

**Greenlee County**  
Town of Duncan and Clifton

# ALL HAZARD MITIGATION PLAN



Final: August 2021

**5.3.3 Levee Failure**

**Description**

FEMA defines levees as man-made structures (usually earthen embankments) that are designed and constructed in accordance with sound engineering practices to contain, control or divert the flow of water so as to provide protection from temporary flooding (FEMA, 2009). National flood policy now recognizes the term “levee” to mean only those structures which were designed and constructed according to sound engineering practices, have up-to-date inspection records and current maintenance plans, and have been certified as to their technical soundness by a professional engineer or certain federal agencies. FEMA has classified all other structures that impound, divert, and/or otherwise impede the flow of runoff as “non-levee embankments”. In Greenlee County, these “non-levee embankments” might be comprised of features such as non-certified levees, roadway and railway embankments, canals, irrigation ditches and drains, and agricultural dikes.

In November 2017, Governor Ducey received a letter from the 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 is 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.

In recent years, the United States Army Corps of Engineers (USACE) has been working with Arizona to assess and update 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. The Arizona Department of Water Resources (ADWR) will serve as the state’s lead agency for levee safety. By participating in the USACE project and coordinating with FEMA through the Cooperating Technical Partnership (CTP) program, ADWR will work with FEMA, USACE and local officials to better inspect, maintain, and track levees within their communities.

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

Mechanisms for levee and non-levee embankment failure are similar to those for dam failure. Failure by overtopping could occur due to an inadequate design capacity, sediment deposition and vegetation growth in the channel, subsidence, and/or a runoff that exceeds the design recurrence interval. Failure by piping could be due to embankment cracking, fissures, animal borings, embankment settling, or vegetal root penetrations.

**History**

Levees and non-levee embankments have been used in Greenlee County for many years to protect communities and agricultural assets from flooding, as well as to facilitate the delivery and removal of irrigation water. These levees range from simple earthen embankments pushed up by small equipment to large engineered embankments placed on one or both sides of a watercourse. The structural integrity of levees with regard to flood protection and policy has been discussed at a national level since the early 1980s but was elevated to a high priority after the collapse and breach of New Orleans’ levees after Hurricane Katrina in 2005. In 2009, a draft report was issued to Congress by the National Committee on Levee Safety (NCLS, 2009) summarizing recommendations and a strategic plan for implementation of a National Levee Safety Program.

There are no documented failures of certified levees within Greenlee County. Non-levee embankment failures, however, occur on a regular basis and the risk posed by the many uncertified embankments in the county can be significant depending on their location. This is especially true in the Duncan area where there have been documented flooding events involving a breached or failed non-

levee embankment. It is noted that the term dike is often used in the literature to describe a non-levee embankment. The following are a few examples of flooding that involved non-levee embankment failures:

- In December 1978, widespread heavy rainfall from December 16-20 caused some of the costliest and widespread flooding in Arizona history. Waters from the Gila River rose to seven feet deep in the town of Duncan, and 75 homes were destroyed when a dike broke (ADEM, 2010).
- In late December 1992 - early January 1993, a series of winter storms produced record breaking precipitation amounts and severe weather across much of Arizona. Heavy rains combined with melting snowpack caused heavy flooding of both local washes and regional rivers within Greenlee County. A 400 foot breach in a protective dike caused five businesses and six residences to be inundated by water up to two feet deep (USACE, 1994; ADEM, 2010).
- In February 2005, a rain on snow event produced moderate flooding along the Gila River at Duncan where a section in the town's dike system broke flooding one occupied structure and the state highway near the Duncan high school (NWS Tucson, 2011).

#### **Probability and Magnitude**

There are varied probability or magnitude criteria regarding levee failure due to variability in levee design, ownership and maintenance. For flood protection credit under the NFIP, FEMA has established certain deterministic design criteria that are based on the 1 percent (100-year) storm event and corresponding minimum freeboard requirements. Federally constructed levees are usually designed for larger, more infrequent events such as the 0.04% and 0.02% probability (250 to 500 year) events plus freeboard. Recent recertification procedures proposed by U.S. Army Corps of Engineers, require that a certifiable levee have at least a 90% assurance of providing protection from overtopping by the 1% chance exceedance flood for all reaches of a levee system with a design freeboard height of at least three feet. For levees with more than three feet of design freeboard, the assurance is increased to 95%, and no certification will be made for levees with less than two feet of freeboard unless approved via a waiver process. This assurance is only for containment (overtopping failure) and does not include probability of failure by other modes such as piping (USACE, 2007).

As of the writing of this Plan, the only FEMA certified levee within Greenlee County is the Clifton Levee. The landside of the levee is delineated as a Shaded Zone X with an "Area Protected by Levee" description. This area was chosen by the Planning Team to represent the High hazard levee failure limits. Risk associated with other non-certified dikes and levees are represented in the Flooding profile of Section 5.3.2 and will not be duplicated here. The currently identified High hazard levee failure zone in Clifton is indicated on Map 2.

#### **Climate Change Impacts**

The climate change impacts to levee failure are nearly identical to those discussed in the Flooding section. Increases in winter flood intensities, combined with the effects of reduced watershed vegetation due to drought and/or wildfire, could elevate the probability of levee failures in the county, and especially for levees that were not designed to convey/contain flows greater than the 100-year (1% probability) standard. Most federally sponsored levee design and construction will use, or have used, discharges that exceed the 100-year standard, but not all. Mitigation activities should consider using the 500-year event as the minimum design standard to anticipate the impacts of climate change.

**Vulnerability – CPRI Results**

Levee Failure CPRI results for each community are summarized in Table 5-12 below.

<b>Table 5-12: CPRI results by jurisdiction for levee failure</b>					
<b>Participating Jurisdiction</b>	<b>Probability</b>	<b>Magnitude/ Severity</b>	<b>Warning Time</b>	<b>Duration</b>	<b>CPRI Score</b>
Clifton	Possible	Catastrophic	< 6 hours	< one week	3.00
Duncan	Highly Likely	Catastrophic	< 6 hours	< one week	3.90
Unincorporated Greenlee County	Possible	Catastrophic	< 6 hours	< 24 hours	2.90
<b>County-wide average CPRI =</b>					<b>3.27</b>

**Vulnerability – Loss Estimations**

There are no commonly accepted methods for estimating potential levee failure related losses. Many variables including storm size and duration, as well as size, speed, and timing at which a levee breach forms, all contribute to the potential for human and economic losses. Accordingly, no estimates of prior or potential losses are made in this Plan. Potential exposure of human and facility assets to the high hazard levee failure areas will be estimated instead. Table 5-13 summarizes the Planning Team defined critical facilities potentially exposed to a high hazard levee failure zone. Table 5-14 summarizes population sectors exposed to the high hazard levee failure zones. Residential structure exposures to high hazard levee failure areas are summarized in Table 5-15.

In summary, \$1.0 million in county-wide assets are exposed to a high hazard levee failure. An additional \$13.4 million in county-wide high hazard levee failure exposure of HAZUS defined residential facilities is estimated. Regarding human vulnerability, a total population of 247 people, or 2.93% of the total county-wide population, is potentially exposed to a high hazard levee failure event. Should a significant levee structure fail suddenly, it is plausible that death and injury might occur. It can also be expected that a substantial portion of the exposed population is subject to displacement depending on the event magnitude.

<b>Table 5-13: Asset inventory exposure to levee failure</b>				
<b>Community</b>	<b>Total Facilities Reported by Community</b>	<b>Impacted Facilities</b>	<b>Percentage of Total Community Facilities Impacted</b>	<b>Estimated Replacement Cost (x \$1000)</b>
<b>HIGH</b>				
<b>County-Wide Totals</b>	<b>155</b>	<b>4</b>	<b>2.58%</b>	<b>\$1,000</b>
Clifton	61	4	6.56%	\$1,000
Duncan	44	0	0.00%	\$0
Unincorporated Greenlee County	50	0	0.00%	\$0

<b>Table 5-14: Population sectors exposed to levee failure</b>						
<b>Community</b>	<b>Total Population</b>	<b>Population Exposed</b>	<b>Percent of Population Exposed</b>	<b>Total Population Over 65</b>	<b>Population Over 65 Exposed</b>	<b>Percent of Population Over 65 Exposed</b>
<b>HIGH</b>						
<b>County-Wide Totals</b>	<b>8,438</b>	<b>247</b>	<b>2.93%</b>	<b>1,015</b>	<b>29</b>	<b>2.84%</b>
Clifton	3,319	247	7.44%	313	29	9.27%
Duncan	699	0	0.00%	109	0	0.00%
Unincorporated Greenlee County	4,420	0	0.00%	593	0	0.00%

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Table 5-15: Residential structures with High hazard exposure to levee failure						
Community	Residential Building Count	Residential Building Exposure		Residential Building Replacement Value (x\$1000)	Residential Building Value Exposed	
		Total	Percent		Total (x\$1000)	Percent
HIGH						
County-Wide Totals	3,061	148	4.84%	\$287,960	\$13,389	4.65%
Clifton	1,246	148	11.88%	\$112,685	\$13,389	11.88%
Duncan	201	0	0.00%	\$14,910	\$0	0.00%
Unincorporated Greenlee County	1,614	0	0.00%	\$160,365	\$0	0.00%

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

**Vulnerability – Development Trend Analysis**

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

New development and redevelopment of the areas protected by the Clifton levee has been and will continue to be limited. The best mitigation for this area is for structure owners to be thoroughly made aware of the residual risks and to carry flood insurance. For the Town of Clifton, continued performance of routine maintenance and inspection of the existing levee facilities is critical to mitigating failures.

**Changes in Development in the Hazard Prone Area**

The only defined high hazard levee failure area lies within the Town of Clifton, in area which is largely developed. Changes in development in the Town of Clifton have not occurred within the hazard prone area. The Town continues to test and maintain the levee gates in ensure that they are operational in the event of a flood.

Within the Unincorporated County and the Town of Duncan there are no areas of development within a designated high hazard levee failure area.

**Sources**

Arizona Division of Emergency Management, 2018, *State of Arizona Multi-Hazard Mitigation Plan*.

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

FEMA, 2009, Web page at URL: [http://www.fema.gov/plan/prevent/fhm/lv\\_intro.shtm#3](http://www.fema.gov/plan/prevent/fhm/lv_intro.shtm#3)

National Committee on Levee Safety, 2009, *Draft Recommendation For A National Levee Safety Program*.

National Weather Service – Tucson FO, web page at URL:  
<http://www.wrh.noaa.gov/twc/hydro/floodhis.php>

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

**Profile Maps**

Map 2 – Potential Levee Failure Hazard Map

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