CITY OF TUCSON

FLOODPLAIN MANAGEMENT PLAN

TSMS Phase V

August 2016

Acknowledgments

Council Adoption

On August 9, 2016, the Tucson Mayor and City Council adopted the Floodplain Management Plan (FMP) per a resolution. The resolution is included in the Appendix of this report. The following officials were the city government leads at the time the FMP plan was adopted.

2016 Mayor and Council
Jonathan Rothschild, Mayor
Regina Romero, Ward 1
Paul Cunningham, Ward 2
Karin Uhlich, Ward 3
Shirley Scott, Ward 4
Richard Fimbres, Ward 5
Steve Kozachik, Ward 6

2016 City Manager
Michael Ortega

Project Team

The Tucson Floodplain Management Project team would like to thank the FMP committee members for their support and participation in the development of the plan. Over a five-month period, the committee members met monthly to identify the flooding hazards Tucson faces and to define an action plan. The FMP committee worked diligently with the goal of protecting Tucson's citizens by using their expertise in planning, engineering, environmental sciences, and policy formation to inform the development of the FMP.

Elizabeth Leibold, P.E., CPM, CFM, Civil Engineer, in Tucson's Transportation Department (TDOT) and previously the Planning and Development Services Department (PDSD), was the lead advocate for completing the Tucson FMP, and was assisted by Peter McLaughlin, Lead Planner in the Planning and Development Services Department, as well as Fred Felix, P.E., Tucson City Engineer, who serves as the City of Tucson Floodplain Administrator. At the project outset, Ernie Duarte was the Director of PDSD who sought to complete the FMP with the general goal of reducing flood hazards and reducing flood-related costs to the Tucson citizens. When the FMP plan was completed and adopted in 2016, Nicole Ewing-Gavin was the Director of PDSD. Robert Bezek, Regional Engineer, and Patricia Rippe, Natural Hazards Program Specialist, served as FEMA Region IX advisors while Maureen Towne, Risk MAP Coordinator for the Arizona Department of Water Resources (ADWR), also provided guidance during the FMP process. Sarah Houghland, BakerAECOM, prepared the 2016 FMP under contract as FEMA Region IX's Production and Technical Services (PTS) Contractor.

Committee Member List

A diverse group was convened to form the committee, including key participants listed below. A complete listing of committee members is provided in Appendix (p.56) of this report.

Table 1. Key committee participants

Name	Organization	Title	FMP Committee
Bill Zimmerman	Pima County Regional Flood Control District	Deputy Director	Public/Structural Flood Control Projects
B.J. Cordova	Tucson Clean & Beautiful	Membership & Communications	Tucson/Natural Resource Protection
Brent Borchers, P.E. / Kevin Woner	Terracon	Office Manager / Environmental Scientist	Public/Property Protection
Claire Jean Prager	Coldwell Baker Residential Brokerage	Associate Broker	Public/Preventive Measures
Elizabeth Leibold, P.E., CPM, CFM	City of Tucson, PDSD Engineering	Civil Engineer	Tucson/Preventive Measures
Joanne Hershenhorn	City of Tucson, Office of Integrated Planning	Project Coordinator	Tucson/Preventive Measures
Jim Robinson	City of Tucson, Transportation Dept. ITS Division	GIS Technician	Public/Property Protection
John Wise, P.E, CFM	Stantec	Managing Principal	Public/Property Protection
John Wood, P.E., LEED-AP	Presidio Engineering SAHBA Representative	President	Public/Preventive Measures
Kieran Sikdar	Watershed Management Group	Program Manager	Public/Natural Resource Protection
Larry Roberts, P.E., MS	Arroyo Engineering	Principal Engineer	Public/Preventive Measures, TSMS (lead contributor)
Maureen Towne, CFM	ADWR	Risk MAP Coordinator	State/Public Information
Peter McLaughlin	City of Tucson, PDSD Planning	Lead Planner	Tucson/Structural Flood Control
Richard Remington	Logan Simpson	Senior Biologist	Public/Public Resource Protection
Rob Shand, P.E.	JE Fuller/Hydrology & Geomorphology, Inc.	Civil Engineer	Public/Emergency Services
Steve Tineo, P.E.	City of Tucson, TDOT	Engineering Project Manager	Tucson/Structural Flood Control
Jim Vogelsberg P.E.	City of Tucson, PDSD Engineering	Floodplain Administrator	Tucson/Structural Flood Control

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Executive Summary

The City of Tucson has actively managed its floodplain resources since the mid-1970's, and continues to undertake programs that will improve its resilience to flooding. The City has experienced sixteen (16) flooding and three (3) major storm events from 1983 to 2012. Economic and environmental impacts of flood are severe, and may increase in the future. The City of Tucson, with support from FEMA Region IX, has created the City's first Floodplain Management Plan (FMP) to address community-wide flooding hazards and mitigation measures. As a participating National Flood Insurance Program (NFIP) community, Tucson has a Community Rating System (CRS) rating of 6 which provides Tucson property owners a discount on their low-risk and high-risk flood insurance policies (10% and 20% respectively).

Figure 1: Downtown Tucson 1988

During the FEMA Discovery Process, several at-risk areas in the Upper Santa Cruz Watershed were identified, and community members and local agency representatives participated in discussions to address floodplain mitigation. By creating this FMP, Tucson can better address floodplain management decisions, consider all mitigation alternatives or consequences, and improve its class as a participant in FEMA's Community Rating System (CRS). The FMP is considered an update to the Tucson Stormwater Management Study (TSMS), and will be Phase V of the TSMS. This phase does not override the previous phases but enhances and re-instates TSMS by becoming current in the city's assessment of floodplain management needs and direction. It includes an action plan to best address the highest priority action items identified by FMP Committee Members, and prioritizes actionable mitigation measures, that will reduce the risk to life and property associated with flooding.

Pima County has experienced 13 Major Disaster Declarations and 2 Emergency Declarations.

Table 2. Tucson's FEMA major disaster declarations.

Pima County Presidentially Declared Flood Disaster Events

Major Disaster Declarations		
FEMA Disaster #	Date	Description
4203	11/5/2014	Severe Storms and Flooding*
1940	10/4/2010	Severe Storms and Flooding*
1888	3/18/2010	Severe Winter Storms and Flooding
1660	9/7/2006	Severe Storms and Flooding
1477	7/14/2003	Wildfire*
977	1/19/1993	Severe Storms, Tornadoes, Flooding
884	12/6/1990	Flooding, Severe Storm
691	10/5/1983	Severe Storms, Flooding
570	12/21/1978	Severe Storms, Flooding
551	3/4/1978	Severe Storms, Flooding
540	11/4/1977	Severe Storms, Flooding
343	7/3/1972	Severe Storms, Flooding
217	4/30/1966	Flooding
Emergency Declarations		
3307	1/24/2010	Severe Winter Storms and Flooding
3241	9/12/2005	Hurricane Katrina Evacuation

** Pima County included under statewide Hazard Mitigation Grant Program assistance.*

Figure 2: Sinaloan Narrow-Mouthed Toad - native to the West Branch Santa Cruz River

Given that Tucson is currently at a CRS Class 6 level, this FMP process built on the community's existing floodplain management practices and programs and focused on expanding available resources and utilizing them efficiently. The FMP committee agreed that Tucson's multiple could be grouped into seven (7) main categories, and these hazards (in order of descending vulnerability to Tucson) are:

1. **Public Infrastructure Conveyance**
2. **Flood Areas with Utility/Municipal Structures**
3. **Urban High-Density Flood Areas**
4. **Private Drainage Infrastructure**
5. **Natural Floodplains**
6. **Vegetated Associated Flood Hazards**
7. **Geomorphological Flood Hazards**

The FMP committee summarized Tucson's Floodplain Management Plan goals as:

- **Continuing to identify high-risk areas;**
- **Providing safe, efficient and balanced conveyance for stormwater runoff;**
- **Maintaining, enhancing and/or restoring riparian ecosystems and wildlife corridors;**
- **Increasing community awareness of water harvesting methodologies, floodplain preservation measures, and general flood and erosion information; and,**
- **Expanding incentives for private property owners and developers to implement sustainable flood and erosion hazard mitigation strategies.**

Figure 3: Panorama of the Rillito River downstream/west of Campbell Avenue

Chapter 1

Purpose and Intent of the FMP

INTRODUCTION TO TUCSON

Tucson experiences a desert climate with a rainy summer thunderstorm season called "monsoon", and gets an average of 12 inches of rain annually. While a majority of Pima County is considered rural or moderately developed, Tucson is decidedly an urban area and the challenges it encounters differ and are more pronounced than those endured by the other Pima County communities. Precipitation in Tucson is higher than most desert climates, which is cause for more flash flooding than in other parts of the state. Because many areas of the city do not have storm drain systems, Tucson often experiences flooding in the streets. The most common risks identified within the City of Tucson are flooding, erosion, sediment transport, and flash flood events.

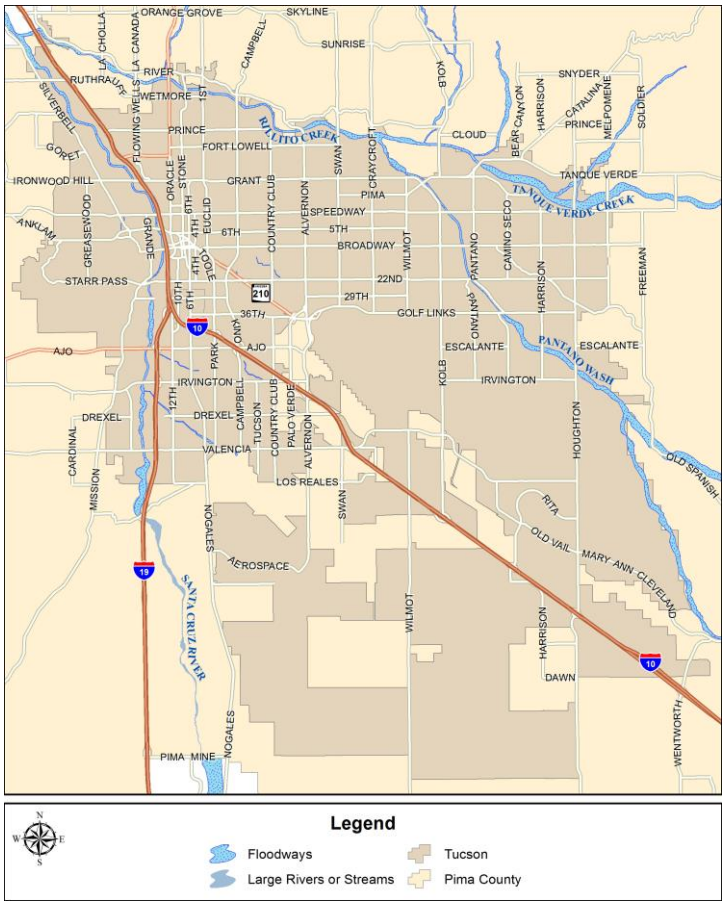


Figure 4: Map of Tucson Arizona with Regional Watercourses labeled

Pima County was one of the most financially impacted areas in the nation during the economic downturn in 2008, and has not experienced the population or development increase that was initially projected (the population rate has actually remained well below 1 percent). With the lack of funding and only recent upswing in economic growth, it is essential to create a plan to mitigate floodplain hazards, while taking into account the potential for public infrastructure deterioration and needed maintenance. Also, with the potential for climate change conditions, communities are at risk for a higher potential for damage caused by natural disasters.

TUCSON'S UNIQUE FLOODPLAINS, EROSION AREAS, AND WATERSHEDS

Located in the upper Santa Cruz River watershed basin, Tucson is bounded by several mountain ranges: Sierrita Mountains and Black Mountain to the southwest, Tucson Mountains to the west, Santa Catalinas to the north, Rincons to the east, and Santa Ritas to the south. Pantano Wash conveys runoff from the eastern portion of the Tucson area, northerly to the confluence with the Tanque Verde Wash where the flow turns westerly. Within the Rillito Creek, the flow combines with Santa Catalina foothill runoff, and then continues to the Santa Cruz River at the north western side of the City. The Santa Cruz River, flowing from Mexico, conveys flows northerly along the western side of the City. Located at the south portion of the City of Tucson limits, the Lee Moore Wash area (a 50 square mile watershed management area), has east-to-west uncertain flow distribution of transitional or braided sheet flooding and channelized flows.

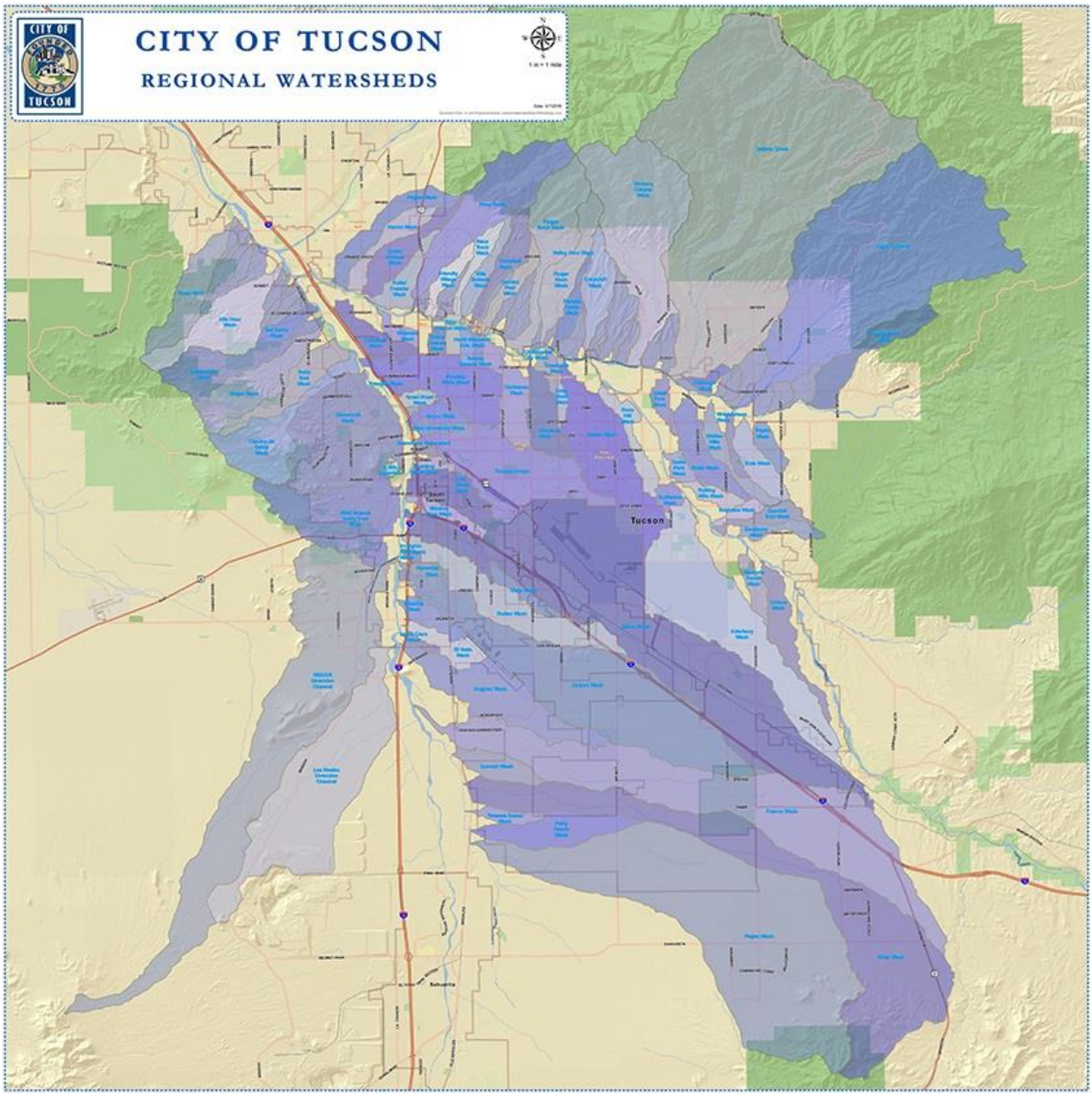


Figure 5: Tucson Region Watershed Map - existing watershed boundaries overlap county-city jurisdictional line, with general flow direction for southern watersheds from southeast to northwest, northern watersheds entering the Rillito Creek from north to south-southwest, western watersheds flowing southwest to northeast to the Santa Cruz River. All of these watersheds contribute to the Upper Santa Cruz Watershed

As mentioned, the City of Tucson receives about a foot of rain every year, with approximately eight inches in the summer and early fall, and the remaining approximate four inches during winter rains. Tucson experiences a series of summer thunderstorms for several months of the year called Monsoon. Rain is typically heavy and downpours can last for several minutes to a few hours, and when atmospheric vapor from tropical storms (also known in Spanish as tormentas) travels continually from the Baja California or the Gulf of Mexico regions, these storm systems can sometimes last several days. (See appendix for anecdotal story by a hydrometeorologist specializing in "atmospheric vapor trains".)

Tucson hazards include not only flooding within the streets, overtopping of washes and channels, flash flooding, erosion along channel embankments, channel migration, but also subsidence or sinkholes, excessive heat, and other hazards. Tucson experiences excessive heat exceeding 100 degrees during June and July, although not as excessive as Phoenix area due to our slightly higher elevation (average elevation of Tucson is approximately 2500 feet above sea level NGVD 88).

Monsoon hazards include risks of adverse impacts from flooding, erosion, damaging winds, hail, microbursts, and lightning. Tucson experiences high incidents of lightning strikes as well as short, concentrated heavy downpours called microbursts with violent and strong winds during Monsoon. These thunderstorm events can cause power outages during the hot summer months taking out air conditioning and creating life-threatening conditions if not restored quickly. Among other flood related issues, Tucson residents are concerned about power outages and access issues across the City of Tucson's bridge and street system during flooding. Fast water rescues by Fire and Police are common occurrence during the monsoon. Erosion and flooding along regional watercourses have resulted in injuries, deaths, and private and public property damage with high repair costs, during catastrophic flood events. Tragically, a large number of flood-related deaths have occurred in cars stranded in deep, fast-moving floodwaters.

Figure 6: Downed power lines along Oracle Road following a storm event

Tucson has a semiarid climate where post-storm evaporation rates are high, and soils are more permeable in the regional watercourses where the fastest rate of infiltration to the underground aquifers occurs. Regarding soil characteristics, Tucson is different than Phoenix and other jurisdictions to the north. Tucson has variable gradients throughout the city and experiences infiltration challenges including caliche and C & D hydrologic soils types. These soils are harder for rainwater to infiltrate and thus ponding issues typically arise.

Figure 7: Emergency responders often conduct swiftwater rescues. Vehicles or people are sometimes swept away in the fast moving water, and many resources are required

Levees and soil cement bank protection are commonly used for regional watercourse containment and erosion protection. Soil cement has been successfully used along most of the regional watercourses. In the past, many manufactured housing structures in the Tucson area were located near or within medium to high risk flood zones, posing risks to manufactured home property owners. Apartment complexes and other rental properties pose different challenges for the City as it addresses flood hazard mitigation. Solar infrastructure has been introduced successfully in shallow floodplain areas and within existing basins, providing safe opportunities to double the use in a floodplain area.

Figure 8: Santa Cruz River bank protection

Subsidence can occur when seepage or other underground issues occur within the bedding soil in utility line trenches. Floodwater that seeps into the soil can undermine utility trenches causing an underground path for floodwaters to follow which can cross into other utility trenches or lead to pipes breaking.

The Tucson Water utility has invested approximately $5 million in a 20-mile Acoustic Fiber Optics (AFO) monitoring and advance warning system that signals Tucson Water staff prior to a large main failure, which could cause flooding and potential loss of hundreds of thousands of gallons of water. A failure of this type occurred in 1999 resulting in millions in property damage from the 38 million gallons of water that flooded the neighboring properties as a result of the pipe break. The most recent example of the effectiveness of the warning system involved a 84-inch diameter water main along San Marcos Boulevard between Greasewood and Mission Roads. Tucson Water was alerted by electronic signal that the main was in danger of breaking. The monitoring system allowed the utility to shut down the water main, drain water from it, and make the needed repairs. The acoustic fiber optic monitoring system with other programs in Tucson Water, led to a 2014 Association of Metropolitan Water Agencies (AMWA) Platinum Award recognizing Tucson Water for their Attributes of Effective Utility Management. Tucson Water was the first American utility to install an AFO system in all of its prestressed concrete cylinder pipeline. Not only does this program save valuable resources, it provides reduced flooding potential for those areas near large water pipelines.

Development within the floodplain increases as less developable area exists in central urban Tucson. Developable areas are still available especially in Tucson's periphery, however these locations tend to have floodplain and erosion hazard design challenges including riparian floodplain and increased elevation changes. Guidelines and requirements are set forth in the City's Environmental Resource Zone, Hillside Development Zone, Lee Moore Wash watershed plan, Watercourse Amenities Safety and Habitat Ordinance, and other regulations. Opportunities exist for aesthetic development designs that incorporate floodplain and human activity zones, setbacks for erosion hazard that also provide for natural floodplain function, recreational areas, trails, and conservation of riparian floodplain habitat.

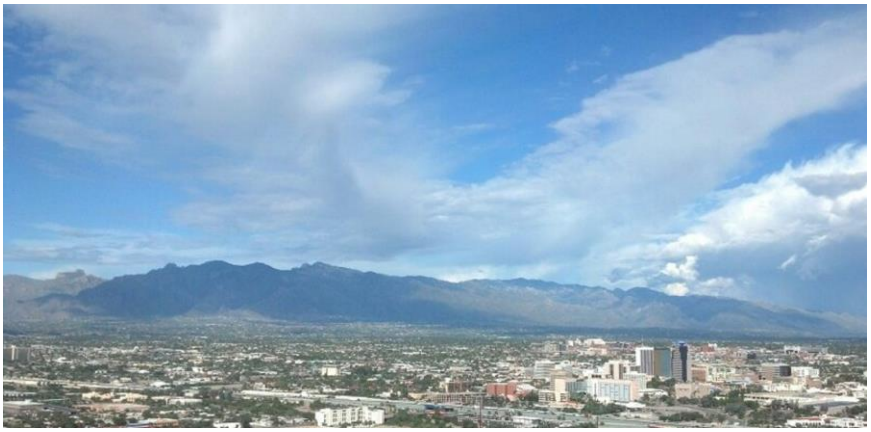
Figure 9: Sediment transport in a natural riparian floodplain

Figure 10: Rillito Creek

Rainfall runoff generally flows from the southeast to the northwest across the Tucson area. Flows are not allowed to be obstructed per code. Runoff generally flows within streets, rights-of-way, and in other drainage systems, from property to property, matching pre-developed flow conditions. Rainfall runoff conveyance in the City of Tucson includes storm drains, side yard swales, wall openings, improved structural channels, natural channels, semi-natural channels, sheet flow, and other systems to continue its path to feed vegetation and eventually, with remaining flow, recharge in the regional watercourses.

Larger detention or reservoir systems (Rita Ranch Regional Basin, Bridges Regional Detention Basin, Ajo Detention Basin, and the Cherry Fields Regional Detention Basins) work to lessen flooding conditions within the City of Tucson with their capacity to handle large storm runoff. These systems also help to lower heat island effect with increased tree canopy, as summer storms travel north and divert around the City of Tucson. Pima County's ALERT system was updated in 2016 and provides a resource for accessing City of Tucson rainfall data and watercourse stage (depth) gauge data, which assists floodplain management by providing information about recent or historic storm events. Utilizing this data, warning systems help prevent flooding damage.

Figure 11: View of Tucson watershed from A Mountain



Tucson's Basin (watershed) Management plan includes non-designated basin management areas, Balanced Basin Management Areas, and Critical Basin Management Areas (where severe flooding issues exist). Development in Balanced Basin Management Areas requires post developed runoff to not exceed pre-developed conditions. In Critical Basin Management Areas, detention requirement includes a reduction of the post-construction flowrate by a minimum of 15% as compared to pre-developed conditions. The most successful basin designs (where there are less post-construction and maintenance issues) include a detention aspect, such as low-flow outlets and positive gradients. When detention is used, there are reduced potential for termites, ponding/stagnant water, structural issues to nearby foundations, and contamination of the groundwater aquifer from fertilizers, herbicides, and other chemicals. Mosquito-borne illnesses are being reduced by the use of detention systems since standing water is minimized. Heidi E. Brown, PhD, MPH, of the Epidemiology and Biostatistics Department at The University of Arizona, concurred that Tucson's drain-down time requirements of 12-hours and 24-hours help to reduce mosquito populations.

DECISION MAKING CONSIDERATIONS FOR TUCSON FLOODPLAIN MANAGERS

Optimal results for flood, erosion, or other hazard management decisions can be realized by utilizing the various documents including the Floodplain Management Plan and reports and data from other phases of TSMS, Flood Risk Map (FRM), and other local GIS data, as well as master drainage plans, and specific City of Tucson plans such as Plan Tucson.

HAZUS is a nationally applicable standardized methodology that contains models for estimating potential losses from floods. HAZUS FRM map was one of the tools created in the FMP project and was generated with collaboration between the FEMA consulting firm and the FMP Committee members' data with effort and special assistance by the City of Tucson's Transportation GIS Technician.

Plan Tucson is the City of Tucson's General & Sustainability Plan, which was ratified by voters in 2013 and acts as a master planning document providing broad planning focus for Tucson, including reducing hazards. Plan Tucson goals and policies are intended to reduce, through preventive measures, the potential harm to life and property in natural hazard areas as well as hazards resulting from human activities and development. All Ward offices encourage the use of Plan Tucson, and other Tucson planning documents, when making decisions regarding the management of floodplain and other hazards.
https://www.tucsonaz.gov/files/integrated-planning/PT_Goals_and_Policies.pdf

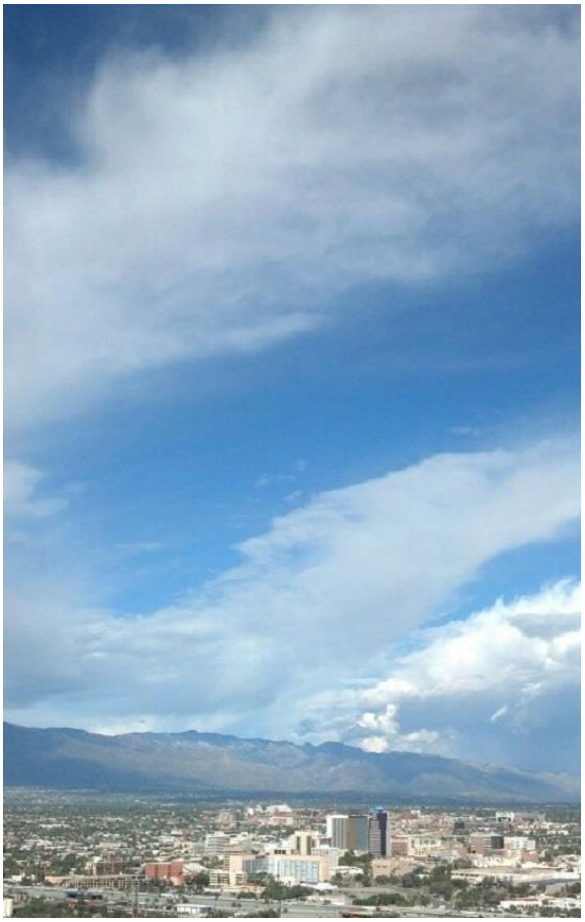


Figure 12: Downtown Tucson

TUCSON HYDROLOGIC MODELING

Tucson Stormwater Management Study (TSMS)

Tucson Stormwater Management and Tucson Watershed Modeling Systems are the City's adopted methodologies. This modeling is ideal for the Tucson area since it models the type of short storms with high intensity rainfall most often experienced during Tucson's Monsoon. Hydrologic modeling of watersheds located within the City of Tucson was previously completed in 1993 as part of the TSMS Phase II, Stormwater Master Plan (Existing-Conditions Hydrologic Modeling, Simons, Li and Associates, November 1995). The development of the TSMS hydrologic modeling resulted in a uniform and consistent technique for predicting stormwater discharges within the City of Tucson. (For more detailed information and background on TSMS see page 16.)

The TSMS hydrologic methodology replicates physical processes of rainfall, runoff, and flood routing. In addition, the physically-based modeling was calibrated to recorded flow events and statistical flood-peak estimates. The results of the TSMS hydrologic modeling was subsequently approved by the Federal Emergency Management Agency on May 21, 1996. On January 22, 1996, the results of the TSMS, Phase II Stormwater Master Plan were adopted, by Resolution, by Mayor and Council.

The TSMS hydrologic modeling was comprised of two main components – (1) the Stormwater System Planner (SSP), a proprietary software program used to compile HEC-1 input files and generate watershed reports from a new extensive City-wide data base, and (2) HEC-1 software used to perform the hydrologic modeling for 59 major watersheds within the geographical boundaries of the City. Numerous additional software components were utilized in calibration, SSP access, and data-base retrievals. The SSP software package was meant to be used by the City and water-resource consultants for stormwater management purposes and the consistent and reliable calculation of stormwater discharges.

Tucson Watershed Modeling System (TWMS)

A new version of TSMS called Tucson Watershed Modeling System (TWMS) is currently under development. TWMS is a more modern map-based system using GIS, ArcView and HEC-HSMS. The hydrologic modeling software developed for the TSMS had consisted of DOS-based programs that had become outdated over time. In order to utilize more current software, as well as utilize more advanced GIS-based data management tools, the City of Tucson initiated development of the TWMS (User's Manual, June 2008) as a replacement for TSMS software package. TWMS incorporates automated watershed management tools in a GIS environment. The TWMS provides the City with the ability to calculate stormwater flow values for use in planning, floodplain management, and hydraulic design.

Figure 13: Regional watercourse near flood stage

INTRODUCTION TO THE FMP PROCESS

The FMP is an outgrowth of the Upper Santa Cruz Discovery process FEMA initiated in the fall of 2011. Discussions between FEMA and city officials resulted in this plan being created to facilitate floodplain management activities in Tucson. FEMA's Risk Mapping, Assessment, and Planning, or Risk MAP program, helps communities identify, assess, and reduce natural hazard risks. Through Risk MAP, FEMA provides information to enhance local mitigation plans, improve community outreach, and increase local resilience to hazards. The Upper Santa Cruz Discovery Report can be found in the Appendix of this report. More information regarding the Discovery process is available on FEMA's website, www.fema.gov. After the Discovery process came to a close, FEMA recognized that there is potential to expand on best management practices and encourage a more resilient community within Tucson. Flood risk products are created as a means to provide concrete evidence and reference materials to those who manage floodplain material data. With the development of an FMP, participants can create an action plan for floodplain management, and can ultimately reduce region-wide flood insurance rates.

Figure 14: Sunset after a Tucson storm

This FMP process was unique in that FEMA assisted primarily with the project management, oversight, and production of final products, while the City of Tucson led the planning efforts and discussions. This process proved beneficial in obtaining the community's first-hand perspectives and objectives. In creating Tucson's FMP, the best assessment was provided by the committee for potential floodplain and erosion hazards, along with the most efficient mitigation actions for alleviating disaster potential. With the city's current CRS Rating, it's apparent that Tucson has already achieved major goals with regard to Floodplain Management. By going a step further in the Risk MAP process, community representatives (and the public) will be able to access tools for floodplain management in the years to come.

As floodplain management increases overall, the flood risk potential for a community will decrease. This FMP not only considers the well-being of the people, but also takes into consideration the natural and built environment. The intent of this product is to present a comprehensive report that discusses existing flood and erosion risks, areas of potential hazard, and ways to address these concerns. Developing an FMP will allow for the utilization of concrete and realistic flood risk products, and at the same time, it increases the public's awareness of flood risk potential. Having this report also increases the ability of state and local officials and their constituency to adapt to hazards and risks that may arise. It allows committee participants to take part in a discussion of ongoing efforts and can be used for a more coordinated effort in case of emergencies. It also helps to increase federal funding for hazardous events and decreases insurance premiums for local property owners. Currently, property owners in Class 6 communities are eligible for premium reductions of 20% if they are located in the Special Flood Hazard Area (SFHA), and 10% if they are outside the SFHA. Improving Tucson's CRS rating will result in increased savings for its residents and other property owners.

The goal is to create an FMP that is unique to Tucson and outlines every issue faced by the urban community. A well-prepared plan will:

- Facilitate an update to the TSMS
- Identify existing and future flood-related hazards and their causes
- Ensure a comprehensive review of all possible activities and mitigation measures is conducted so that the most appropriate solutions will be implemented to address the hazard
- Ensure the recommended activities meet the goals and objectives of the community, are in coordination with land use and comprehensive planning, do not create conflicts with other activities, and are coordinated so that the costs of implementing individual activities are reduced
- Ensure the criteria used in community land use and development programs account for the hazards faced by existing and new development
- Educate residents and property owners about the hazards, loss reduction measures, and the natural and beneficial functions of the floodplain
- Build public and political support for activities and projects that prevent new problems, reduce losses, and protect the natural and beneficial functions of floodplains
- Build a constituency that wants to see the plan's recommendations implemented

QUICK RISK MAP PRODUCT DISCUSSION

Because flood hazards change over time, the Discovery process provides an opportunity to engage in a comprehensive review of activities that contribute to flood risk. Engaging local officials in this process increases their understanding of flood risk and gives them an active role in identifying proactive steps that can be implemented to protect the lives and property of community residents. Through Risk MAP, FEMA provides communities with information that can improve risk communication and enhance local mitigation plans, resulting in decreased flood risk. FEMA has developed a suite of multi-hazard risk assessment products, referred to as Flood Risk Products (FRPs), to assist with this endeavor. FRPs can help community officials assess, visualize, and communicate local flood risk. The FRPs developed as part of the overall project are included in the Appendix of this report.

As part of this project, the following FRPs were developed for Tucson:

- **Flood Risk Report** - The Flood Risk Report (FRR) provides community and watershed-specific flood risk information extracted from the Flood Risk Database (FRD), explains the concept of flood risk, and identifies useful tools and reference materials. The FRR, used in combination with the Flood Risk Map (FRM), is a good tool for communities to use for raising local flood risk awareness.
- **Flood risk database** (including Hazus-MH) - The FRD stores all of the flood risk assessment data, which provides an evaluation of potential financial consequences and other impacts associated with structures located in the Special Flood Hazard Area (SFHA). This data also enables communities to make informed decisions regarding future land development and community infrastructure.
- **Flood Risk Map** - The FRM depicts flood risk data (not necessarily flood limits) for a flood risk project area and is typically used to illustrate an overall picture of flood risk for the area.

Figures 15. Flood damage can be seen on Tucson streets

Planning Phase

Before beginning the FMP process, a Working Group (WG) project team was established to determine how the planning process should go in order to meet the CRS requirements and maximize the resulting points that Tucson will receive toward increasing the city's CRS rating. Representatives from the City of Tucson, the Arizona Department of Water Resources (ADWR), FEMA, and BakerAECOM (FEMA Region IX's Production and Technical Services contractor) were involved with the WG. The WG began meeting on an almost weekly basis beginning in March 2015 to begin identifying different stakeholders that should be invited to the FMP meetings, and discussing meeting activities and format, tasks for the committee, and potential outcomes. The WG continues to meet throughout the entire FMP process.

Figure 16. John Wise P.E. addressing FMP Committee – emphasizing the importance of natural functions of floodplains

TUCSON STAFF INVOLVEMENT

Per CRS requirements, the WG cited that it was very important to try to include stakeholders from as many departments within Tucson as possible to provide action item recommendations that could actually be supported and adopted by those departments. Having a wide range of participants would also provide the committee with a fresh perspective on Tucson as a whole. Without the appropriate community backing, the recommendations and the FMP will not succeed. The different groups within Tucson's governmental structure include the Tucson Department of Transportation (TDOT), Planning and Development Services Department (PDSD which includes engineering and planning), Office of Integrated Planning, Trees for Tucson, Tucson Clean & Beautiful, Tucson Airport Authority, Tucson Water, Tucson City Council Ward Offices, Tucson Police Department, and Environmental Services.

Per the CRS Manual, the FMP committee included stakeholders that covered six categories that reflect the possible activities that can prevent or eliminate the problems caused by flood hazards:

1. Preventive measures (e.g., codes and standards) (PDSD, TDOT, Tucson Water)
2. Property protection (e.g., elevation) (PDSD, TDOT)
3. Natural resource protection (Tucson Clean & Beautiful)
4. Emergency services (Tucson Fire and Police Departments)
5. Structural flood control projects (TDOT with assistance from PCRFCD)
6. Public information (PDSD, Tucson City Council Ward Offices, TDOT)

The list of committee members that attended each committee meeting is included in the meeting minutes in the Appendix of this report.

Figure 17. Desert monsoon sky

OTHER AGENCY COORDINATION

In addition to local Tucson staff, the WG also reached out to other agencies to participate in the process. Those agencies included FEMA, ADWR, the U.S. Army Corps of Engineers (USACE), Pima County Regional Flood Control District (PCRFCD), Arizona Floodplain Management Association, Southern Arizona Home Builders Association, and the Tucson Association of Realtors.

REPORT REVIEW

The City of Tucson initiated TSMS in 1988 in order to develop a comprehensive stormwater management program. Fortunately for the FMP committee, Larry Roberts P.E. of Arroyo Engineering was a member of the team that created the TSMS and Mr. Roberts provided the following TSMS description. The TSMS was planned as a multi-year project with the following four phases:

Phase I: Establish Framework, Goals, and Objectives
Phase II: Develop Stormwater Master Plan
Phase III: Prepare Implementation Program and Maintenance Management Program, Assess Institutional and Financial Elements
Phase IV: Implementation

Phase I of the TSMS was adopted by Mayor and Council in March 1990. The Phase I study utilized an extensive public participation program for soliciting citizen involvement. The Phase I study also redirected future stormwater management efforts toward an emphasis upon nonstructural approaches which maintain or enhance naturally vegetated watercourses.

Phase II of the TSMS was initiated in 1992 in order to develop a Stormwater Master Plan for controlling both stormwater quantity and quality. One of the primary purposes of Phase II of the TSMS was to expand on the results of the Phase I study and develop a Stormwater Master Plan that adequately and economically addresses City-wide stormwater management. The Stormwater Master Plan was prepared under the direction of the City of Tucson by a multi-disciplined consultant team with areas of expertise in water resources, stormwater quality, environmental aspects, public participation, and legal issues. The Stormwater Master Plan was approved by Mayor and Council in 1996.

The Final Report presented the recommended Stormwater Master Plan (Simons, Li & Associates, 1992). Seventeen additional key documents were also prepared as the foundation for the Stormwater Master Plan.

The Final Report of the TSMS, Phase II, Stormwater Master Plan provided a 30-year framework for managing the surface water resources by integrating those technical, economic, social, and environmental factors which are essential for sound stormwater management. The comprehensive, watershed-based plan consisted of six major elements, described as follows:

1. Preservation of Naturally Vegetated Watercourses

Riparian habitat was identified and classified along the naturally vegetated watercourses within the City of Tucson. Approximately 77 miles of these watercourses, representing 570 acres of riparian habitat, were recommended for preservation. This represented 98% of the riparian habitat that was identified. Since then the City has created / adopted code for Environmental Resource Zone and Wash Amenities Safety and Habitat (W.A.S.H.) Ordinance, as well as water harvesting requirements.

2. Flood hazard studies

Flood Hazard Studies were proposed for approximately 41 miles of watercourses where nonstructural stormwater management measures were recommended. These studies were designed to better define the extent of flooding risks and identify possible nonstructural measures such as the purchase of flood insurance or floodproofing. Public education regarding results of the Flood Hazard Studies was also recommended.

The Flood Hazard Studies were proposed to be prepared by the City of Tucson for local floodplain management, and not create any new regulatory floodplains under the jurisdiction of the Federal Emergency Management Agency (FEMA). However, some Flood Hazard Studies may result in the remapping of existing FEMA floodplains in order to provide more accurate information which may actually reduce the size of the regulatory FEMA floodplain. The new data were to also be used by the City to determine whether additional studies were warranted.

3. Stormwater Quality Investigations

Although no significant problems with the quality of stormwater runoff were documented. The stormwater sampling equipment however is outdated and it is recommended to be updated for the 5 sampling sites in order to obtain more reliable data.

4. Stormwater Capital Improvement Programs

The major structural component of the TSMS was 47 capital improvement projects which generally involved channelization, bank protection, storm drains, or detention/retention facilities. The 47 projects, which were prioritized into a series of 5-year programs, would result in over 2,000 homes and 3 million square feet of commercial and industrial buildings protected from flooding. Some of these projects have been completed and others are being designed or awaiting funding source.

5. Miscellaneous Capital Projects

The need for various small, less costly projects was identified to address localized flooding problems throughout the City. These smaller projects generally consisted of roadway culverts, storm drains, channel improvements, and grade control structures. Due to funding issues, these types of projects have been limited.

6. Recommendations for Implementation

Recommendations were prepared for new or revised City policies, regulations, standards, and practices which were necessary to fully implement the Phase II Stormwater Master Plan. The actual development of new or revised polices was completed as part of the TSMS, Phase III, Implementation Program.

The Phase III Implementation Program was initiated in 1996 to develop new or revised City policies, regulations, standards, and practices in order fully implement the Phase II Stormwater Master Plan. The key new or revised items are listed as follows:

1. Revised Drainage Standards Manual,
2. Draft Stormwater Quality Ordinance,
3. Implementation Plan for Preservation of Naturally Vegetated Watercourses,
4. Detailed Scope of Work for Flood Hazard Studies,
5. Detailed Scope of Work for Design Analyses of Capital Improvement Projects,
6. Identification of remapping needs for existing FEMA Flood Insurance Study,
7. Implementation Plan for Miscellaneous Capital Projects, and
8. Plan for Addressing Stormwater Quality and NPDES Requirements.

TSMS serves as the foundation for the FMP, and many reports listed below share the same goals as TSMS. The reports included:

- 2012 Upper Santa Cruz Discovery Report (FEMA)
- 2012 Pima County Flood Insurance Study (June 16, 2011) (FEMA)
- 2008 Tucson Watercourse Maintenance Guidelines (Tucson)
- 2006 Water Harvesting Guidance Manual (Tucson)
- 2012 Pima County Multi-Jurisdictional Hazard Mitigation Plan (HMP) (PCRFCD)
- 2003 City of Tucson Habitat Conservation Plan (PCRFCD)
- 2013 Pima County Community Wildfire Plan (Pima County)
- 2011-2015 Action Plan for Water Sustainability (Tucson)
- 2006 Tucson Parks & Recreation 10-year Strategic Plan (Tucson)
- Tucson Police Department Strategic Plan (2013-2018) (Tucson)
- Solving Flooding Challenges with Green Stormwater Infrastructure in the Airport Wash Area (2015) (Tucson Ward 1)
- Plan Tucson: City of Tucson General & Sustainability Plan (2013) (Tucson)
- 2013 City of Tucson Unified Development Code (Tucson)
- 2014 Tucson Emergency Operations Plan
- Multiple PCRFCD Studies

IN-PROGRESS /RECENTLY COMPLETED FLOODPLAIN MAPPING STUDIES OF MOST CONCERN FOR TUCSON

1. Arroyo Chico Multi-use Project *(see next page for project overview)*
2. Paseo de Las Iglesias Phase I: Santa Cruz River Bank Protection, Ecosystem Restoration, and Linear Parkway Project
3. Agua Caliente Physical Map Revision: completed, many homes were removed
4. Address the Zone A that was added along Pantano Wash due to an unaccredited levee in the June 2011 update to Tucson's Flood Insurance Rate maps.
5. Tucson Water's Realignment and Recharge Project.

OVERVIEW: ARROYO CHICO/TUCSON ARROYO FLOODPLAIN REDUCTIONS

FEMA issued a Letter of Map Revision (LOMR) effective June 13, 2016, for the remapping of the floodplains for the Tucson Arroyo, Arroyo Chico and High School washes to reflect the drainage improvements for the "Tucson Drainage Area/ Arroyo Chico Multi-Use Project". This is a US Army Corp of Engineers (USACE) project, in partnership with the PCRFCD and the City of Tucson. The map revision impact portions of City of Tucson Wards 1, 5 and 6 and Board of Supervisors Districts 3 and 4. PCRFCD notified approximately 600 property owners about the upcoming map revision that impacts their flood insurance rates. The new LOMR maps will reflect the reduced flood hazards as a result of these projects. This is a multi-phase flood control project, and each phase of the project has provided additional benefits to the community and users beyond the direct flood control benefits.

The Tucson Arroyo and its tributaries -- High School Wash, Railroad Wash, Citation Wash, Paseo Grande Wash and Naylor Wash -- drain an area of 11.4 square miles located in central and downtown Tucson. The watershed is almost fully developed and contains a mix of residential, commercial and industrial areas. The downtown drainage infrastructure was originally constructed in the 1920s, 30's and 40's, which includes 1.7 miles of underground culverts. Because of the increased runoff due to urbanization the capacities of the existing drainage infrastructure was inadequate to convey the peak flows caused by intense thunderstorm events, resulting in frequent and severe flooding of residential, commercial and industrial areas along the entire length of the arroyo. Potential flood damages to both private properties and public infrastructure were estimated by the USACE at $2.7 million (1998 prices) annually.

Figure 18: Phase I The fairways at Randolph South (like Kennedy Park) were reconstructed to be storm detention basins and are categorized as reservoirs.

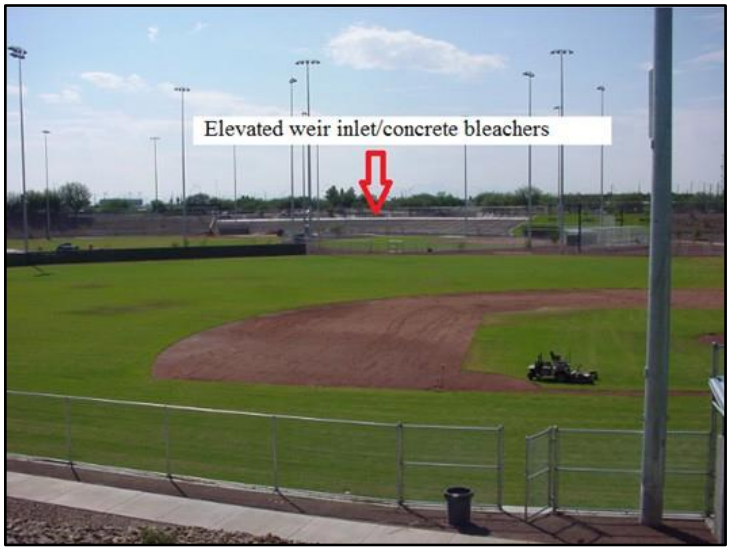


Figure 19: Phase 2A - Cherry Field basins are now a combination sports facility and flood control detention reservoirs maintained by Pima County.

Figure 20: Phase 2B - Park Avenue Basin 2 Under Construction

Figure 21: Phase 2B: basin 2 Sept. 8, 2014

Figure 22: Construction of High School Wash storm drain

CITY OF TUCSON PARTICIPATION

The City of Tucson has played a major role in the overall Tucson Arroyo and Arroyo Chico improvements. The City provided the land for Randolph South Detention Basin, participated in the design and were the contracting agency for the construction of the Randolph South Basins. The City also donated a significant portion of the land needed for development of the Park Avenue Basins. The City also donated other lands to TUSD, provided improvements Tucson High School, and allowed temporary use of their parks to offset impact to TUSD during construction of Cherry Field basins as part of the IGA.

The City Transportation Department also installed storm drain system in the area of Main Avenue at the downstream portion of the Tucson Arroyo. The City has also replaced the Arroyo Chico storm drain along 8th Street for future transportation improvements, and is planning further upgrades to the storm drain system on the upstream portion of Tucson Arroyo as part of the future "Downtown Links" road improvements.

Figure 23: Downstream of the Arroyo Chico drainage improvements is the "Downtown Links" road improvement project which was not formally a part of the Tucson Arroyo Chico Conditional Letter of Map Revision (CLOMR)

PROJECT WEBSITE AND EDUCATION TOOLS

An important component of the FMP process is encouraging community participation in the FMP's development. A project-specific FEMA Web page was created on RiskMAP Region IX's Website prior to the first FMP committee meeting. The FMP meeting logistical information was posted to this website at: www.R9map.org for the duration of the FMP project. In addition, meeting minutes and other pertinent information were posted to this location. This information was also posted to Tucson's project Web page www.tucsonaz.gov/pdsd/ floodplain-information.

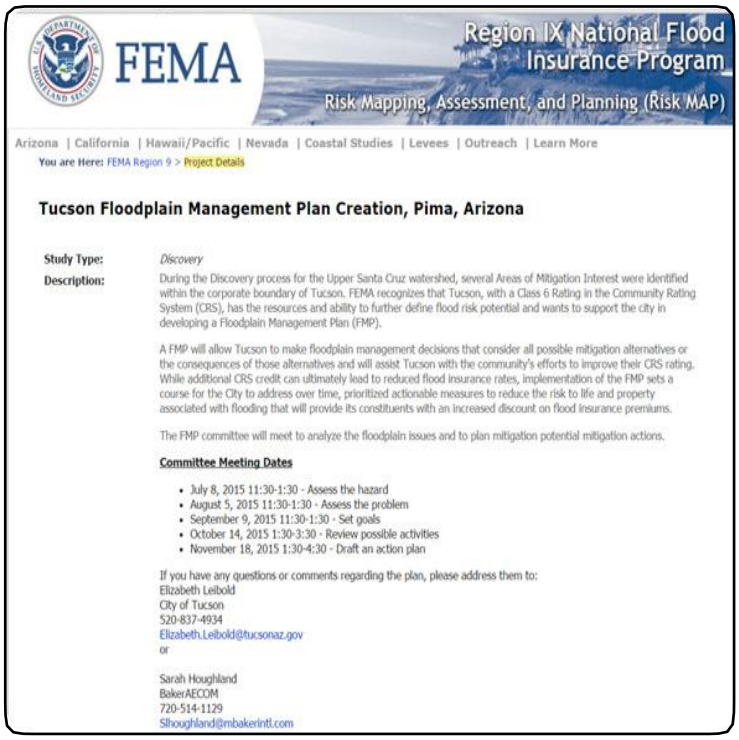


Figure 24: FEMA's Tucson FMP website

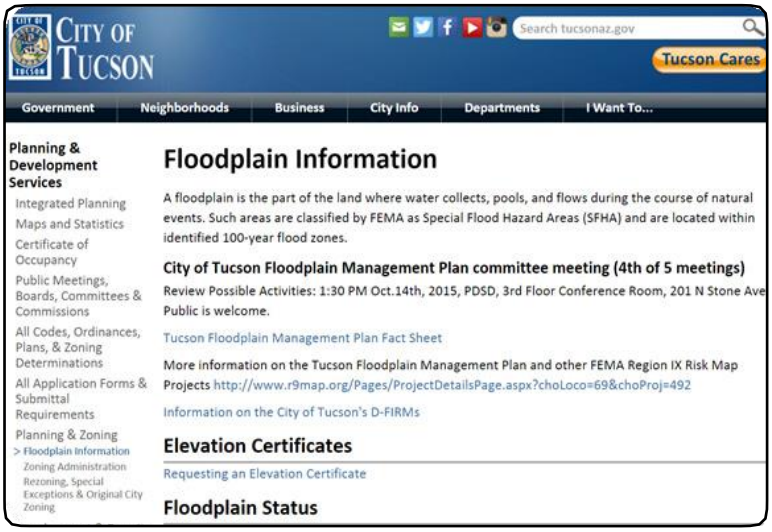


Figure 25: The City of Tucson's FMP information website

Since the FMP process is a foreign concept to many, the project team drafted a Fact Sheet as a quick way to convey important components of the FMP process. This Fact Sheet was posted to the project Web page and was displayed in the PDSD on the first floor of the County- City Public Works Building at 201 North Stone Avenue.

Planning Process Conducted Through A Planning Committee

In addition to representatives from Tucson's local government, the WG solicited participation in the FMP process from the public and other stakeholders outside of Tucson's local government. As part of the planning process, Tucson residents, as well as individuals from local consulting engineering and planning firms, the PCRFCD, the University of Arizona, and the Tucson Association of Realtors lent their time and expertise to create a robust FMP that will guide future project planning in the city. The committee lists and meeting attendee lists are located in the Appendix of this report.

Public Meetings Held on Draft Plan/Other Public Information to Encourage Input

On March 7, 2016, Tucson hosted a public meeting from **5:00 pm to 7:00 pm in the Children's Conference Room at the Joel D. Valdez Main Library, 101 North Stone Avenue, in Tucson**. This public meeting was in the form of an open house. Members of the WG presented the draft FMP to the community with the intent of soliciting review comments to improve the report's content. A FMP Fact Sheet was also presented at the meeting. In addition to the FMP plan, the city took this opportunity to present the draft floodplain ordinance to Tucson's residents. Tucson advertised the Open House in The Daily Territorial Newspaper on February 19, 2016; on the Tucson Web site at www.tucsonaz.gov/pdsd/floodplain-information beginning February 17, 2016; and on the FEMA Region IX Web site www.R9map.org beginning February 17, 2016. The Open House meeting notice, attendee list, and comments are included in the Appendix of this report.

While hard copies of the FMP report were available to review at the open house, attendees were encouraged to access the project Web site www.R9map.org and download a digital copy of the report. A Fact Sheet with an executive summary of the FMP and directions on how to download the report were available at the open house in case attendees preferred to review a digital copy of the report. The public comments and responses were prepared for the public hearing.

Figure 26: The public outreach announcement on the city's website

Community Rating System FMP Steps

The FMP planning process is based on hazard mitigation planning steps and is summarized below:

Phase 1

Organize to prepare the plan.
a) Involvement of Office Responsible for Community Planning.
b) Planning committee of department staff
c) Process formally created by the community's governing board.

Phase 2

Involve the public
a) Planning process conducted through a planning committee.
b) Public meetings held at the beginning of the planning process.
c) Public meeting held on draft plan.
d) Other public information activities to encourage input.

Phase 3

Coordinate with other agencies.
a) Review of existing studies and plans (REQUIRED).
b) Coordinating with communities and other agencies.

Phase 4

Assess the hazard.
a) Plan includes an assessment of the flood hazard (REQUIRED).
b) Plan includes assessment of less frequent floods.
c) Plan includes assessment of areas likely to flood.
d) The plan describes other natural hazards (REQUIRED).

Phase 5

Assess the problem.
a) Summary of each hazard and their impact on the community (REQUIRED).
b) Description of the impact of the hazards.
c) Review of all damaged buildings/flood insurance claims.
d) Areas that provide natural floodplain functions.
e) Development/redevelopment/population trends
f) Impact of future flooding conditions outlined in Step 4, item C.

Phase 6

Set goals.

Phase 7

Review possible activities.
a) Preventive activities.
b) Floodplain Management Regulatory/current & future conditions.
c) Property protection activities.
d) Natural resource protection activities.
e) Emergency services activities.
f) Structural projects.
g) Public information activities.

Phase 8

Draft an action plan.
a) Actions must be prioritized (REQUIRED).
b) Post-disaster mitigation policies and procedures.
c) Action items for mitigation of other hazards.

Phase 9

Adopt the plan.

Phase 10

Implement, evaluate, and revise.

a) Procedures to monitor and recommend revisions.
b) Same planning committee/successor committee that qualifies under Section 511.a.2 (a) does the evaluation.

Assessing the Hazard

To the credit of the diverse participants, the hazard brainstorming session included a wide array of hazards Tucson faces. The hazards were identified by participants based on experiences and known issues caused by the hazard and via technical data gathered as part of the FEMA Discovery Process, Existing Flood Insurance Rate Map (FIRM) and Flood Insurance Study (FIS), Tucson data studies, PCRFCD data studies. Also, public complaints were considered to help identify and prioritize the hazards. The SFHA shown on the FIRMs generally formed the basis of the assessment, but Tucson and the PCRFCD flood studies, not yet included on the FIRM's and FIS, were also considered. In addition, the four repetitive loss properties in the city were also evaluated. As the committee progressed through the brainstorming session, they also considered areas not mapped on the FIRM that experience flooding, either due to riverine or localized flooding issues.

It is important to note that while TSMS is organized on a watershed basis, the FMP considers Tucson as a whole. The FMP committee decided that the FMP should be more broadly based than TSMS. Since this FMP will be the first RiskMAP floodplain management plan for Tucson, the FMP document acts not only as the Phase V of TSMS, but is also intended to currently perform as a higher level planning document. During the 5-year review of the plan, the FMP committee can evaluate whether they want to change the format to be watershed-based, or if they prefer to continue to look at Tucson as a whole.

The FMP committee brainstorming session revealed multiple hazards, so the WG decided that it would be beneficial to group the hazards into seven main categories. These hazard categories are listed below along with the hazards that were identified. Not all hazards listed in the groupings carry the same weight, but for the sake of this report they will all be discussed in terms of the main category subject. In addition, some hazards are listed in multiple categories.

FLOOD AREAS WITH UTILITY/MUNICIPAL STRUCTURES

This hazard statement describes the types of structures that are at risk during the 1-percent-annual-chance flood event, and possibly lower frequency flood events. These structures include the different types of utility and municipal structures that are at risk from flood.

- **Buildings with sensitive storage**
- **Critical facilities**
- **Dams/reservoirs**
- **Emergency Management buildings**
- **Existing underground contamination plume areas**
- **Groundwater contamination**
- **Land subsidence/sinkholes**
- **Landfills**
- **Nursing homes**
- **Overhead utility lines**
- **Police/Fire Stations**
- **Railroads**
- **Sand & Gravel operations**
- **Underground utility lines**
- **Undersized drainage structures**
- **Wastewater/Effluent Discharge**
- **Wells**

GEOMORPHOLOGIC FLOOD HAZARDS

This group of hazards designate the multitude of different geomorphological hazards that result from flooding. Debris flow as defined in this grouping consists of debris on steep terrain, like what is seen in canyon areas.

- Channel headcutting
- Contamination plumes
- Debris flows
- Erosion zone setbacks – mostly an issue in older neighborhoods
- Groundwater contamination
- Land subsidence
- Lateral erosion
- Mud flows
- Natural earth fissures
- Sand and gravel operations
- Sedimentation
- Septic tanks
- Uncertain flow paths
- Wells

NATURAL FLOODPLAINS

This hazard grouping involved all potential hazards associated with floodplains.

- Alluvial fans
- Bajadas – not as steep as alluvial fans
- Braided flows
- Buffel grass
- City of Tucson Flood Hazard Areas – jurisdictional floodplains
- Erosion hazard areas
- Environmental Resource Zone floodplain areas
- FEMA SFHAs
- Habitat issues
- Invasive species
- Monsoons
- Post-wildfire areas
- Regional Watercourses
- Riparian habitat issues
- Sedimentation
- Sheet Flows
- Uncertain flow paths
- Vados
- W.A.S.H. Ordinance watercourses
- Watershed boundaries
- Watersheds

PRIVATE DRAINAGE INFRASTRUCTURE

This hazard subset is the most difficult to regulate because the hazards occur on private property.

- Channel headcutting
- Detention
- Drywells
- Green infrastructure
- Low Impact Development (LID)
- Low-flow crossing
- Ponding
- Retention
- Riparian habitat issues
- Sedimentation
- Standing water
- Water harvest areas – techniques should not cause adverse impacts

PUBLIC INFRASTRUCTURE CONVEYANCE

The hazards in this grouping encompass all potential hazards that arise in the public infrastructure domain.

- Bridges
- Channel headcutting
- Dams
- Detention
- Dip crossings
- Green infrastructure
- Levees
- LID
- Lowflow crossing
- Maintenance of Drainage Facilities
- Non-levee embankments
- Ponding
- Railroads
- Retention
- Riparian habitat issues
- Sedimentation
- Standing water
- Undersized drainage systems
- Undersized drainage structures
- Water harvest areas - techniques should not cause adverse impacts

VEGETATION ASSOCIATED FLOOD HAZARDS

This category highlights potential flood hazards that are a result of vegetation in the floodplain.

- Buffel grass
- Debris flows
- Habitat issues
- Illegal dumping
- Invasive species
- Lightning
- Ponding
- Riparian habitat issues
- Standing water

URBAN HIGH-DENSITY FLOOD AREAS

Tucson is primarily an urban setting and differs from the PCRFCD urban watercourse. Due to the city's higher population density, encroachment in the floodplain is an issue. As land becomes scarcer, more development begins occurring in the floodplain. Concerns of floodplain preservation, natural floodplain function, and safety result from this encroachment.

- Buffel grass
- Channel headcutting
- City of Tucson Flood Hazard Areas- jurisdictional floodplains
- Critical facilities
- Development
- Drywells
- Erosion zone setbacks
- FEMA SFHA's
- Green infrastructure
- Illegal dumping
- Invasive species
- LID
- Low-flow crossing
- Mobile Home parks
- Ponding
- Railroads
- Riparian habitat issues
- Sedimentation
- Septic tanks
- Standing water
- Urban agricultural areas in the floodplain
- Water harvest areas – techniques should not cause adverse impacts.

The committee then prioritized the hazards according to the group consensus regarding Tucson's overall vulnerability to each hazard. The results were as follows, where 1 is the hazard Tucson is most vulnerable to, and 7 is the hazard to which Tucson is least vulnerable.

Tucson's hazard Vulnerability assessment:

1. **Public Infrastructure Conveyance**
2. **Flood Areas with Utility/Municipal Structures**
3. **Urban High-Density Flood Areas**
4. **Private Drainage Infrastructure**
5. **Natural Floodplains**
6. **Vegetated Associated Flood Hazards**
7. **Geomorphological Flood Hazards**

Figure 27: Santa Cruz River Bike Lane Underpass – flooded

OTHER HAZARDS IN TUCSON

In addition to flood hazards, as previously stated, Tucson is also vulnerable to a variety of other natural and man-made hazards. A review of the 2012 Pima County Multi-Jurisdiction HMP showed that while Tucson is generally affected by all risk hazard profiles, FMP Committee determined that there is only significant risk from the following hazards (in addition to flood):

- Drought
- Earthquake
- Severe Wind
- Subsidence

LESS FREQUENT FLOOD HAZARDS

An investigation of the numerous hazards that were identified showed that, somewhat surprisingly, Tucson is not seriously vulnerable to the hazards listed below:

Alluvial Fans: Despite being located in the desert, where conditions are favorable, there are no known alluvial fans in Tucson. Most of Tucson is located in the valley and not in the foothills or mountains, where alluvial fans most commonly occur. Although there are no formal alluvial fans, there are areas throughout the city that exhibit similar characteristics. Watersheds on the north side of the City of Tucson flow toward the Rillito Creek regional watercourse conveying alluvial sediments from the Catalina foothills.

Dams: In Tucson, there are three locations of dams in the city, with one being located in Kennedy Park another located in Randolf South, and the new location at the Cherry Field Detention Basins. These dams do not pose a significant danger to the community and are considered reservoirs.

Levees: Levees also do not present a significant hazard to Tucson. The only FEMA accredited levee segments occur along the Santa Cruz River on FIRM panels 04019C1666L, 04019C1667L, 04019C1669L, 04019C1688L, and 04019C2276L for two separate levee segments in northwestern Tucson. Additionally, there is an unaccredited levee at Craycroft Road along Pantano Wash on FIRM panel 04019C1713L, in the northeastern part of the city. Floodwalls are rarely utilized although exist along the Silvercroft Wash to protect a non-profit hospital, medical offices, and residences for nuns, as well as along the Santa Cruz River southeast of the Cushing Street Bridge.

FUTURE CONDITION CONSIDERATIONS AND THEIR POTENTIAL IMPACT TO FLOODPLAINS

Population: Since the last Census in 2010, the Pima Association of Government (PAG) estimates Tucson's population has grown at a steady, but slow, pace from 0.13 percent to 1.48 percent. According to the PAG's 2013-2050 Incorporated Places Population Projects for Pima County and Incorporated Areas, Tucson's population is expected to grow by approximately 1 percent per year through 2050. Since the population growth isn't expected to increase rapidly and is expected to be on a steady projection, Tucson can take this opportunity to get out ahead of future development in areas where the floodplain mapping is outdated or non-existent.

Development/Redevelopment: Since Tucson is largely developed, new development will occur mostly on the outskirts of the city which also correlates to the more rural areas in the city where the SFHAs are likely old or non-existent. Also, redevelopment in Tucson is likely to occur to replace aging infrastructure. Tucson's floodplain ordinance addresses development issues by defining setbacks along watercourses, outlining other subdivision and development project requirements, and outlining detention and retention system constraints.

Climate Change: Currently, Tucson does not have specific regulations to address climate change outside of the conditions prescribed in Executive Order 13677, *Climate-Resilient International Development*, that was released on September 23, 2014. To meet the requirements in the Executive Order, federally-funded floodplain management projects and activities will be required to include evaluations of potential climate change impacts in Tucson as part of the analysis. The climate change assessment will consider if there are noticeable changes to weather patterns and if there are side effects caused by these changes. The evaluations should include Plan Tucson policies (Energy & Climate Change Element) which may have an impact on Tucson's floodplain management practices by influencing regulations, maintenance practices, and hydrologic and hydraulic analysis methodologies.

Figure 28: Climate change will be considered for future federally-funded flood risk projects

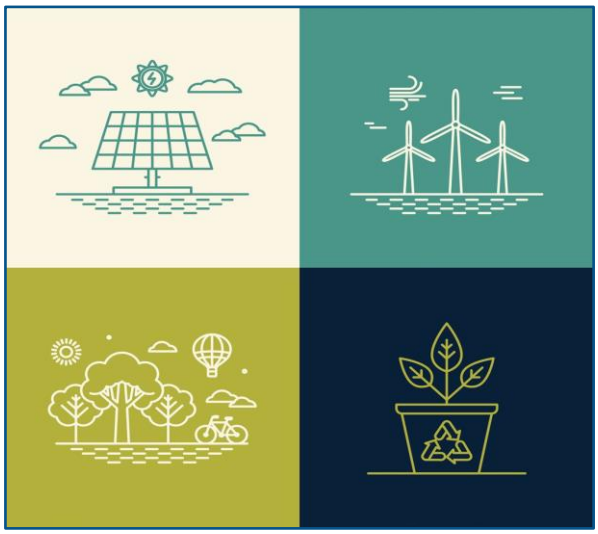
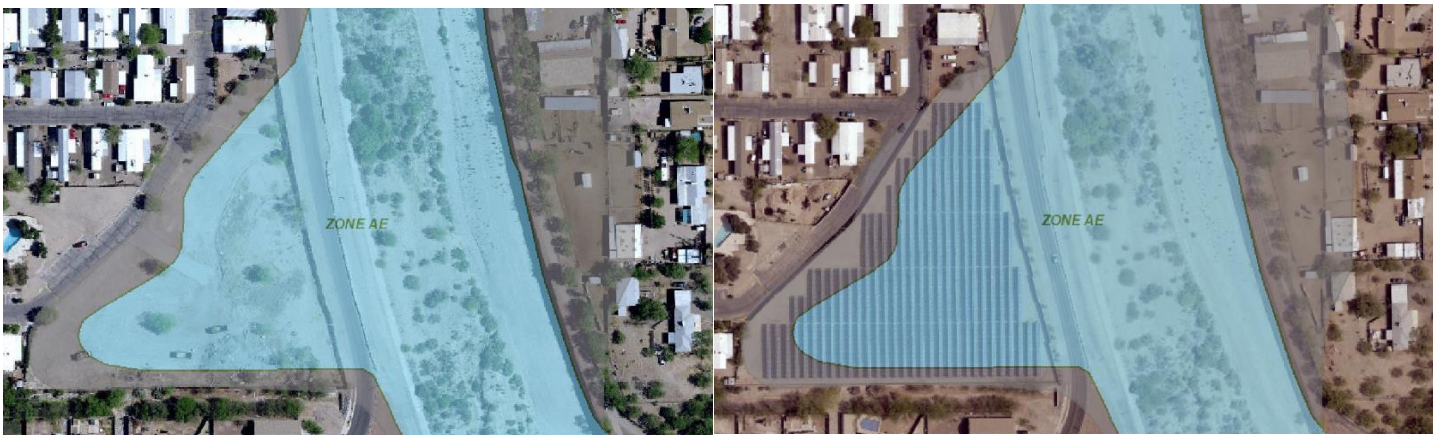


Figure 29: Sustainable practices create vibrant communities



Figures 30 & 31: Before & after: dual purpose: ineffective flow area floodplain & solar project – reduces community's electrical costs.

Assessing the Problem

Seven main hazards were identified and sub-groups formed based on these hazards which include:

1. Public Infrastructure Conveyance
2. Flood Areas with Utility/Municipal Structures
3. Urban High-Density Flood Areas
4. Private Drainage Infrastructure
5. Natural Floodplains
6. Vegetated Associated Flood Hazards
7. Geomorphological Flood Hazards

For each of the seven main hazard groupings, the problems were assessed according to these five criteria, which represent the impact of the hazards on:

i. Life, safety, health, procedures for warning and evacuation
ii. Public health including health hazards due to floodwaters/mold
iii. Critical facilities and infrastructure
iv. The community's economy and tax base
v. Number and type of affected buildings

Questionnaires were provided during these breakout sessions to help the committee members organize their thoughts. In the end, the top five problems caused by the seven identified hazards were listed.

1. Public Infrastructure Conveyance
   a. Ingress/egress for access and evacuation
   b. Inundation, etc., from embankment breach
   c. Swept away hazard at low water, etc.
   d. Drowning hazard for ponding
   e. Loss of utility service

2. Flood Areas with Utility/Municipal Structures
   a. Emergency response plans are current and active
   b. Inadequate access to hospitals and emergency resources during a flood event
   c. Impacts to the cost of developing and attracting new businesses
   d. Hazards from contamination and debris
   e. Loss of tax base due to disruptions

3. Urban High-Density Flood Areas
   a. Erosion
   b. Contamination of stormwater
   c. Standing water/ponding – mobility (car, bike, pedestrian, etc.) and West Nile Virus
   d. Wash clogging (debris, vegetation) – maintenance
   e. Unplanned historic growth

4. Private Drainage Infrastructure
   a. Access – ensuring community flow during all issues that may arise with varying problems
   b. Contamination of groundwater and natural facilities near or adjacent to properties. Be able to make proper notification of hazards whether private or public contaminants
   c. Erosion and sediment from basins
   d. Ponding water in all areas and the hazards that may be produced.
   e. Public/private notifications.
   f. West Nile Virus/mosquito transference of unhealthy viruses throughout the neighborhoods and surrounding communities.

Figure 32: Christmas W.A.S.H. (Watercourse Amenities Safety and Habitat) watercourse. Flood stage for this watercourse extends over the wash embankments.

5. Natural Floodplains
   a. Access
   b. Utilities
   c. Flood warning program and process
   d. Pre-1980 structures not compliant
   e. Regulations and enforcement – keep development out of natural floodplains which poses both a challenge and an opportunity for the community

6. Vegetated Associated Flood Hazards
   a. Debris flows – naturally generated vegetation debris that blocks flows, water conveyance, etc.
   b. Invasive species – Buffel Grass and Salt Cedar fire effects and intensity, power poles, utility structures
   c. Riparian habitat – human occupancy within the riparian corridor, notification and evacuation of occupants when events occur Ponding – mosquito breeding, public use, potential health issues
   d. Riparian habitat – lack of mapping of what vegetation is actually in the floodplain, where are concentrations of invasive species/good native habitats, etc.

Figure 33: As floodwater erode side banks, natural lateral migration of washes occur

7. Geomorphological Flood Hazards
   a. Groundwater contamination – runoff from the auto service industry and airport-related facilities (surface contamination leading to groundwater contamination); landfills and sand and gravel operations
   b. Channel headcutting and erosion – loss of taxable land; economic hardships on the community, property owners; the general public
   c. Subsidence – leads to property damage and economic hardship-condemned facilities and structure collapse; leads to fissures/roads and structure damage; alters flow paths
   d. Mud flows – road and structure/property damage; infrastructure/facility damage
   e. Wells – impacted groundwater; monitoring wells; flumes

Figure 34: Flooding can easily damage city infrastructure

REVIEW OF ALL DAMAGED BUILDINGS/FLOOD INSURANCE CLAIMS (HAZUS)

Hazus, FEMA's loss estimation and hazard modeling software, was used to conduct a flood risk analysis based on the 1-percent-annual chance flood event for structures within Tucson. This enhanced analysis leveraged locally managed inventory, hazard, and terrain data.

Parcel boundaries were used in conjunction with assessor data tables to create building centroids representing structure types and values. A comprehensive 1-percent-annual-chance flood event floodplain was developed by combining FEMA and local data sources, and a flood depth grid was developed using a citywide elevation surface derived from Tucson's LiDAR data. These enhanced data inputs were modeled in two Hazus scenarios in order to estimate damages to structures and aggregated census block data within the city.

Tucson has had 1,783 flood insurance policy claims as of February 2016. The policies account for $1,623,950 in total premiums that represent $387,788,700 in total coverage. There have been 620 claims in the community. This information was taken from FEMA's Community Information System (CIS) database.

REPETITIVE LOSS PROPERTY

There are only four properties in Tucson that are considered Repetitive Loss Properties (RLP). RLP properties receive letters from the city to inform the owners of ways to protect against future flood damage. At this time, Tucson has been looking into mitigation actions for the property owners. One property owner had taken steps to hire a civil engineer to prepare a drainage report to look at floodproofing and to physically help protect the home from flooding from Christmas Wash. Two of the properties are located along Bronx Wash, and the other property is located along Navajo Wash. The City is also researching possible funding for mitigation projects one or more of these RLP areas from our City contributions to PCRFCD, federal mitigation funding such as a Flood Mitigation Assistance (FMA) Grant, or possible future Stormwater Utility funds. Repetitive Loss Maps have been generated by the city floodplain engineering staff, and due to federal privacy protection laws, are located with the Floodplain Administrator and floodplain management staff.

Setting Goals and Defining Actions

Working on the Action Plan as a group included prioritizing action items and making recommendations as to which actions to include in the report. Time was also utilized to discuss post-disaster mitigation policies and procedures and action items of mitigation of other hazards. The goals the committee identified align with Tucson's overall goals, and they support the FMP committee's vision for how Tucson can address flood hazards in the future. The goals can be directly correlated to the community's hazard mitigation activity strategies, and a brief discussion of how each goal furthers Tucson's objectives has been included below the goal statement.

THE CITY OF TUCSON FLOODPLAIN MANAGEMENT PLAN GOAL IS TO:

Reduce flood and erosion hazards, damage, and associated costs by:

- ✓ Identifying high-risk areas.
- ✓ Providing safe, efficient, and balanced conveyance for stormwater runoff.
- ✓ Maintaining, enhancing and/or restoring riparian ecosystems and wildlife corridors.
- ✓ Increasing community awareness of water harvesting methodologies, floodplain preservation measures, and general flood and erosion information.
- ✓ Expanding incentives for private property owners and developers to implement sustainable flood and erosion hazard mitigation strategies.

1. Identifying high-risk areas. While many flooding sources in Tucson have been mapped and officially recognized by FEMA, the city acknowledges that some flooding sources are in need of restudy due to development and other pressures. In addition, determining the locations of the high-risk areas will help inform capital improvement plans, outreach strategies, and emergency management plans in addition to having many other purposes.

Figure 35: Sediment transport is common in the desert

2. Providing safe, efficient, and balanced conveyance for stormwater runoff. Whether this goal is referring to capital improvement projects or to restoring natural watercourses, the intent is for Tucson to address areas where stormwater runoff causes an issue for its residents in the manner described by the goal statement.
3. Maintaining, enhancing, and/or restoring riparian ecosystems and wildlife corridors. This goal is important to Tucson because the community is proud of and protective of its natural resources. Tucson is a unique desert community, and its natural features make it a desirable place to explore. Protecting the natural habitat while balancing the pressures an urban community faces is of the highest importance.
4. Increasing community awareness of water harvesting methodologies, floodplain preservation measures, and general flood and erosion information. Enhancing and diversifying community outreach activities will be a focus for Tucson. It is important to understand your community prior to formulating an outreach plan. For Tucson, a systematic and targeted approach to disseminate information is likely the best way to deliver the messages regarding the topics listed in the goal statement.
5. Expanding incentives for private property owners and developers to implement sustainable flood and erosion hazard mitigation strategies. The intent of this goal is to foster community support and awareness of flood hazards. By providing incentives to property owners, Tucson will likely be more successful in achieving its floodplain management objectives.

Figure 36: Sandbagging is an easy and cost-effective technique to battle flooding

REVIEWING POSSIBLE ACTIVITIES

All major problems caused by the hazards were assessed by reviewing them in consideration to the possible activities that can be implemented to address the hazards and further Tucson's FMP goals. The possible activity topics included:

i. Preventive activities
ii. Floodplain management regulatory/current and future conditions
iii. Property protection activities
iv. Natural resource protection activities
v. Emergency services activities
vi. Structural projects
vii. Public information activities

The committee considered all possible activities as potential mitigation measures, noting which ones were valid and which ones should not be considered. The problem statements were arranged in matrices according to hazard, and the top five problems were listed so that they could be assessed against their potential mitigation activities in a systematic way. Blanks in the matrices mean that the activities were considered, but the FMP committee did not deem them applicable. The full spreadsheets are located in the Appendix of this report. As the committee filled out the matrices, they were asked to highlight the activities the committee recommended most for those problem statements. Although not all activities were selected for inclusion in the action plan, the city will catalogue all responses for consideration in future updates to the FMP.

Figure 37: Tucson's landscape in bloom

Action Plan

Building on the work completed by reviewing the potential mitigation activities, the committee then reviewed the activities that were considered valid and recommended three to five that could be implemented for each of the seven major hazard groups. Projects in the 2012 Pima County Hazard Mitigation Plan are also identified in this report.

The following four questions were evaluated for each recommendation and these items must be identified in the Action Plan:

1. Who is responsible for implementing the action?
2. When it will be completed?
3. How it will be funded?
4. What goal does the action support?

MITIGATION ACTIVITY SUMMARY PRIORITIZATION

The following flood hazard mitigation projects are either beginning, completed, or ongoing and some were included in the 2012 Pima County HMP:

Table 3. Actions for Flood Hazards to be Mitigated (List to be updated in the PCHMP if not already in the PCHMP)

Mitigation Action/Project	Hazard(s) Mitigated	Estimated Cost/Funding Source	Completion Date	Responsible Agency
Identify funding source and construct two bridges and 50 box culverts with 380 back-up power units for signalized intersections at high flood hazard crossings - in the City of Tucson limits in accord with the COT Department of Transportation 5-year plan. If a box culvert cannot be constructed, an automated warning device, consisting of a barricade, signs, and flashing lights will be installed.	Flood, Severe Wind	$100 million, Staff Time Grant Funds	Ongoing effort with long-term horizon. Schedule dependent upon funding.	Department of Transportation/Streets Administrator and Streets Chief Engineer
Alamo Wash Watershed Study, Christmas WASH and other **drainage studies** - Watershed Study to include proposed solutions to drainage issues.	Flood / Erosion / Sediment Transport	(currently preparing scope) / PCRFCD	Annual - Ongoing	Transportation Department / Director
Re-direct the drainage canal at Barrio Viejo.	Flood	$425,000 Grant Funds, General Fund, PCRFCD	2013	Transportation Dept./Project Administrator
CLOMR - In compliance with the National Flood Insurance Plan (NFIP), the City of Tucson will continue to require the preparation and submittal of a Conditional Letter of Map Revision (CLOMR) or Conditional Letter of Map Revision based on Fill (CLOMR-F) for all proposed development within FEMA-delineated SFHAs.	Flood	Staff Time	Annual - Ongoing	Transportation and Development and Planning Services Departments / Directors
Compliance - The City of Tucson will maintain compliance with NFIP regulations by enforcement of the current floodplain management ordinance through review of new development located in the floodplain	Flood	Staff Time	Annual - Ongoing	Development and Planning Services Department & Transportation Departments / Directors
Storm Inspections - improve floodplain administration under the NFIP program by sending inspectors into the field when we receive a flood warning from the National Weather Service, to assess bridges, washes and other critical infrastructures within the City of Tucson.	Flood / Erosion / Sediment transport	Staff Time	Annual - Ongoing	Transportation and Development and Planning Services Departments / Directors
Kolb Road Extension to Sabino Canyon Road - Extend Sabino Canyon Road South of Tanque Verde Road to Kolb Road. Work includes fixing failing gabions, a new 4 lane roadway with curb, sidewalks, and a raised median in addition to two roadway bridges. One bridge across the Mullin's Landfill and another across the Pantano Wash.	Flood / Erosion	$18,000,000 / RTA / HURF	June 2017	Transportation Department / Director

Mitigation Action/Project	Hazard(s) Mitigated	Estimated Cost/Funding Source	Completion Date	Responsible Agency
Plan Tucson - City of Tucson General & Sustainability Plan includes broad planning focus for Tucson, including goals and policies to reduce hazards.	All	Staff Time	Annual - Ongoing	All departments
Acoustic Fiber Optics (AFO) monitoring and advance warning system - Promote Disaster-resistant water delivery system by constructing redundant water transmission lines. The Utility and the community will be less susceptible to loss of water delivery due to natural or manmade disasters. Pipeline management program including electromagnetic (EM) assessment and AFO monitoring to provide warning so pipeline can be fixed before pipe breaks and causes sinkholes, flooding, and / or erosion.	Flood Subsidence / Sinkholes	$7.9 million / Operations Budget	Ongoing with full completion by 2020.	Tucson Water Department/Water Administrator Maintenance & Operations
Columbus Wash improvements - Part of Grant Road master project improvements.	Flood	$1,000,000 / PAG, HURF	2017	Transportation Department / Director
Cushing Street Bridge - New bridge across the Santa Cruz River with floodwalls and other improvements along Cushing Street.	Flood	$14,500,000 U.S. Department of Transportation / RTA	completed 2012	Transportation Department / Director
Downtown Links - roadway and drainage improvements - Completion of last phase of the Tucson Arroyo - Arroyo Chico master drainage project (St Mary's phase completed already by City of Tucson , and other phases including Cherry Fields detention system was completed in 2016.)	Flood	$53,000,000 / RTA	2019	Transportation Department / Director
1st / Grant Road Detention Basin - Part of Grant Road master project improvements.	Flood	$650,000 / RTA	2018	Transportation Department / Director
Houghton, Broadway to 22nd - Drainage improvements with additional of all-weather crossings to transform a 2-lane rural roadway to a 6-lane multi-modal Desert Parkway improving cross town mobility, reducing congestion and improving safety.	Flood	$26,834,108 / RTA, COT DIFFO	August 2016	Transportation Department / Director
Houghton, Irvington to Valencia Roadway Widening - Drainage improvements with additional of all-weather crossings to transform a 2-lane rural roadway to a 6-lane multi-modal Desert Parkway improving cross town mobility, reducing congestion and improving safety.	Flood	$24,091,029 / RTA, PC Bonds, COT DIFFO	July 2016	Transportation Department / Director
Stone Avenue Drainage Improvements - Box culvert improvements at Stone Avenue near Mabel Avenue.	Flood	$18,600 / RTA / HURF	2017	Transportation Department / Director

POST-DISASTER MITIGATION POLICIES AND PROCEDURES (2014 TUCSON)

The 2014 Tucson Emergency Operations Plan defines activities that need to be conducted following a disaster. The Emergency Operations Plan lists organizations that take part of the emergency response and the different roles the organizations are responsible for during a disaster. The Tucson Office of Emergency Management and Homeland Security and the Emergency Support Function Leaders Group are the main organizations responsible for coordinating policy and the different groups within Tucson that are in charge of the management of the Emergency Operations Plan. Multiple support agencies participate in long-term incident management and recovery operations. The plan also specifies the information that is required in the After-Action Report (AAR) that summarizes emergency response successes along with recommendations for future improvements.

ACTION ITEMS FOR MITIGATION OF OTHER HAZARDS

The following mitigation actions and projects summaries were taken from the 2012 Pima County HMP. This project list only contains action items for non-flood hazards. All flood hazard projects have been included in the recommendation matrices listed in a previous section.

Table 4. HMP Action for other Hazards

Mitigation Action/Project	Hazard(s) Mitigated	Estimated Cost/Funding Source	Completion Date	Responsible Agency
Tucson Water, a division of the Utility Services Department, will secure its assets and facilities by implementing actions as identified in the Federally mandated Water System Vulnerability Assessment completed in October 2002.	Terrorism, Vandalism	$20 million Operations Budget	On-going with full completion by 2020	Water Department/Water Engineer & Operations
Work with the Arizona Geological Society and USGS on projects that mitigate geo-hazards (e.g., continue the feasibility study with the AZGS and USGS Water Plan 2000-2050. Construct second recharge facility to be known as the Southern Avra Valley Recharge and Recovery Project (SAVSARP). The utility could then use its entire allotment of Central Arizona Project water and provide capacity for recharging additional water supplies. Construction will take 5 years.	Drought, Earthquake, Subsidence, and other geo-hazards	$51.2 million Operations Budget	Ongoing effort with long-term horizon. Schedule dependent upon funding	Water Department/Staff

The Tucson FMP committee came up with one defining Action Plan Goal that aligns with Tucson's overall goals. This goal can be directly correlated to the community's hazard mitigation activity strategies, and a brief discussion of how each goal furthers Tucson's objectives has been included below the goal statement.

THE CITY OF TUCSON FLOODPLAIN MANAGEMENT PLAN GOAL IS TO;

Reduce flood and erosion hazards, damage, and associated costs by:

1) Identifying high-risk areas.
2) Providing safe, efficient, and balanced conveyance for stormwater runoff.
3) Maintaining, enhancing and/or restoring riparian ecosystems and wildlife corridors.
4) Increasing community awareness of water harvesting methodologies, floodplain preservation measures, and general flood and erosion information.
5) Expanding incentives for private property owners and developers to implement sustainable flood and erosion hazard mitigation strategies.

Figure 38: Houghton Road Improvements on Atterbury Wash Watershed

The following chart (Table 5) looks at these 5 Goals and the Activities identified by the FMP Committee and provides information about the responsible entity for the Activity and schedule.

Problem Statement	Recommended Activity Responsible Party		Target Completion Date	Goal Activity Supports 1	2	3	4	5
Public Conveyance Infrastructure	Research high-risk dip crossing locations and look into replacing dip crossings with 100-year drainage structures.	City Engineer, TDOT, Floodplain Managers, Permits Manager. Planning & mapping in progress.	On-going effort with long-term horizon. Schedule dependent upon funding.	X	X		X	
	Map all-weather access routes in the City.		2017	X	X		X	
	Map areas where barricades are used for low water crossing. Assess / expand Operation Splash. (TDOT Engineer)		2017	X	X		X	
	Assure Utilities are obtaining required permits in floodplain and erosion hazard areas.		Annual - On-going		X		X	
	Provide one-hundred year conveyance structures.		On-going effort with long-term horizon. Schedule dependent upon funding.	X	X		X	
Utility Municipal Structures	Annual Plan and Implement: Educate crews. Encourage consistency between agencies/jurisdiction. Improve procedures for Operations & Maintenance Forces to remove trash, debris, landscaping clippings from public ROW. Promote Routine Maintenance with a plan for crew / educate crews.	Operations & Maintenance	Annual - On-going	X			X	
	Meetings on a *"Annual"* Basis, Educate & Outreach, Open Houses/PSA's/HOA's, Newsletters, Annual Outreach to the Public and share the Emergency Response Plan(s)	Floodplain Manager, Public Information Office	Annual - On-going			X	X	X
	Map water lines and note condition of lines that run under flood retarding structures such as UPRR and ADOT embankments. Prepare for All Utilities	TDOT, Floodplain Manager	2017	X				
Urban High Density	Improve systems for identifying locations along stormwater conveyance systems that are at high risk of erosion; and routinely monitor at least annually and especially after major flow events	TDOT Stormwater Management	2017 and monitor on an annual basis	X	X			
	Improve procedures for routine maintenance to prevent and remove accumulation of debris; and provide public information on how to prevent clogging and obstruction of stormwater conveyance systems	TDOT	Annual - On-going	X			X	X
	Include policy in Stormwater Management Plan to update plan every 5 to 10 years or as reasonable to address population migration and annexations	TDOT Stormwater Management	On-going effort to be revisited every 5 to 10 years.	X	X			
	Coordinate with ecologist/biologists ramification of standing water in natural resource areas and implement acceptable sustainable mitigation practices	TDOT Stormwater Management	On-going effort with long-term horizon. Schedule dependent upon funding.	X		X	X	X
	Assure procedures comply with MS4 permit requirements	TDOT Stormwater Management	Annual - On-going	X	X	X	X	X
Private Drainage Infrastructure	Create list and obtain focused flood hazard studies to rank areas that need to be addressed. Create map of high incident of access issues for emergency response activities.	TDOT/Dev. Services with funding from RFCD	2017 and monitor on an annual basis	X			X	
	Educate property owners, HOA's, realtors, insurance agents, landlords, and general public.	Environmental Services	Annual - On-going				X	X
	Incorporate proper sediment trap (first flush) basins, utilize water harvesting to minimize sediment from unstable soil.	Development Services	On-going		X	X	X	
	Establish positive drainage during design, construction & maintain throughout life of facility.	Development Services	On-going		X	X	X	
	R & D BMP to improve soil infiltration & minimize compaction utilizing native grasses/trees/organic desert mulch.	Development Services	Annual - On-going					X

Table 5. Action Plan

Problem Statement	Recommended Activity	Responsible Party	Target Completion Date	Goal Activity Supports 1	2	3	4	5
Natural Floodplains	Produce overlays of priority areas where known roadway, infrastructure, structure areas have had flooding issues from vegetative debris flow - City of Tucson to map and describe flood plain road crossing (bridge span, culvert crossing, low water hardened crossing) and rate the effectiveness of flood water conveyance, ad structure integrity (High Impact: in channelized waterways - not going in for natural areas?)	TDOT Stormwater Management	2016 and monitor on an annual basis	X	X	X		
	City of Tucson will develop habitat management plans that include and are complimentary to WASH ordinance requirements, ERZ code (restricting development within the flood plain), the ERR reporting requirements for proposed floodplain disturbance and all other applicable local, state, and federal codes, ordinances or regulations (High Impact)	TDOT Stormwater Management			X	X		
	City of Tucson to work with Tucson Clean and Beautiful to delineate target areas for intense public outreach on managing flood waters and family safety tips during floods (Maintenance Practices, flood prevention, opportunities, involvement)	Tucson Clean & Beautiful	2017 and monitor on an annual basis				X	
	City of Tucson to locate, map and prioritize areas of significant channel head cutting adjacent to private property	TDOT Stormwater Management	2016	X				
	City of Tucson will develop recommendation for acquisition, relocations or additional flood protective measures for at-risk properties (TCB Involvement)	Tucson Clean & Beautiful	2016 and monitor on an annual basis	X	X			X
	City of Tucson would work with Tucson Clean and Beautiful and Southern Arizona Buffelgrass Coordination Center in producing information brochures designed for city elected officials, administrator and additional information for the general public informing of the value of healthy riparian corridors within the City of Tucson and planned management activities to maintain and enhance riparian corridors for the City resident's quality of life (TCB Involvement)	Tucson Clean & Beautiful, South Arizona Buffelgrass Coordination Center	2017 and monitor on an annual basis				X	
	Multi-jurisdictional Flood Panel - for Realtors - floodplain info outreach activity. City of Tucson to develop informational pamphlets, bulletins and other communication to be delivered to transient encampment warning of dangers of occupancy in the flood plain due to potential flood and fire	Tucson Realtors Association, TDOT Stormwater Management	2016 and monitor on an annual basis	X			X	
	City of Tucson to produce geo-database of all critical facility infrastructure within flood plain and flood prone areas.	TDOT Stormwater Management	2016 and monitor on an annual basis	X	X		X	
	City of Tucson to review ERZ code, WASH ordinance, ERR standards to develop vegetation management guidelines including trimming woody vegetation to 6 feet above ground, describe seed mix for herbaceous understory of perennial grasses for soil stabilization within 0.5 miles upstream of priority water conveyance impact areas.	TDOT Stormwater Management	2017	X	X	X		

Table 5. Action Plan

Problem Statement	Recommended Activity	Responsible Party	Target Completion Date	Goal Activity Supports 1	2	3	4	5
Vegetated Hazards	City of Tucson will map and describe vegetative associations to the alliance level within watercourses using Manning n values, hydraulic vegetation density (COT GIS - COT Engineering)	TDOT GIS	GIS shapefiles 1st qtr 2016, vegetation mapping 2nd 3rd qtr 2016 and 2017 priority HUCs, density calculations find mapping 4th qtr 2016, COT Engineering appropriate funds, FEMA grant 2017 pre disaster grant	X	X	X		
	City of Tucson will work with the Southern Arizona Buffelgrass Coordination Committee to develop (or expand) and recommend incentives for private land owners and developers to implement programs to reduce invasive species within flood prone areas while protecting toboso swale areas - and assist in riparian habitat restoration	TDOT Stormwater Management	3rd qtr 2017 after #1 vegetation and density mapping completed Funding - SABCC, COT Engineering appropriated funds			X	X	X
	City of Tucson to review ERZ code, WASH ordinance, ERR standards to develop vegetation management guidelines including trimming woody vegetation to 6 feet above ground, describe seed mix for herbaceous understory of perennial grasses for soil stabilization within 0.5 miles upstream of priority water conveyance impact areas	TDOT Stormwater Management	2017			X		
Geomorphological	Watershed management planning that includes restrictions for retention systems where groundwater contamination occurs. Onsite Containment (require properties with hazardous materials to construct basins to store and treat runoff) Contamination Hotline	TDOT Stormwater Management	2017 and monitor on an annual basis	X	X		X	
	Inspection & Maintenance program. Also, map locations of high-risk erosion hazard areas. Erosion Damage Hotline (where residents can call a central phone # to report erosion risk or damage to infrastructure like roads and utilities).	TDOT Stormwater Management	Annual - On-going	X		X	X	
	Emergency Service & Utility Notification Hotline	TDOT Stormwater Management	2017 and monitor on an annual basis				X	
	Bank Stabilization. Revegetation of Slopes. Post-fire reseeding programs to help reduce soil transport after storm events in rural areas.	TDOT Stormwater Management	Annual - On-going		X	X		
	Erosion Hazard setback regulations - update to reflect higher risk areas. Mapping Risk Areas (PCFCD)	TDOT Stormwater Management	Annual - On-going		X	X		
	PSAs, public information through utility bills and building permits. Explain what is practical for erosion prevention for desert climate area.	TDOT Stormwater Management	Annual - On-going				X	

Plan Adoption and FMP Updates

ADOPTION BY TUCSON CITY COUNCIL

The Action Plan for the Floodplain Management Plan as adopted by Mayor and Council by formal resolution can serve as a floodplain and erosion hazard management reference tool for all City of Tucson departments and divisions.

FMP UPDATES

The FMP committee will convene on a yearly basis to monitor and assess the action plan implementation process. The committee will prepare an evaluation report to submit with Tucson's annual CRS recertification documentation. Per CRS guidelines, the report "must be submitted to the governing body, released to the media, and made available to the public."

In 2020, the Tucson FMP committee will convene to review the 2016 FMP and to recommend updates by October 1, 2020, or four years after the plan was adopted. Following the initial update, the FMP evaluation and updates can be scheduled to occur concurrently with the community's normal 5-year CRS review cycle for the other CRS activities. In addition, it would be beneficial if the FMP and CRS review cycles synced up with the Pima County Regional HMP process so that the project lists in the FMP and HMP match. The FMP review cycle tasks should include at a minimum:

1. Convene the same committee that prepared the plan or one that meets the criteria identified in the CRS manual.
2. Hold a public meeting to review the updated report.
3. Review new studies and information that was completed after the FMP was created.
4. Review the hazard and problem assessments and update if necessary.
5. Review goals and update if necessary.
6. Review the action plan and update to account for actions that were completed, ones that are no longer necessary, and to add in new actions.
7. Consider adoption by Mayor and Council.

During the 5 year plan review, the FMP committee can evaluate whether they want to change the format of the report to being watershed based off if they prefer to continue to view Tucson as a whole.

References

- 2010 Census www.factfinder.census.gov
- 2013 Community Rating System Manual (FEMA)
- 2014 Tucson Emergency Operations Plan
- 2012 Upper Santa Cruz Watershed Discovery Report (FEMA)
- Pima County Flood Insurance Study (June 16, 2011) (FEMA)
- Tucson Stormwater Management Study Phases I – IV (Tucson)
- 2008 Tucson Watercourse Maintenance Guidelines (Tucson)
- 2006 Water Harvesting Guidance Manual (Tucson)
- 2012 Pima County Multi-Jurisdictional HMP (PCRFCD)
- 2003 City of Tucson Habitat Conservation Plan (PCRFCD)
- 2013 Pima County Community Wildfire Plan (Pima County)
- 2011-2015 Action Plan for Water Sustainability (Tucson)
- 2006 Tucson Parks and Recreation 10-year Strategic Plan (Tucson)
- Tucson Police Department Strategic Plan (2013-2018) (Tucson)
- ERZ and WASH Ordinances Watercourse Analysis: Southeast Region and TSMS Recommendations (Tucson, Department of Transportation)
- Sustainability Tools for Assessing and Rating Communities/STAR (Tucson Office of Integrated Planning)
- Plan Tucson: City of Tucson General and Sustainability Plan (2013) (Tucson)
- Arroyo Chico Post Project Conditions Map (PCRFCD)
- ALERT System Map & Rain Gauge Data (PCRFCD)
- Solving Flooding Challenges with Green Stormwater Infrastructure in the Airport Wash Area (PCRFCD, Tucson Ward 1)
- Take Back Our Parks (Tucson Ward 4)
- The University of Arizona Epidemiology and Biostatistics Department
- Center for Western Weather and Water Extremes Scripps Institution of Oceanography cw3e.ucsd.edu
- Lee Moore Wash Basin Management Study (PCRFCD/Tucson)
- Ruthruaff Basin Management Plan (PCRFCD)
- Arroyo Chico Multi-Use Project (PCRFCD)
- Pantano Wash Bank Protection & River Park: Craycroft Road to Tanque Verde Road (PCRFCD)
- Paseo de las Iglesias Phase I: Santa Cruz River Bank Protection, Ecosystem Restoration, and Linear Parkway,Ajo Way to Silverlake Road (PCRFCD)
- Green Valley Drainageway #6 Improvements (PCRFCD)
- Mission View Wash Drainage Improvements (PCRFCD)
- Pantano Wash Bank Protection - Speedway Blvd. to Tanque Verde Rd (PCRFCD)
- Airport Wash South Basin Management Study (PCRFCD)
- Green Valley Hydrology Study (PCRFCD)
- Agua Caliente Wash Letter of Map Revision (PCRFCD)
- Santa Cruz River at Grant Road Floodplain Study (PCRFCD)
- PAG's 2013-2050 Incorporated Places Population Projects for Pima County and Incorporated Areas
- Open House Attendee List & Public Comment Summary
- FMP Committee Meeting Minutes & CRS 510 FMP Checklist
- FEMA's Community Information System (CIS)
- 2014 Tucson Emergency Operations Plan

Appendices

The full report can be downloaded at https://www.tucsonaz.gov/tdot/floodplain-administration and www.R9map.org. The appendices to this report include information regarding:

a. Flood Risk Map
b. Project Fact Sheet
c. Open House Notice
d. FEMA - City of Tucson FMP Charter
e. Hydrometeorologist's anecdotal story of Tucson's climate
f. FMP Committee Attendance Tracking
g. Tucson City Council Adoption Resolution

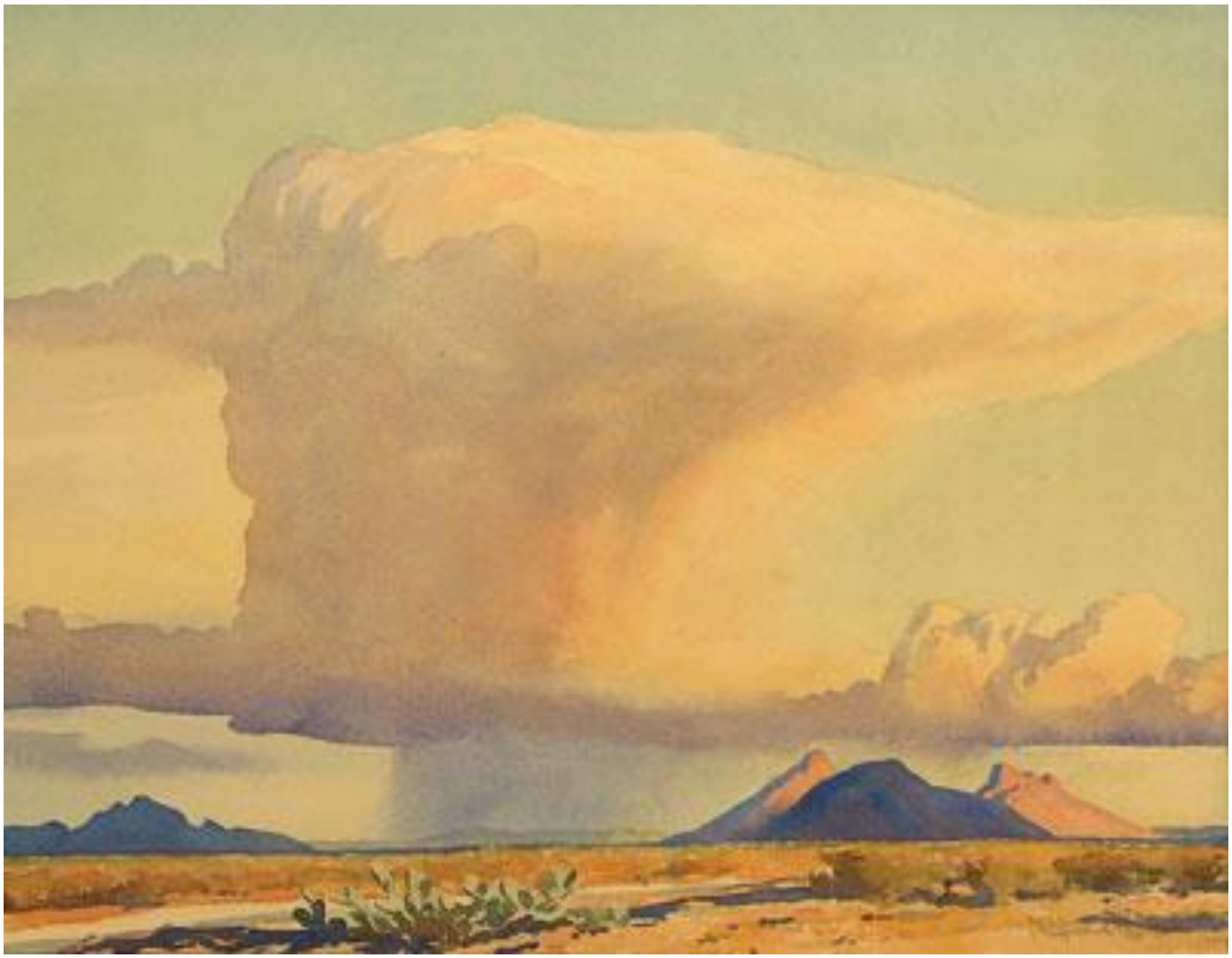


Figure 39: Storm over Tucson (Painting by Maynard Dixon)