

Special Study #46

**Sheet Flood Mapping for
Unincorporated Pima County**

By: Pima County Regional Flood Control

2007

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PIMA COUNTY
REGIONAL FLOOD CONTROL DISTRICT
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SUBJECT: Special Study #46, Sheet Flood Mapping for Unincorporated Pima County

PURPOSE:

Significant portions of Pima County are subject to shallow sheet flow flooding, the regulation of which is problematic on a parcel by parcel basis. The purpose of the sheet flood mapping under this Special Study is to provide uniformity in how building permits are processed and development is regulated within sheet flood areas in order to ensure that improvements are adequately protected from flood hazards.

EXECUTIVE SUMMARY:

The mapping was conducted in a manner equivalent to a Level I Flow Analysis for sheet flooding as outlined in Arizona State Standard SSA 4-95, Identification of and Development Within Sheet Flow Areas. More specifically, the assessment included the use of GIS to isolate areas identified as having characteristics typical of sheet flood areas, such as shallow (<5%) slopes, and sheet flood indicative soils. Using these areas as a starting point, an expert work group composed of civil engineers, hydrologists and planners evaluated the target areas to better refine the mapping. In addition to the factors above, the work group included the following factors in the decision-making process:

- Size of the watersheds impacting the area of concern
- Utilization of detailed topography, vegetative patterns and recent aerial photography to determine flow paths
- Identification of features such as agricultural ditches and berms with the potential to create ponding areas upstream and/or potential break-out flows downstream due to berm failure
- Personal knowledge of historical flooding events

Additional details regarding the mapping process are in the attached addendum titled "Method To Delineate Sheet Flow Areas within Unincorporated Pima County"

In the absence of large-scale, two-dimensional modeling, this Special Study represents the best available data, and by this document shall be a regulatory floodplain pursuant to the Floodplain and Erosion Hazard Management Ordinance, as Title 16 of the Pima County Code.

APPROVED BY:

Suzanne J. Shields 8/8/2007
Suzanne Shields Date
Director



SS/BEJ

Method to Delineate Sheet Flow Areas within Unincorporated Pima County

Overview

This report describes the procedure used to identify and map areas subject to sheet flooding within unincorporated Pima County. Three major sheet flow areas were identified in this project, along with a number of smaller sheet flow locations. The three major areas are associated with broad alluvial fan formations common to the region. Smaller sheet flow areas were mapped at various locations, mainly within the more urbanized settings of the Tucson metropolitan area.

The methodology developed for this study was based on the Arizona Department of Water Resources, State Standard 4-95: "Identification of and Development Within Sheet Flow Areas," and a review of relevant literature to determine common characteristics of sheet flow areas. The analysis includes various types of sheet flow described in the Arizona State Standards including: natural sheet flow, urban sheet flow areas, overland flow, anastomosing flow, and distributary systems.

The project was structured using geographic information systems (GIS) as the basic analytical tool. This allowed assessment of a range of data and greatly facilitated identification of sheet flow areas. Given the breadth of territory within Pima County, the first step in this process was to eliminate areas from the map that were outside the purview of Pima County jurisdiction or otherwise not subject to future development. Excluded at this stage were incorporated municipalities, federal and tribal lands, parks and preserves and State of Arizona land. These jurisdictional limits were established since the final product is intended for regulatory purposes as defined in the Pima County Floodplain and Erosion Hazard Management Ordinance. Special Flood Hazard areas mapped by the Federal Emergency Management Agency (FEMA) were also excluded at this point. Flooding hazards for these areas have already been determined and regulatory measures in place.

Once jurisdictional limits were identified, the next step involved excluding locations where sheet flooding could not be supported physically. This involved generating a slope analysis for eastern Pima County and excluding areas showing greater than five percent slope. The five percent slope criterion was adopted based on Arizona State Standards and the consensus opinion of geologists and engineering professionals within the community. This conservative threshold ensured that no territory with sheet flow of any significance would be removed from further consideration. The consensus opinion was that sheet flooding could not occur in areas with slopes greater than two and one-half to three percent slope.

With jurisdictional and physical limits defined, variables showing positive association with sheet flooding were plotted. The intent was to broadly identify a number of sheet flow "target areas" for more in-depth analysis. Target areas were determined by the coincidence of low slope and the presence of sheet flow indicator soils.

An expert work group composed of civil engineers, hydrologists and planners was convened to evaluate each of the target areas. The work group identified sheet flow areas and boundary limits for each area based on local drainage conditions and a variety of physical land characteristics. The main criteria used in this assessment included: slope, the presence of sheet flood indicator soils, size of the contributing drainage area(s), areas of avulsion, drainages exhibiting poorly defined or non-existent channels, channel breakouts, and local topographic features. Details on this process are presented below.

Lastly, sheet flow areas were field checked to verify accuracy, and where needed, refinements were made to boundary lines. All of the smaller urban sheet flow areas were field checked in this process. Selected portions of the larger alluvial fan designations were also field checked.

Step-by-Step Process

Detailed steps in this analysis and the criteria used to delimit sheet flow areas were:

1. Eliminate areas outside of Pima County jurisdiction.

- Incorporated areas within Pima County, federal lands, tribal lands, county parks, preserves, etc.
- FEMA 100-Year Floodplains (this included mapped sheet flow areas since the intent of this project was to delineate new, unmapped areas).
- State of Arizona lands. While some Arizona state land will be converted and sold to private concerns, generally this was not considered an immediate prospect. In addition, it was determined that state land conversions would be reviewed by the Regional Flood Control District at the time of sale to determine sheet flow and other flood hazards. Nevertheless, in some cases it was decided to include state-owned lands within designated sheet flow areas. This was done in situations where sheet flooding was clearly evident on state holdings and where continuing the designation could be made easily and was a logical extension from the core sheet flow polygon.

2. Eliminate areas where sheet flows could not be supported physically.

Based on a review of relevant literature and professional engineering opinion, areas of steep slope exceeding five percent were eliminated from consideration at the outset of this project. The five percent criterion represents an extra margin of safety since the prevailing opinion was that sheet flow is highly unlikely to occur in areas greater than two and one-half to three percent slope. The process of eliminating territory from further consideration greatly reduced the geographic area requiring more in-depth assessment.

3. Identify target areas for in-depth analysis.

For the remaining territory on the map, target areas were identified in the GIS analysis based on the covariance of the following mapped features:

- Areas of low slope (zero to three percent).
- Areas of containing "sheet flow indicator soils." A group of "sheet flow indicator soils" was identified from soil survey data obtained from the U.S. Natural Resources Conservation Service (NRCS). NRCS and Arizona Geological Survey staff were consulted to identify approximately 30 NRCS soil types that were indicative of sheet flow conditions. These soils mainly involved more recent, alluvial soil types. Since this stage of the analysis was concerned with identifying potential target areas, a broad perspective was adopted to include both core soil types as well as soils thought to be even marginally associated with sheet flow conditions. Fluvent soils, mainly found in channel bottoms, were also included since they would also reveal occasional breakout areas.

4. Delineate preliminary sheet flow areas through aerial photo interpretation using an expert group.

A group of staff hydrologists, planners and civil engineers was convened to examine each target area to determine whether sheet flooding existed in those areas. This phase of the analysis entailed viewing recent aerial photography, and evaluating drainage and physical land characteristics for each target area. The work group considered the size of the contributing drainage upstream from the suspected sheet flow area, slope conditions, drainage areas with poorly defined channels (or no channels at all), areas of avulsion, breakouts, distributary flows, vegetation patterns, and detailed topography, among other factors.

5. Additional refinements.

A number of locations within Pima County with known flooding problems have been the subject of Special Studies. Flooding problems in these locations have been analyzed in great detail and regulatory requirements established to ensure public safety. Thus, Special Study limits were removed from mapped sheet flow designations. Another refinement was to remove more recent subdivisions from the sheet flow areas. This was done mainly in the Thornydale and Lambert Lane area and near Vail west of Camino Loma Alto. Recently platted subdivisions were removed since flooding issues for these areas have already been analyzed and engineering improvements in place to address drainage issues.

6. Field checks.

Field checks were made to verify sheet flow conditions and to refine boundary lines as needed. Field visits were made to all of smaller urban sheet flow areas, and to selected portions of the larger alluvial fan designations.

Description and Characteristics of Designated Sheet Flow Areas

Specific characteristics and designation criteria pertaining to each of the major sheet flow areas are presented below.

Picture Rocks-West Tucson Mountains. This is a broad alluvial fan with less dense suburban and rural development. A key feature shaping the western boundary of this area is the FEMA 100-year floodplain of the Brawley and Black Washes. Sheet flooding conditions were apparent in most of the lower fan locations right up to the existing 100-Year floodplain limits. Several small outlier designations were also made adjoining this area, mainly within the distributary flow pattern of the Brawley Wash. The Picture Rocks-West Tucson Mountain area also has large holdings of state-owned parcels. Although generally excluded from consideration, sheet flow designations were occasionally extended into state lands. This was done where physical sheet flooding conditions were clearly evident on state holdings and where boundary lines could be easily extended from the core sheet flow area. Lastly, several prominent topographic features and Special Study areas were excluded from the sheet flow maps.

Diamond Bell-Sierrita Mountain. A prototypical alluvial fan, this large area is characterized generally by rural development, and some wildcat subdivisions. As with the Picture Rocks-West Tucson Mountain boundaries, existing FEMA floodplains of the Upper Brawley Wash form most of the northern and western borders of the sheet flow area. Tohono O'odham jurisdictional lands largely define the eastern boundary (sheet flow conditions clearly extend into Tribal land in this area), while significant tracts of state land lie to the south. Toward the southern limit of this area, it was apparent that the larger alluvial fan structure and sheet flow conditions continued well into state-owned land, in many cases all the way south to the Buenos Aires National Wildlife Refuge. While conversion of state land in this area is probably not imminent, it was decided to include these areas since sheet flooding conditions were clearly visible, and extension from the core area could easily be made.

Southwest Area-Santa Rita Mountains. This is a large alluvial fan is generally bounded by the Santa Cruz River to the west, Sahuarita Road to the North, Sonoita Highway to the east, and the Santa Rita Experimental Range to the south. Generally, the area is sparsely settled with rural development and large tracts of state-owned land. Sheet flow conditions were observable in nearly all of the lower fan formation, extending west to the FEMA-mapped floodplains of the Santa Cruz River.

Municipal and jurisdictional limits were important determining factors in this area. In this region, it was again decided to include large areas of state-owned land in the sheet flow polygon since the fan characteristics and sheet flooding were readily apparent. As mentioned, the Santa Rita Experimental Range forms much of the southern border of this area; it was excluded from consideration for jurisdictional reasons. One further jurisdictional consideration in this area concerns the Town of Sahuarita. In the lower fan locations near the Santa Cruz River, sheet flow

areas were identified and designated within the corporate limits of the Town of Sahuarita. This was done for regulatory purposes and was the only instance where sheet flows were mapped in an incorporated jurisdiction. Finally, several prominent ridges and various locations with more defined channels were excluded from the sheet flood polygon.

Small Sheet Flow Areas. A series of small sheet flow areas were also mapped in this project, mainly within more urbanized locations of the Tucson metropolitan area. According to Arizona State Standards, urban sheet flooding can occur in areas where "development has obscured natural drainage patterns or where urban drainage facilities are severely undersized." These conditions coupled with: "1) Low topographic relief perpendicular to the primary flow direction; 2) Lack of defined channels downstream of a relatively large drainage area; and, 3) Significant flow in streets during ordinary rainstorms" often produce sheet flow conditions. A number of locations in the Tucson basin met these criteria and were also discernable from the GIS analysis showing low slope and the presence of sheet flood indicator soils.

Locations included: 1) the Thornydale and Lambert Lane area near the Town of Oro Valley, 2) areas adjoining mapped floodplains of the Agua Caliente Wash, 3) the Vail area near Old Spanish Trail and Camino Loma Alto, 4) Interstate 10 and South Pantano Road, 5) Palo Verde Road neighborhoods south of Benson Highway, 6) South Cardinal Avenue and West Drexel Road, 7) the Franco Wash near South Country Club Road, and 8) two small areas near the eastern county border.

Boundary lines for many of the smaller urban sheet flow areas were determined by jurisdictional limits with incorporated areas, as well as existing mapped FEMA floodplains. The presence of recent subdivisions was also an important factor for two of these locations. The Thornydale/Lambert Lane area and the Vail area near Camino Loma Alto and Via Rancho del Lago both have large tracts of new development and many recent subdivisions. Newer subdivisions (post 1970s) were excluded from sheet flow designations because they already have engineering and constructed drainage improvements in place.

As noted, identifying sheet flow in smaller urban locations can be difficult since the underlying land and drainage characteristics are often obscured by existing development. Because of this, all of the urban sheet flood areas were field checked to verify the boundaries mapped by the work group. Modifications were then made to the boundary lines for many of the small sheet flow areas based on the field observations.

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