supports local and tribal governments in updating their hazard mitigation plans by offering planning resources and technical assistance, utilizing new and emerging hazard data tools, and providing guidance on state priorities for mitigation. These efforts also inform the state of the overall capability of local and tribal governments to implement mitigation actions and may influence the state's risk assessment and mitigation priorities.

Each county has developed specific requirements and capabilities based on their individual needs and circumstances to increase their resilience. Each city, town, or district has varied capabilities listed in their respective local and tribal hazard mitigation plans. Despite the many challenges local, county, and tribal jurisdictions face, they have consistently demonstrated resistance to hazards, as demonstrated by the low frequency of escalated event at the state level. Local, county, and tribal jurisdictions utilize laws, policies, programs, staff, funding, and other resources to maintain and increase capacity to serve the community by reducing future disaster losses.

The following are examples of local capabilities at the county level that can contribute to mitigation activities and provide a basis for implementing mitigation strategies and actions. The data presented in the following subsections are from the counties through their most recently approved, or pending approval, hazard mitigation plans.

Building Codes

Many jurisdictions adopt the Uniform and International Building Codes with amendments to mitigate the impacts of various hazards. Building codes ensure that the design and construction of buildings meet optimal safety requirements and standards.

The state does not enforce the adoption of building codes. Counties and local jurisdictions are given autonomy in developing and implementing building codes based on their needs and concerns. Of the 15 counties in Arizona, 13% have adopted the 2018 IBC, 20% have adopted the 2015 IBC, 27% have adopted the 2012 IBC, 6% have adopted the 2006 IBC, 13% have adopted the 2003 IBC, and 20% have not adopted any version of the IBC.

Comprehensive Planning

Comprehensive planning is a state requirement and a foundation for various planning documents and ordinances that provide for their respective jurisdiction's future growth and improvement. A comprehensive plan is a document that guides the future actions of a community by presenting a vision for the future with long-term goals and objectives for all activities that affect the local government. Comprehensive planning provides for citizens' health, safety, and general welfare through orderly development and designated land use.

Of the 15 counties, 20% have adopted updated comprehensive plans since 2017, 53% have adopted updated comprehensive plans between 2010 and 2016, and 27% have yet to adopt comprehensive plans, with their last adoption occurring before 2010.

Emergency Operations Plans (EOP)

Under ARS 26-308, state emergency plans shall be in effect within all subdivisions and jurisdictions within the state, and the governing bodies of each subdivision and jurisdiction may develop additional emergency plans in support of state emergency plans, including all response and recovery efforts outlined in the State Emergency Response and Recovery Plan (SERRP).

Of the 15 counties, 47% have adopted an updated EOP since 2022, 20% are currently in the update process, 7% are overdue for an update, and 26% have not adopted or made public their EOP.

Floodplain Management

State legislature delegates the responsibility of adopting regulations to each county flood control district and its floodplain manager. The floodplain manager is responsible for corrective and preventative measures that reduce flood damage. These measures include zoning, subdivisions, and special-purpose floodplain ordinances. Floodplain management further includes regulations that promote public health and safety and minimize losses from flooding. Additionally, floodplain management considerations may include zoning restrictions and regulations for areas known to house repetitive loss and severe repetitive loss properties.

Of the 15 counties, 40% have adopted updated floodplain ordinances since 2017, 47% have adopted updated flooding ordinances between 2010 and 2016, and 13% have yet to adopt updated flooding ordinances, with their last adoption occurring before 2010.

Subdivision

The state requires counties to identify land to be subdivided or proposed for sale or lease, whether immediate or future, into six or more lots or parcels. Subdivisions provide for orderly growth and development that secures adequate provisions for water supply, drainage, stormwater detention, sanitary sewerage, health and safety requirements, and protection from floods, ensuring the identification of sufficient sites for schools, recreational areas, and public facilities.

Of the 15 counties, 40% have adopted updated subdivision ordinances since 2016, 27% have adopted updated subdivision ordinances between 2010 and 2016, and 33% have not recently adopted updated flooding ordinances, with their last adoption occurring before 2010.

Zoning

The state requires counties to adopt ordinances identifying zones for a particular purpose or residential area. Zoning practices divide the county into land use zones as delineated on the official zoning maps and set regulations for promoting citizens' health, safety, morals, convenience, and welfare.

Of the 15 counties, 40% have adopted updated zoning ordinances since 2017, 40% have adopted updated zoning ordinances between 2010 and 2016, and 20% have yet to adopt updated zoning ordinances, with their last adoption occurring before 2010.

Dam Safety/HHPD Management

There are multiple county, city, town, and special districts within Arizona that own and operate HHPDs. Other local communities are located within a dam failure hazard area even though they do not own or operate any dams. Policies, programs, and capabilities that are currently in place for local communities in Arizona to implement mitigation actions that will reduce vulnerability due to the presence of HHPDs vary greatly across communities and whether a community is an owner or not. The following represent some examples of typical capability resources

Flood Control Districts

All Arizona counties and several other specially defined geographies, have organized special taxation districts per allowances under state law, with a primary focus on the design, construction, and operation/maintenance of flood control structures for the benefit of the cities, towns, and public within the county boundaries. Often their oversight includes HHPDs, most of which are primarily designed to provide flood control and are otherwise dry during non-flood conditions. These districts have a dedicated tax levee funding source and depending on their size, may have department/groups dedicated to dam safety with technically qualified staff or consultants available to identify effective mitigation actions/measures (A/M) that will reduce the vulnerability created by the structures they manage.

Local City/Town Departments

In some cases, city/town owned HHPDs are managed through a standing department of the community and typically employ consultants to assist with management, development and implementation of HHPD mitigation strategies. In some cases, these snaller communities will work cooperatively with the county flood control district to leverage those resources and technical expertise.

ADWR Dam Safety Unit

The dam safety unit at ADWR is a resource to local HHPD owners for assistance with inspections, identification of mitigation needs, regulatory requirements, and technical review. ADWR also serves the non-dam-owning public as a regulatory and dam safety monitoring resource for communicating concerns and coordination with HHPD dam owners. See Section 5 of this Plan for further detail of services provided by ADWR.

Mitigation Challenges

In the sampled LHMPs, some challenges communities faced in implementing their hazard mitigation plans were lack of funding, insufficient technical expertise among staff, and staff turnover, leading to loss of institutional knowledge. The three factors mentioned often led counties to have expired plans or programs that can lead to missing funding opportunities for Hazard Mitigation Assistant (HMA) Grants, which can limit resiliency efforts, mitigation activities, and overall preparedness. Additionally, many local governments cannot be competitive in the national HMA programs due to the cost match, lack of grant writing and planning staff, and even emergency managers.

Mitigating certain community lifelines can also challenge local communities due to barriers to acquiring funding for privately owned facilities such as power, gas, communications, water and sewer, etc. When a key facility is identified to be at critical risk, communities must rely on private interests to implement and fund the mitigation. This requires extensive coordination, communication of the need, and demonstrating cost-effectiveness to the owner. Too often, the response is post-hazard with critical interruption of services or goods.

Despite these challenges, there are some ways communities can take action to promote mitigation efforts independently. Communities are crucial in advancing mitigation strategies through grassroots initiatives and local resources. One effective approach is establishing community-led task forces or committees dedicated to mitigation planning and implementation. These groups can identify local vulnerabilities, prioritize mitigation measures, and mobilize volunteers and community members to participate in mitigation projects.

Additionally, communities can tap into their resources by organizing fundraising events or seeking grants and partnerships with local businesses and organizations. These funds can be invested in infrastructure improvements, disaster preparedness programs, and public awareness campaigns.

Furthermore, educational initiatives within communities are essential for building resilience. Residents can be encouraged to participate in training programs on disaster response and mitigation techniques, empowering them to take proactive steps in safeguarding their homes and neighborhoods.

Although the three factors mentioned above have impacted community resiliency somewhat, AZ communities have continued to submit project applications. AZ has submitted over 400 million dollar’s worth of project applications within the last three years and is on track to surpass that amount.

LOCAL & TRIBAL PLANNING COORDINATION, PLAN INTEGRATION, AND FUNDING PRIORITIES

Local and Tribal Planning Coordination

DEMA/EM is committed to actively supporting local and tribal governments in developing and updating their hazard mitigation plans by offering planning assistance guidance, training opportunities, and assistance in acquiring grant funding when needed. When assisting local or tribal governments, we tailor our approach to align with their specific objectives. The expiration dates of the plans primarily drive our coordination and aid efforts. However, we remain flexible to address emergent challenges, such as new hazard developments or significant alterations required in local and tribal plans. A central focus of our support is to ensure that each plan accurately represents the distinctive attributes of the participating jurisdiction or tribe. We recognize the diversity in geography, hazards, beliefs, resources, leadership, and values within each community and tribe.

In addition to offering technical support, DEMA/EM plays a crucial role in reviewing local and tribal hazard mitigation plans within specified timeframes. All local jurisdictions must submit their plans to DEMA/EM for an initial assessment, typically within 120 days of plan expiration, before they are forwarded to FEMA for final review and approval, as our reviews can take up to 30 days. Our reviews align meticulously with FEMA's latest assessment tools and protocols.

When a plan falls short of meeting requirements during our initial assessment, we extend assistance to revise and refine the plan to ensure its effectiveness and successful review by FEMA. This collaborative effort allows us to work closely with local and tribal entities to expedite the approval process.

A critical aspect of our coordination involves conducting plan evaluations during the plan's valid timeframe, typically every year. This annual review process helps identify and overcome obstacles to plan implementation by continuously evaluating progress on the outlined mitigation strategies. Mitigation plans are designed to be dynamic documents that receive ongoing monitoring, with each review typically taking around 30-60 days to complete.

We also offer plan update assistance for communities that need more resources or technical expertise to update their Hazard Mitigation Plans independently. The insights derived from these reviews, whether conducted annually or in the aftermath of a disaster, play a pivotal role in shaping implementation decisions and streamlining the update process, ensuring that plans remain up-to-date and effective in safeguarding our communities. As part of our commitment to enhancing planning capabilities, DEMA/EM regularly conducts FEMA course G393: Mitigation for Emergency Managers and FEMA course 318: Mitigation Planning for Local and Tribal Communities at various locations across the state. These courses enhance participants' understanding of planning processes, equipping them to engage more effectively in mitigation planning endeavors. Moreover, we organize workshops that focus on grant opportunities and submissions.

DEMA/EM remains dedicated to fostering robust hazard mitigation planning across local jurisdictions and tribal communities, contributing to safer and more resilient environments.

Local Plan Integration

The state's goal is to ensure state mitigation planning efforts and priorities align and reflect local and tribal plans with a statewide comprehensive approach. Supporting local and tribal hazard mitigation planning and participation is essential for building resiliency. Thus, we continue integrating and linking the SHMP with pertinent local government programs and planning efforts. To ensure future success in this area, we intend to:

- Maximize the use of hazard mitigation resources, grants, and funds to reduce the impact of future disasters at the local level;
- Maintain collaborative and cooperative relationships with local emergency managers, land use planners, and the scientific and technical communities involved in hazard mitigation;
- Improve communications with stakeholders, legislators, and special interest groups involved in hazard mitigation;
- Develop a statewide program of support for hazard identification and analysis and a risk-based approach to project identification, prioritization, and support for local governments;
- Support integration of the SHMP and its strategy with state, county, and local sustainability plans, Long Range Transportation Plans (LRTP), coordination with the Metropolitan Transportation Program (MTP)/Regional Transportation Plan (RTP),

general master plans, and other planning documents such as general/comprehensive plans, where appropriate.

- Encourage local jurisdictions and counties to develop effective multi-jurisdictional mitigation plan updates by;
  - Provide plan expiration reminders to local communities one year before expiration and additional notifications as needed by offering technical assistance from DEMA/EM.
  - Identify plans expiring two years before expiration and provide HMA funding opportunities to assist with the plan update and development.
  - Host collaborative seminars or workshops to bring awareness to the SHMP and recent mitigation efforts.
  - Disseminate the latest requirements, guidance publications, and lessons learned by DEMA/EM and offer plan coordination and technical assistance to local jurisdictions and tribal governments.
  - Deliver FEMA updates, courses/training, quarterly newsletter, and grants workshops/training.
  - Utilize and update the DEMA/EM website to house the SHMP and resources for county and tribal emergency managers to use for their plan update and development.
  - Encourage using this Plan's framework to allow smooth integration with the State Plan.

Prioritizing Local Funding and Planning Activities

DEMA/EM administers FEMA's Hazard Mitigation Assistance (HMA) grant program for the State of Arizona. The grant program is delivered to state agencies and local jurisdictions, while tribes in Arizona apply directly to FEMA. The HMA program consists of three grant programs: Building Resilient Infrastructure and Communities (BRIC) (formerly Pre-Disaster Mitigation (PDM)), Flood Mitigation Assistance (FMA), and Hazard Mitigation Grant Program (HMGP).

Project proposals for HMA grant programs may at times, encompass a wide variety of hazard mitigation solutions. In the development of planning related activities for hazard mitigation solutions, focus is placed on prioritizing communities and local jurisdictions that would receive planning and project grants under available funding programs, which would include but is not limited to, consideration for communities with the highest risks, repetitive loss structures, and most intense development pressures. Further, for hazard mitigation grant project proposals, a principal criterion for prioritizing activities will be the extent to which benefits are maximized according to a cost benefit review of proposed projects and their associated costs.

The prioritization factors used for BRIC and FMA may include:

- Direct impact on life safety
- Projects that provide the most benefits to the community
- Mitigation of repetitive loss (RL) or severe repetitive loss (SRL) structures/properties
- Benefit to impoverished communities

- Non-planning activity projects
- Cost-effectiveness
- Impact on Socially Vulnerable/Underserved Communities

HMGP's additional funding factor is the structure/property located in the affected area(s).

Projects undergo a thorough and unbiased review conducted by a panel of participants selected based on knowledge and experience, and are often members of other state agencies or local jurisdictions.

High Hazard Potential Dams

Many of the dams in the state are owned and operated by local and tribal governments. In most cases, those owners have programs to monitor, operate and maintain those facilities. The majority of the locally owned dams function as flood retarding structures and are dry most of the time. The non-federal HHPD structures are regulated by ADWR Dam Safety program, which sets the criteria and policy for the design, monitoring, operation and implementation of mitigation actions. ADWR works with local dam owners to provide technical resources, regulatory oversight, and compliance enforcement to ensure the HHPD dams are up to current safety policy.

Local mitigation efforts often involve addressing changes to requirements, changes in watershed conditions or hydrologic data, and mitigation of identified maintenance issues or necessary design changes. Challenges often include a lack of technical expertise or staffing, funding, or conflicting management goals. ADWR helps local dam owners leverage resources from programs like the HHPD grants, NRCS grants, and USACE to effect mitigation efforts.

Implementation of mitigation measures and actions is primarily administered at the local level. In some cases, local agencies use tax levees to fund mitigation measures and the regular maintenance and operation of the dams and associated facilities. In most cases, federal participation is required due to the magnitude of the costs. Ranking HHPD-funded mitigation actions or projects follows the same general procedure listed above, with additional priority given to dams receiving an "unsafe" classification from ADWR. The state continues to evaluate the implementation of HHPD grants and is working to address limitations and deficiencies as they arise. The program is still fairly new and more will be revealed over this next Plan cycle.

SECTION 7: PLAN MAINTENANCE AND IMPLEMENTATION

MONITORING AND EVALUATION

The regulation requires a plan maintenance process that establishes a method and schedule for monitoring, evaluating, and updating the plan, a system for monitoring the implementation of mitigation actions and project closeouts, and a system for reviewing progress on achieving goals identified in the mitigation strategy. These maintenance components are discussed in this section.

DEMA/EM staff are responsible for developing and maintaining the Plan; additional participants in plan maintenance may include the members of the Planning Team, the State Hazard Mitigation Officer (SHMO), and their designee.

The objective will be to review the Plan annually, but at minimum, every two years, to reflect significant policy changes that took place during the preceding year(s) and to report on progress made and other findings. The review will take place at the end of the calendar year. The DEMA/EM staff and other participants will perform this review as follows:

- Examine progress or changes in hazards and emergency/disaster occurrences.
- Review, revise, and update the state capability assessment and the statewide mitigation strategy to reflect changes in policies, priorities, programs, and funding.
- Examine progress on mitigation measures in the statewide mitigation strategy.
- Identify challenges in implementing mitigation measures.
- Recommend how to solve such challenges, possibly by increasing the involvement of state agencies, partners, stakeholders, and the private sector.
- Review hazard profiles for which significant new information is available that could change the risk level or area of impact.

The review findings will be documented and distributed to DEMA/EM staff and others involved in the review. DEMA/EM will maintain the documentation.

After an emergency or disaster, the Plan will be reviewed. DEMA/EM staff will coordinate the review with the Planning Team, subject matter experts, and other stakeholders. Observations and data related to the disaster will be shared to identify specific mitigation needs related to the disaster-affected area. This information will help to inform how the Plan is affected and where adjustments may be warranted. The post-disaster review may replace an annual review in any year that a major disaster occurs, depending on the disaster event's severity and time of year.

UPDATING THE PLAN

DEMA/EM staff, the SHMO, and their designee will facilitate the review and update of the Plan every five years to ensure the goals and objectives for Arizona are current and reflect priorities. The following will be encouraged and invited to participate; previous Planning Team members, subject matter experts, and other stakeholders from the following sectors:

- State Agencies;

- Emergency Management;
- Academia; and
- Organizations/Agencies that address Climate change and regional Climate Change Collaborative Entities.

The review and update process will begin at a minimum of 1 year before plan expiration. This process will incorporate all revisions and findings resulting from annual and post-disaster reviews, particularly new hazard identification and risk assessment information. The significant areas of focus during the update will be as follows:

- Revising the risk assessment to remain current and accurate. This may include adding or omitting hazards, incorporating new information on risk and vulnerability, and integrating information from local mitigation plans.
- Assess and evaluate the state's mitigation capabilities to reduce risk and increase resiliency.
- Examine and document the progress and determine the effectiveness of the mitigation actions outlined in the mitigation strategy.
- Examine the effectiveness of funded local mitigation projects and determine the implementation's success and challenges.
- Examine the overall implementation of the Plan, identify challenges, and develop recommendations to overcome them.
- Following review and revision of the Plan, analyze the maintenance and project monitoring processes and make changes to improve these processes as needed.

The overall update process will be conducted using a team approach, and decisions will be made by consensus to ensure the knowledge and experience of the team is used to develop the most accurate and effective Plan possible.

The Plan will be sent to FEMA for review and promulgated by the Director of DEMA/EM upon an approvable pending adoption determination from FEMA. The most current Plan will always be available on the DEMA/EM website.

MONITORING, IMPLEMENTATION, AND REVIEWING PROGRESS

Monitoring Projects

FEMA Funded

The SHMO is responsible for monitoring and evaluating the progress and completion of FEMA-funded mitigation projects. Monitoring activities ultimately begin with a meeting between the State Mitigation Office (SMO) and the sub-grantee to ensure all parties are aware of the requirements set forth by federal regulations and the appropriate grant program. The amount of monitoring conducted varies depending on the complexities of the project and the expertise/experience of the sub-grantees. Recognizing "danger signals" can indicate the amount of monitoring necessary for a project. "Danger signals" can present as failing to file timely quarterly reports or showing a lack of progress, expenditures that do not match the percentage of project completion, a change in project manager, etc.

The State Mitigation Staff conducts project monitoring through ongoing communication, random site visits and inspections, and by analyzing quarterly reports to verify progress. Upon completion of a project, the State Mitigation Staff will schedule a final inspection with the sub-applicant. The final inspection includes a final site inspection and a review of the financial documentation in preparation for an audit by the state.

Project timelines and schedules for FEMA-funded projects will vary and depend on the grant program guidelines.

DEMA/EM will utilize any and/or all of the above methods as determined by the SHMO.

Non-FEMA Funded

In coordination with the designated lead agencies/stakeholders, the DEMA/EM Planner will conduct reviews of the Plan to evaluate the progress of the mitigation strategy and measures. Mitigation strategy reviews will be documented and should include information regarding mitigation action priority levels, funding source(s), resources, project start/completion dates, and progress of specific activities. Additionally, these reviews will be utilized to analyze the applicability of the existing mitigation measures and address challenges hindering implementation.

Monitoring Projects in this Plan

The mitigation measures in this Plan will be evaluated as outlined in the Plan Maintenance section. Documentation of the measures will be updated as monitoring and reviews occur and when additional progress is reported or other communication/correspondence is made regarding the measures. The database will include but is not limited to the following information:

- Measure
- Priority level
- Lead and participating agencies
- Funding or resource source(s)
- Project start/complete dates
- Correspondence/communication
- Progress indicated by specific activities

Mitigation measures presented in this Plan were presumed to be actionable and at least started if not completed by the expiration of this Plan. The designated measure's "lead" is responsible for securing the necessary funding and other resources, coordinating the project's implementation, monitoring progress, and maintaining detailed records of related activities.

Accountability of Funds

DEMA/EM, serving as grantee, has primary responsibility for project management and accountability of funds as indicated in 2 CFR, Part 200. DEMA/EM is responsible for ensuring that sub-grantees meet all program and administrative requirements.

The SHMO is responsible for monitoring mitigation projects in accordance with 2 CFR, Part 200. The process to track and monitor mitigation activities has not changed.

Sub-Grantee Record Keeping Requirements

Federal regulations (44 CFR, Parts 13.20 and 206.205) require each Sub-grantee to maintain a system that accounts for FEMA funds on a project-by-project basis. The system must disclose the financial results for all activities accurately and completely. It must identify funds received and disbursed and reference source documentation.

Federal regulations (OMB Circular A-87 and 44 CFR, Part 13.20) require that costs claimed under federal programs must be adequately supported by source documentation such as canceled checks, invoices, payroll, time and attendance records, contracts, etc. Each Sub-grantee must maintain full documentation in order to receive payment. The Sub-grantee will be required to document all expenditures and implement monitoring procedures for review by the SMO. Quarterly reports are to be submitted to DEMA/EM on the status of completion dates, any changes in the scope of work, and project costs to date. The SHMO will require the submission of documentation before any reimbursement is made.

Closeout Procedures

Subgrant Closeout

Prior to close out of a subgrant, Mitigation Office staff will inspect all projects for completion and compliance. If documentation, inspections, and other reviews reveal issues in performance of work or the documentation, staff will work with the subgrantee's applicant agent to correct the deficiencies before closeout. Items required to be submitted with the subgrant closeout request are:

- Final invoice with supporting documentation;
- Final quarterly report;
- Letter requesting final reimbursement; and
- Project photographs.

Elevation projects will also require:

- Before and after photos;
- Copies of pre- and post-construction elevation certificates; and
- Signed, recorded deed notices.

Acquisition projects will also require:

- List of all properties acquired, including address, parcel number, longitude, and latitude; and
- Copies of signed recorded deeds.

The SHMO will submit the final closeout request to FEMA, including the above documents.

The SHMO will submit a final project closure package to terminate the FEMA-State Agreement when all subgrants have been closed. The package will include:

- A list of all projects with eligible expenditures; and
- Certification that all funds have been expended in accordance with the FEMA-State Agreement utilizing the SF 425.

When these funds have been paid, the SHMO determines the final eligible administrative allowance and requests reimbursement from FEMA. Upon receipt of this allowance, the SHMO notifies the Regional Administrator in writing that no further claims for the project will be made and that all program activity has been closed.

ANNEX A

PLANNING TEAM MEETING DOCUMENTATION

ANNEX B

PREVIOUS MITIGATION STRATEGY ASSESSMENT

Lead Agency: Arizona Counter Terrorism Information Center (ACTIC)					
ID	**Hazard Addressed:** **Action:**	• **Priority:** • **Estimated Completion:** • **Potential Funding Source:** • **Objective Satisfied:**	**Status**	**Disposition**	**Explanation**
8.0	Cyber Terrorism Conduct community outreach to improve cyber resilience by educating residents, businesses, organizations, and government entities on cyber hygiene and best practices. This capability includes creating a public-facing website for cybersecurity, building a library of cybersecurity products, such as unclassified threat/incident alerting and notification products, FAQs, newsletters, and presentations, and facilitating events and presentations. Because the internet is one connected network, improving the security practices of one individual can help protect Arizona and the world.	• High • Ongoing • Urban Areas Security Initiative grant program • 1, 2, & 3	Meets current requirements	KEEP	At this time no changes are foreseen as far as Priority, Potential Funding or Objective Satisfaction.
8.1	Cyber Terrorism Improve and expand the cyber threat/incident alerting and notification capability. This will provide timely alerts/notices of in-process and/or potential cyber threats and incidents. This will also include possible measures to prevent, detect, and respond to the threats, to residents, companies, community partners, organizations, state, local, tribal, law enforcement, military, and other entities. This will enable the State of Arizona to potentially prevent and minimize the impact of cyber incidents.	• High • 2023 • Urban Areas Security Initiative grant program • 1, 2, & 3	Meets currents requirements	KEEP	No foreseen changes in Priority or funding and should continue into fiscal year 2024.

Lead Agency: Arizona Department of Environmental Quality (ADEQ)

ID	Hazard Addressed: Action:	• Priority: • Estimated Completion: • Potential Funding Source: • Objective Satisfied:	Status	Disposition	Explanation
4.0	Hazardous Materials Manage an online database for Hazardous Materials and Extremely Hazardous Chemicals in which facilities in Arizona upload Tier II information for viewing by Fire Departments and Local Emergency Planning Committees for response and planning activities to mitigate against HazMat incidents.	• High • Ongoing/Annually • ADEQ • 1, 2, & 5	Currently system is in place	Keep	The Emergency Response Unit (ERU) within ADEQ manages the Tier II reporting site and communicates with all LEPCs and participating FDs.
4.1	Hazardous Materials Distribute funds to the Local Emergency Planning Committees (LEPCs) to support HazMat planning, training, and equipment. The LEPCs have Response Plans in the event of a HazMat incident. The HazMat training is for first responders and the equipment enhances the County HazMat Teams.	• High • Ongoing • HMEP program • 5 & 6	Currently grant is ongoing	Keep	On average ADEQ has $500k annual in funding available for participating FDs and LEPCs to utilize for hazardous materials equipment and/or training. The funding comes from 2 sources, the federal HMEP grant, and state appropriated funds from Tier II reporting fees.
4.2	Hazardous Materials Provide consultative services, conduct and participate in workshops and coordinate development and review of plans and programs for 15 LEPC.	• Medium • Ongoing • ADEQ • 1, 2, & 5	Currently services are in place	Keep	ERU is designated by the State Emergency Response Commission as SERC staff to assist in plan development, LEPC assistance and compliance, and hosts semi-annual workshops.

Lead Agency: Arizona Department of Health Services (ADHS)					
ID	**Hazard Addressed:** **Action:**	• **Priority:** • **Estimated Completion:** • **Potential Funding Source:** • **Objective Satisfied:**	**Status**	**Disposition**	**Explanation**
10.0	Infectious Disease ADHS will enhance and modify the states Medical Electronic Disease Surveillance System (MEDSIS) in at minimum quarterly increments. This will ensure more rapidly generated reports, searching for or pulling data from medical cases or patients, and integrating surveillance data from local, tribal, federal, and disease monitoring systems among international public health partners along the Mexico border. This will allow for timely and effective epidemiological investigations to minimize risk to the public.	• High • 2023 • Public Health Emergency Preparedness grant • 1, 2, & 3	In Progress	Keep	Only 2 MEDSIS production updates were released so far due to the HIV MEDSIS integration. The 2 production updates included two new standardized lab and drug tables to streamline overdose reporting and surveillance, added a duplicate check to the Batch Case Creation function, implemented Batch contact record creation to reduce contact record entry burden, and updated Hep A, Hep C, and COVID DSO to align with MMGs in prepare for case notification implementation. Multiple system enhancements were pushed into production to improve overall system performance and user experiences.
10.1	Infectious Disease Update and enhance emergency Medical Counter Measure plans, and conduct drills and exercises to ensure medical counter measure capabilities are integrated with local and tribal public health and health care coalitions. This will create capacity to cope with demands on the healthcare infrastructure and rapidly communicate risks to the public.	• Medium • 2023 • Public Health Emergency Preparedness grant • 1, 2, & 5	Completed	Keep	In October 2022, ADHS-BPHEP MCM Coordinator updated the MCM Operational Plan and conducted a workshop highlighting changes/updates to the plan in November 2022. Some key update considerations; plan maintenance section, language and process updates from COVID-19 and addition of warehouse operations outlined. Additional training and or workshops will be conducted to partners in the future.

Lead Agency: Arizona Department of Administration (ADOA)

ID	Hazard Addressed: Action:	• Priority: • Estimated Completion: • Potential Funding Source: • Objective Satisfied:	Status	Disposition	Explanation
9.0	All Hazards Develop a comprehensive framework to facilitate the implementation of a standardized and sustainable Safety Management System (SMS) for all state agencies, boards, and commissions.	• High • 2023 • ADOA • 1, 2, 3, & 5	Ongoing/ Sustaining	Keep	The Arizona Department of Administration - Risk Management Division (ADOA-RMD) has developed a framework and a methodology for all state agencies, boards, and commissions to achieve a functional Safety Management System (SMS). Over the past five years, ADOA-RMD has been collaborating with multiple state agencies to establish a baseline SMS score and raise it in a sustainable manner. Many of the larger agencies have implemented the SMS in some form, which has generally been correlated with a reduction in injuries and property damage.
9.1	Terrorism – Cyber Building a Cybersecurity Workforce Economic Development The State of Arizona, through the Governor's AZ Cyber Team Executive Order, will drive cybersecurity and IT related workforce economic development and education. This will be a collaborative effort that will include representatives from public, private, and education sectors.	• High • Ongoing • N/A • 1 & 5	Ongoing	Modify	1) Please reassign to the Arizona Department of Homeland Security as primary. 2) ADOHS recommended rephrasing of the Action's description as follows: "The State of Arizona, through the Arizona Department of Homeland Security and Arizona Department of Administration, will drive cybersecurity and IT related workforce economic development and education. This will be a collaborative effort that will include representatives from public, private, and education sectors."

Lead Agency: Arizona Department of Water Resources (ADWR)

ID	Hazard Addressed: Action:	• Priority: • Estimated Completion: • Potential Funding Source: • Objective Satisfied:	Status	Disposition	Explanation
2.0	Flooding Assist local jurisdictions in acquiring, or otherwise mitigating, property located in the 100-year floodplain, beginning with repetitive loss properties.	• High • Ongoing/Annually • Existing Staff/Budget • 4 & 7	Ongoing	Keep.	
2.1	Dam Failure Provide information to county and local emergency management and floodplain management officials regarding the status, potential hazards, and risks associated with deficient dams to ensure they make better informed decisions regarding planning and development.	• Medium • Ongoing/Annually • Existing Staff/Budget • 1, 2, 4, & 5	Ongoing	Keep	
2.2	Dam Failure Identify adequate funding sources within the dam repair program, which is designed to assist the state and the dam owners in the protection of life and property. Report to the Director of ADWR.	• High • Ongoing/Annually • Existing Staff/Budget • 1 & 6	Ongoing	Keep	ADWR has used monies from the Dam Repair Fund to leverage Federal funds (approx.. 2 Federal dollars for each ADWR dollar) to assist dam owners who participate in the High Hazard Potential Dam program with FEMA and the NDSP.
2.3	Flooding Continue to encourage and educate local officials and renters who live in areas that are flood prone to acquire flood insurance through the NFIP.	• Medium • Ongoing • Existing Staff/Budget • 1, 2, 3, & 4	Ongoing	Keep	

Lead Agency: Arizona Department of Water Resources (ADWR)					
ID	**Hazard Addressed:** **Action:**	• **Priority:** • **Estimated Completion:** • **Potential Funding Source:** • **Objective Satisfied:**	**Status**	**Disposition**	**Explanation**
2.4	Flooding Encourage communities to begin or continue participation in the Community Rating System (CRS) program. The program offers credit for various activities that potentially reduce flood damages and assist property owners in receiving reduced insurance premiums.	• Low • Ongoing • Existing Staff/Budget • 1, 2, 3, & 4	Ongoing	Keep	
2.5	Dam Failure Coordinate with county/community emergency management and floodplain management officials to provide information regarding the locations and potential hazards of existing dams so communities can make better informed development decisions.	• Low • Ongoing/Annual • Existing Staff/Budget • 1, 2, 4, & 5	Ongoing	Keep	

Lead Agency: State Climate Office & Arizona State University (ASU)					
ID	**Hazard Addressed:** **Action:**	• **Priority:** • **Estimated Completion:** • **Potential Funding Source:** • **Objective Satisfied:**	**Status**	**Disposition**	**Explanation**
6.0	All Natural Hazards The State Climate Office will pull together a Natural Hazards webpage that describes Arizona's weather/ climate related natural hazards and explains measures the public can take before, during and after the events to keep themselves and their property safe. Will also include links to resources for assistance before and after extreme weather events. This will be linked to Arizona State University's web pages, as many of the students at the University are from other states and may be unaware of Arizona's weather/climate hazards.	• High • 2023 • Existing Staff/Budget • 1 & 2	Completed	Keep	https://azclimate.asu.edu/weather/weather-safety/ All items currently available on the website.
6.1	All Natural Hazards The State Climate Office, in conjunction with Arizona State University, will create a University-wide weather webpage showing current weather conditions across the four campuses and include NWS alerts, special weather statements, watches and warnings for the area and the state. This page will link to the Natural Hazards page.	• High • 2023 • Existing Staff/Budget • 1 & 2	Largely completed	Modify	A mesonet (weather station network) is being developed for the 4 ASU campuses. TBD uncertain date. Currently, there are no weather stations available to portray weather conditions on each individual ASU campus in real time. https://azclimate.asu.edu/weather/ The website shows current weather conditions, hazard alerts, forecasts, satellites imagery for the Phoenix area and across the state.

Lead Agency: Arizona Department of Agriculture (AZDA)					
ID	**Hazard Addressed:** **Action:**	• **Priority:** • **Estimated Completion:** • **Potential Funding Source:** • **Objective Satisfied:**	**Status**	**Disposition**	**Explanation**
7.0	All Hazards The AZ Department of Agriculture will publish the Arizona Secure Food Plan in order to increase awareness of food safety for producers while reducing the vulnerability of agricultural producers from natural and human-caused hazards. The Secure Food Plan will consist of three major components: secure beef, dairy, and egg plans. The goals of these plans will be to assure a continuous food supply to consumers and maintain business continuity for producers during both disease outbreaks and other emergencies that can affect agricultural products. These plans will provide for efficient and effective emergency response to maximize the movement of safe and healthy products to the market and consumer. We will provide these plans to agriculture stakeholders so that they can begin adoption of these plans in order to be better prepared for future emergencies.	• High • 2023 • Existing Staff/Budget • 1, 2, & 3	In Progress	Keep	Secure food plans continue to be drafted and modified according to stakeholder input, which is in a continuous stage of change.

Lead Agency: Department of Forestry and Fire Management (DFFM)					
ID	**Hazard Addressed:** **Action:**	• **Priority:** • **Estimated Completion:** • **Potential Funding Source:** • **Objective Satisfied:**	**Status**	**Disposition**	**Explanation**
5.0	Wildfire Ensure Arizona Firewise Communities program and fire prevention information is distributed statewide. It has been repeatedly demonstrated that education is a key component in convincing the public to endorse and adopt wildland fire prevention and Firewise principles and activities.	• High • Ongoing • Existing Staff/Budget • 1, 2, 3, & 4	Ongoing	KEEP	
5.1	Wildfire Maintain GIS wildfire incident database and share data with local jurisdictions and others that may benefit from using it to identifying areas at risk and prioritize project areas based on present fuels, threat to the public, and natural resources and to track the location and progress of ongoing projects.	• High • Ongoing • Existing Staff/Budget • 1 & 2	Ongoing/Still Under Development	Modify	Currently there are many agencies that maintain fire data however, this information is not readily shared. This should be modified to a more CWPP metric as then the local communities will track their own fire data and projects so it is a one stop shop for this information.
5.2	Wildfire Encourage cities, communities, and other municipalities to specify landscaping requirements based upon Firewise principles. This is necessary for those living in or owning property in the WUI or Communities at Risk to manage the fuels on their properties to reduce their risk from wildland fires.	• High • Ongoing • Existing Staff/Budget • 1, 2, & 3	Ongoing	KEEP	

Lead Agency: Department of Forestry and Fire Management (DFFM)					
ID	**Hazard Addressed:** **Action:**	• **Priority:** • **Estimated Completion:** • **Potential Funding Source:** • **Objective Satisfied:**	**Status**	**Disposition**	**Explanation**
5.3	Wildfire Add requirements to building codes for fire resistive materials for new construction and additions to existing construction. One element of Statewide Strategy for Restoring Arizona's Forests: encourage community leaders to take steps to mitigate against wildfire by encouraging local implementation of WUI codes.	• High • Ongoing • Existing Staff/Budget • 4 & 5	Has not begun and at large scale	DELETE	This is not something that can be easily accomplished as we (the state) does not have much control over individual community decisions. The best way to mitigate wildfire is to follow firewise and ready, set, go standards which is already in other bullet points.
5.4	Wildfire Continue to complete wildland fuels reduction projects as appropriate and renew/revise agreements as necessary.	• High • Ongoing • FEMA, other federal funding • 4 & 5	Ongoing	KEEP	

Lead Agency: Arizona Geological Survey (AZGS)

ID	Hazard Addressed: / Action:	• Priority: • Estimated Completion: • Potential Funding Source: • Objective Satisfied:	Status	Disposition	Explanation
3.0	Flooding ~~Investigate~~ Conduct assessments to identify areas with the potential for debris flows and flooding in the post-fire environment & identify high-risk areas for incorporation into mitigation plans and to target areas for mitigation activities.	• High • Ongoing/Multi-year project • FEMA ~~RiskMap~~ PDM, HMGP and BRIC programs • 1, 2, 3, 4, & 5	Ongoing	Modify	We have several projects around the state that are either ongoing or are slated to begin in the fall. We collect data from burned areas to help improve hazard assessment models, and we work with local county flood control districts to identify areas that could be prone to post-fire flooding so mitigation efforts can begin prior to the occurrence of a wildfire. Coconino County was previously studied, Yavapai County is being studied now, and FEMA HMGP funds have been allocated for Gila County.
3.1	Flooding Conduct surficial geologic mapping to evaluate piedmont areas that may be prone to flooding. Make the resulting map products available on the AZGS document repository for use in planning efforts at the local, county, and tribal levels.	• Medium • Ongoing • Existing Staff/Budget, Statemap program • 1, 2, & 7	Ongoing	Keep	This work is conducted through the USGS Statemap program. New mapping areas around the state are selected by an advisory committee.
3.2	Fissure Conduct earth fissure planning map briefings for state and local agencies whose responsibilities are affected by fissures.	• Low • Ongoing • Existing Staff/Budget ~~FEMA HMA program~~ • 2 & 5	Ongoing	Modify	3.2 and 3.7 should be combined
3.3	Geohazards Outreach: Earthquake, Fissures, Flooding, and Landslides Perform outreach to deliver awareness of geologic hazards – earthquakes, earth fissures, landslides, debris flows, and flash floods via ~~workshops,~~ online resources, media, and other outreach avenues through AZGS Geologic Extension Service.	• Medium • Ongoing • Existing Staff/Budget, FEMA NEHRP program 1, 2, 3	Ongoing	Keep	Combine 3.3 and 3.4? It's all outreach.

Lead Agency: Arizona Geological Survey (AZGS)					
ID	**Hazard Addressed:** **Action:**	• **Priority:** • **Estimated Completion:** • **Potential Funding Source:** • **Objective Satisfied:**	**Status**	**Disposition**	**Explanation**
3.4	Earthquake Distribute earthquake hazard information via hard copy and internet (including posters and presentations, monitoring and activity updates, etc).	• Low • Ongoing • FEMA HMA program, NERHP, AZGS • 1 & 2	Ongoing	Keep	Through a FEMA NEHRP Grant, AZGS is continuing its outreach efforts with the ShakeOUt Event every fall, and working directly with county and Tribal Emergency Managers through the Arizona Council for Earthquake Safety (ACES). AZGS has also presented research on unreinforced masonry buildings and AZ earthquakes at the National Earthquake Program Managers meetings.
3.5	Earthquake Investigate quaternary (young) faults to estimate the time since the most recent event, average recurrence intervals or slip rates and to estimate paleoearthquake magnitudes. This information can be used for seismic hazard assessments, including probabilistic earthquake hazard maps, which in turn can be used to plan mitigation projects.	• ~~Low~~ Medium • Ongoing • US Geological Survey, StateMap Program, ADOT, Bureau of Reclamation • 1, 2, 3, & 5 ~~1&2~~	Ongoing	Keep	AZGS has studied several active faults in the state, such as the Mead Slope fault near Hoover Dam, Lake Mary fault in Flagstaff, and the Carefree fault in Scottsdale Arizona. Fault studies such as these provide earthquake recurrence and size information that is used in the National Seismic Hazard Map to be released in 2025.
3.6	Landslide Coordinate research priorities to develop a predictive understanding of ~~landslide processes~~ post-fire debris flows & triggering ~~mechanisms~~ rainfall intensities. Make the resulting information available to federal, local, county and tribal entities to aid in issuing warnings, and in planning and mitigation efforts.	• Medium • Ongoing • ~~US Geological Survey~~ FEMA HMGP • 1 & 2	Ongoing	Modify	This kind of research currently is only being conducted on post-wildfire debris flows.
3.7	Fissure Identify and map known fissures across the state. Publish the maps and make available at AZGS's Earth Fissure Viewer. This information can aid the local, county, and tribal entities in their planning and mitigation efforts.	• ~~Low~~ Medium • Ongoing • ~~State Budget~~ Existing Staff/Budget, FEMA BRIC program • 1, 2, 3 & 5 ~~1&2~~	Ongoing	Modify	3.2 and 3.7 should be combined

Lead Agency: Arizona Geological Survey (AZGS)					
ID	**Hazard Addressed:** **Action:**	• **Priority:** • **Estimated Completion:** • **Potential Funding Source:** • **Objective Satisfied:**	**Status**	**Disposition**	**Explanation**
3.8	All natural hazards Add the GIS layers from 2018 state hazard mitigation plan risk assessment maps to the natural hazards viewer.	• ~~High~~ Low • 2020 • Existing Staff/Budget • 1, 2, & 3	Ongoing	Keep	The Natural Hazards Viewer was just updated.

Lead Agency: Department of Emergency and Military Affairs Division of Emergency Management (DEMA)					
ID	**Hazard Addressed:** **Action:**	• **Priority:** • **Estimated Completion:** • **Potential Funding Source:** • **Objective Satisfied:**	**Status**	**Disposition**	**Explanation**
1.0	All climatic hazards ~~Promote and disseminate climate change research and workshop information and data to state agencies, local, county, and tribal jurisdictions in order to enable all parties to prepare for the potential future conditions of the state.~~ Share and educate local, tribal, and state agency partners on climate resiliency efforts and information during annual hazard mitigation workshops to enable all parties to adapt to emergent threats and potential future conditions of the state.	• High • Ongoing • Existing Staff/Budget • 1,2, & 3	On-going	Modify	Modifying the action so it is time-bound, as there is no metric in place. Also modifying to align with EMPG.

ANNEX C

LIST OF ARIZONA HIGH HAZARD POTENTIAL DAMS