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COUNCIL WORK SESSION SUMMARY ROUTING SLIP

Meeting Date August 24, 2015

TITLE: ARROYO MANAGEMENT PLAN.

Are there attachments to the Council Work Session Summary?	**Yes** ☒	**No** ☐
Will there be a Video Presentation for this item?	**Yes** ☐	**No** ☒
Will there be a PowerPoint Presentation for this item?	**Yes** ☒	**No** ☐
If "yes", will a copy of the PowerPoint Presentation be included on the Council Work Session Agenda?	**Yes** ☐	**No** ☒

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City of Las Cruces®
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Council Work Session Summary

Meeting Date: August 24, 2015

TITLE: ARROYO MANAGEMENT PLAN.

PURPOSE(S) OF DISCUSSION:

☒ Inform/Update

☒ Direction/Guidance

☐ Legislative Development/Policy

BACKGROUND / KEY ISSUES / CONTRIBUTING FACTORS:

The purpose of this work session item is to review the status of the draft Arroyo Management Plan and note the comments of various stakeholders who have participated in the development of the plan. Staff will also be requesting direction from City Council in regards to proceeding with consideration of the plan.

The Arroyo Management Plan was recommended for approval by the Planning & Zoning Commission in November 2014. The City Council has discussed the plan at work sessions in February and March of this year. An overview of the plan's goals, policies and implementation strategies were presented at both meetings. Staff was directed to discuss the plan with the NM State Land Office and other stakeholders; and then after these discussions, to schedule the plan for another work session with City Council.

Staff will make a presentation to summarize the major elements of the plan and the comments of the stakeholders involved with drafting of the plan. Staff will also present the City Council with options for the adoption of the plan.

SUPPORT INFORMATION:

1. Attachment "A", Arroyo Management Plan draft.

Exhibit “A”

CITY OF LAS CRUCES
ARROYO MANAGEMENT PLAN

November 12, 2014

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ACKNOWLEDGEMENTS

CITY COUNCIL

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District 1: Councillor Miguel G. Silva
District 2: Councillor Greg Smith, Mayor Pro-Tem
District 3: Councillor Olga Pedroza
District 4: Councillor Nathan Small
District 5: Councillor Gill Sorg
District 6: Councillor Cecelia Levatino

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CHAPTER 1. INTRODUCTION

Arroyos are recognizable geographic features of the southwestern Chihuahuan Desert surrounding Las Cruces, New Mexico. Arroyos provide natural pathways for surface water runoff to flow from higher elevations to low-lying lands and ultimately the Rio Grande. Vegetation in and adjacent to arroyos provides habitat for many Chihuahuan Desert wildlife species. Arroyos are non-static, living systems and their shapes, sizes, depths and directions change in response to the frequency and intensity of storm events. As both urban and rural development increases, many arroyos have been rerouted, channelized, or dammed to protect property and increase useable land. These actions have altered natural drainage function, wildlife connectivity, and the propagation of vegetation in some areas.

Surrounding Las Cruces, development and open spaces exist together, and the natural terrain is part of the community character. It has often been the practice to carve out development and leave the rest for open space, but planning for open spaces first may prove to be more valuable for property owners and the desert environment in the long run. Through sound development standards, new land uses can incorporate characteristics of the existing natural environments – topography, soils, vegetation, geology, and hydrology – so that ecologically-sensitive[1] and dynamic lands are protected. Safe and effective engineering standards for flood control, utilities, stormwater conveyance, and water storage are important factors for all development. But specifically in arroyo environments, development designs can be implemented to maintain the natural character of the arroyo. It is also important to maintain

[1] One Valley One Vision 2040 describes critical and sensitive land as “land that generally should be conserved in its natural state (e.g., surface water, floodplains, wetlands, arroyos, steep slopes, protected wilderness, wildlife habitat, tree stands, and cultural areas) in a manner that reasonably compensates, provides incentives, maintains similar existing property rights, or balances the public and property owner interests.”

arroyos to ensure historical drainage patterns adhere to water quality regulations administered by the U.S. Environmental Protection Agency's (EPA) National Pollutant Discharge Elimination System (NPDES) permit program.

Arroyos can also provide a variety of recreational opportunities. Proper design of trails, trail amenities, connectivity, equestrian facilities, street crossings, parking, signage, etc. can result in opportunities that meet the needs of all users. Economic development is also impacted by how our arroyo systems are managed, as quality of life and a community's green industry become larger considerations when businesses and people choose where to relocate.

Purpose of the Arroyo Management Plan

The City of Las Cruces wants to protect the major arroyos as open space and encourages private property owners to preserve smaller tributaries where ever possible when designing new neighborhoods. Healthy arroyo systems impact many aspects of life in Las Cruces and the AMP provides policy guidance designed to improve quality of life and help accomplish the following goals:

- Protect and manage major arroyos in their natural state;
- Allow maintenance of historic flows in arroyos;
- Protect private property;
- Improve flood control & drainage functions;
- Accommodate and protect essential utility installation and maintenance;
- Improve stormwater quality;
- Strengthen compliance with the NPDES permit;
- Protect native vegetation and wildlife habitat;
- Encourage responsible and profitable development;
- Increase protected open space; and
- Increase trails, trail connectivity, and recreational opportunities.

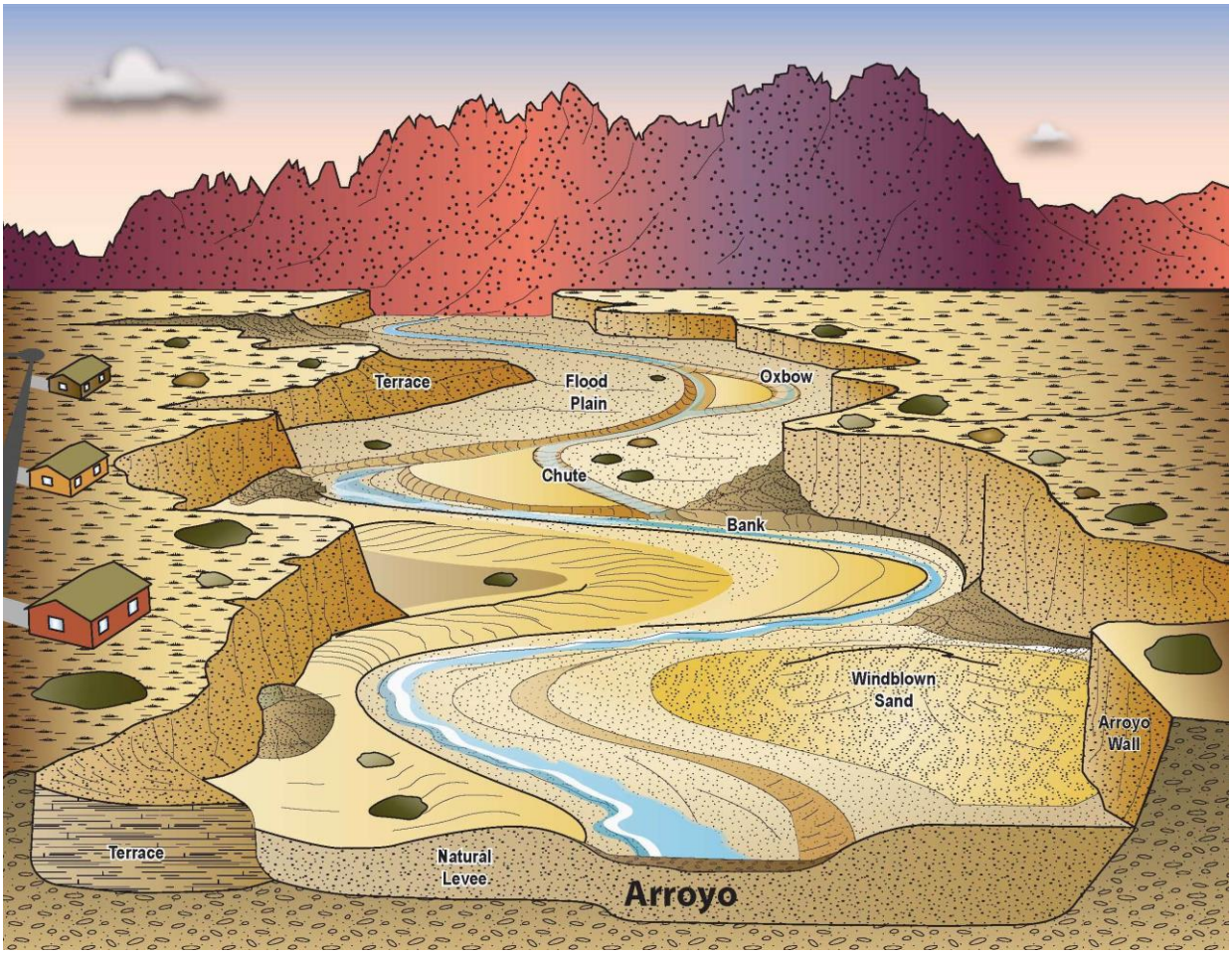
The City of Las Cruces Arroyo Management Plan will be used by the City to help guide regulations in the Development Standards, Subdivision Code (Chapters 32 and 37 respectively of the Las Cruces Municipal Code) and all other relevant codes as amended. It will guide design and development adjacent to arroyos on the East and West Mesa areas in a manner that adheres to the Comprehensive Plan, Storm Water Management Plan, Mesilla Valley MPO Transportation Plan, Parks and Recreation Master Plan, and other related plans adopted by the City. Any future action or activity that stems from the AMP policies will have a common basis for drainage management throughout the city by reducing flooding, improving water quality and mimicking the pre-development hydrologic conditions. This in turn protects the health, safety and welfare of the general public.

Geographically, the AMP includes major arroyos on the East and West Mesas, undeveloped floodways, unnamed 100-year flood zones, including areas in the Extraterritorial Zone (ETZ), and largely native areas on the West Mesa escarpment. Because most of the development in the Las Cruces area has been directed east toward the Organ Mountains, numerous studies have been completed addressing stormwater, watershed management, soils, vegetation, etc. For this reason, much of the information presented in this document is based on data collected for the East Mesa. But the AMP will guide development on the West Mesa in the same way it will on the East Mesa, and the same goals and policies will be relevant as the community grows to the west. Additional policies will address the West

Mesa escarpment where drainage to the Rio Grande varies greatly from drainage on the East Mesa. Map 1, below, shows the AMP Planning Area and the major arroyo systems.

Within this planning area, arroyos and the lands adjacent to them are owned by many parties, mainly the New Mexico State Land Office, U.S. Bureau of Reclamation, City of Las Cruces and numerous private owners. While some of the policies in the plan may guide maintenance efforts in already-developed areas, the plan is primarily intended as guiding policy for public and privately-owned lands that are undeveloped. Historically, developers have followed the regulations in place at the time of development. In the absence of regulation, plan policies are not binding, but can guide decision making. Appropriate land use practices must balance the rights of landowners with the protection of the region's unique landscapes, arid vegetation and natural wildlife habitat. It is also critical to understand the potential impacts of human actions on a regional and watershed perspective. By managing arroyo systems holistically – looking broadly at the watershed level – we can help to ensure that the full potential of arroyos as a community asset is realized and in doing so, maintain the desert's ecological health over time.

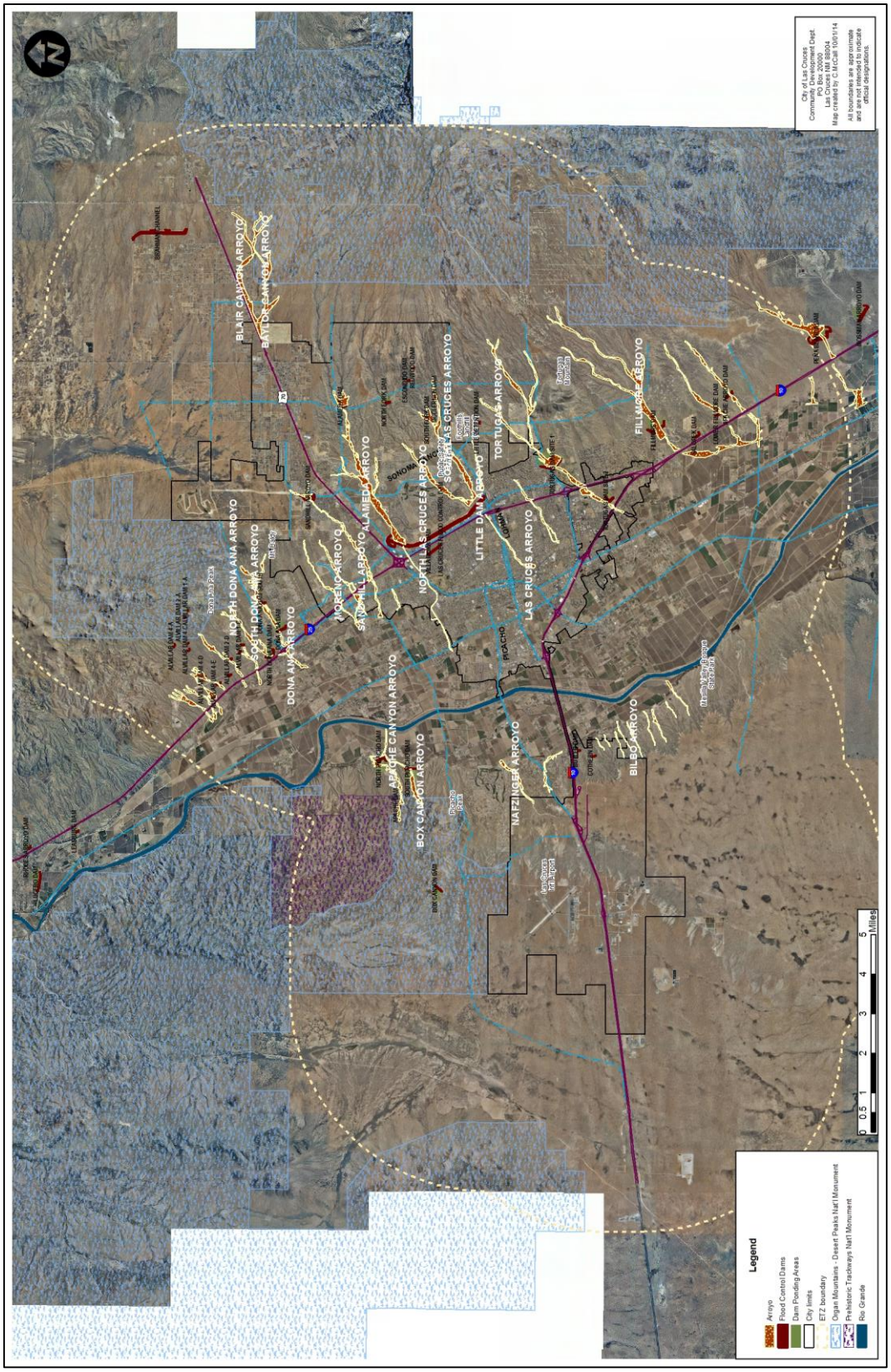
Figure 1 Arroyo Characteristics



Although every arroyo is different, this diagram shows the many elements an arroyo may have, depending on location, soils, width and the slopes of its edges.[2]

[2] Graphic by P. Bennett, after http://geochange.er.usgs.gov/sw/impacts/geology/puerco1

Map 1. AMP Planning Area



Planning Background

During the first half of the 20th century, Las Cruces was a small community and was situated in the mostly flat valley floor and stormwater runoff was easily contained on site. But capacity overload was common, resulting in frequent damage to property. This led to the more formal implementation of on-lot ponding to reduce excessive runoff in roadways. While the City recognized the need for flood control and drainage, Article 4.5 of the *Rules and Regulations Governing the Subdivision of Land within the City of Las Cruces,* adopted in 1956, makes only one indirect reference to arroyos: "The developer should keep in mind that natural watercourses can be an attractive asset to his subdivision as well as to the community and, where possible, should improve and beautify the watercourses to this end."

Inspired by the success of the Albuquerque Metropolitan Arroyo Flood Control Act of 1967, the City Commission (as it was known at that time) asked the New Mexico legislature to draft one for Las Cruces. Delegated through state statute, the Las Cruces Metropolitan Flood Control Authority (LCMAFCA, 1968) was formed to administer stormwater management throughout the Las Cruces area. Apparently the taxing provisions provided in the legislation were not adequate for what Las Cruces wanted and the organization was never formed.

The City's 1968 *Comprehensive Plan* described the conditions of the drainage system at that time: a system that "includes major drains and laterals developed for irrigation purposes and used to carry stormwater, retention dams, collection basins, open ditches, storm drainage and the major arroyos. The existing storm drainage facilities are not adequate" because the dams were not designed for high hazard duty, and the open ditches were primarily agricultural drains designed for water table control, not high storm water flows. The excessive surface flow resulted in street flooding, washing out of unpaved streets and property damage. According to the plan, "the open ditches and storm drains that are available offer some protection to the areas they serve, but even these facilities are generally inadequate or create problems where a ditch ends and the water must revert to surface flow." The Capital Improvement Program section of the plan addressed these problems by proposing storm sewer improvements and a major retention dam along the east side of Interstate 25. Now known as the Las Cruces Flood Control Dam, it was a joint project between the City of Las Cruces and the U.S. Army Corps of Engineers and was completed in 1975.

The 1975 *City of Las Cruces Land Subdivision Regulations* also included a design standards section that dealt with drainage issues. However, the standards don't include specific requirements for construction and as growth increased, developers, builders, property owners, City officials, etc., found them inadequate to regulate development. Arroyos are not specifically mentioned in these regulations.

The City continued addressing stormwater management by adopting an ordinance in 1987 that established more detailed regulations for flood control. *An Ordinance for the Purpose of Flood Damage Prevention* called for: restricting or prohibiting uses that were dangerous to health, safety or property in times of flood or that would cause excessive increases in flood heights or velocities; controlling the alteration of natural floodplains, stream channels and natural protective barriers; and regulating the construction of flood barriers which may unnaturally divert flood waters or which may increase flood hazards to other lands.

Flood control standards continued to evolve in the 1990's. The City's *Storm Water Management Policy Plan* (November 1992) states as a goal, to "develop an overall City storm water system that promotes aesthetics and multiple-use activities through the use of 'natural' arroyos or linear park systems,

preservation of open space, and visual enhancement." It identified the following arroyos as suitable for open space corridors: Fillmore Arroyo, Telbrook Arroyo, segments of Little Dam Arroyo, North and South Fork Las Cruces Arroyo, Alameda Arroyo, a segment of Sandhill Arroyo and unnamed major arroyos as identified on the Major Arroyo Corridor Identification Map. The Storm Water Management Policy Plan also calls for a Major Arroyo Plan, which would identify how each major arroyo would be used. A plan was not drafted at that time.

The City's 1999 *Comprehensive Plan* addressed arroyo preservation in a more meaningful manner. It called for the creation of a major arroyo plan with policies to protect and maintain the existing natural environment and to minimize impacts created by development. It addressed safe hillside and escarpment development, and the use of arroyo systems as trails and trail connections. Also, for the first time in the City's comprehensive plan, the topic of the physical health of residents was addressed: the 1999 Plan included policies that supported ways to promote physical activity thereby improving the overall health of our communities. The *Draft Storm Water Management Plan* (SWMP), adopted in 2009, outlines the City's 5-year program to comply with the EPA's Final NPDES General Permit for Small Municipal Separate Storm Sewer Systems (MS4s) in New Mexico to improve stormwater quality in accordance with the Clean Water Act of 1972. The SWMP describes six minimum control measures, which if carried out, would significantly reduce pollutants being discharged into the stormwater drainage system, and ultimately the river. The City's Public Works Department adopted the EPA's Best Management Practices (BMP) to address each of the six areas. They include public education and involvement, discharge detection and elimination, construction site storm water runoff control, post-construction stormwater management, and pollution prevention for municipal operations.

The Mesilla Valley Metropolitan Planning Organization's (MPO) *Transport 2040 Transportation Plan*, adopted in June 2010, includes policies to identify major arroyos in the Las Cruces area as potential trail corridors. Its Trail System Priorities map contains text on a tiered network of trails, examples of improved and unimproved trail facilities, and a discussion of potential pavement types. The aim of these policies is to provide a variety of transportation choices that serve all users by developing safe, reliable, and convenient non-motorized transportation modes, i.e. pedestrian and bicycle facilities.

The *One Valley One Vision 2040 Regional Plan*, adopted in 2012, reinforces various arroyo policies found in the *1999 Comprehensive Plan* and *Transport 2040*. It calls for the preservation of open space; improving our water supply by better management of stormwater and the effects of erosion; providing an adequate network of corridors for wildlife (e.g., buffer zones adjacent to arroyos or wildlife over/under passes); developing strategies for low-impact recreation along arroyo buffers; and increasing access to non-motorized transportation options to promote healthy living and provide mobility alternatives. *One Valley One Vision 2040* also supports an arroyo and open space management plan that would "help protect our sensitive environmental resources".

The *Parks and Recreation Master Plan*, updated in 2013, suggests integrating the siting of proposed trail segments into the development design process and requiring development projects along designated trail routes to incorporate the trail as part of the project. It also supports the MPO's *Transport 2040's* Trail Plan by calling for a comprehensive parks and trails facilities mapping program that promotes active lifestyles in Las Cruces and integrating arroyos into the trail system. Additional policies address trail accessibility for all users and promote an open space protection program.

The 1999 Comprehensive Plan was amended in 2013 as *Comprehensive Plan 2040* and carries these policies forward to present day. In addition, the Future Concept Map in the amended plan specifically

calls for “conservation areas” consisting of areas of historical, cultural, environmental value or open areas that could become community assets and are worth conserving, such as arroyos (Goal 35, Policy 35.1). At present, the 2001 Zoning Code as amended has three zoning districts related to open space and arroyos: Flood Control (FC); Open Space-Recreation (OS-R); and Open Space-Natural/Conservation (OS-NC).

For a comprehensive listing of the goals and policies in the plans and ordinances noted above, see Appendix 2, Planning Background.

CHAPTER 2. GLOSSARY AND ACRONYMS

Access points: Low impact areas that form entrances into the arroyo buffer from adjacent urbanization. These points provide access for pedestrians, cyclists, equestrians, and, occasionally, motor vehicles for purposes of maintenance and operations.

Alluvial fan: A fan-shaped pile of sediment that forms where a rapidly flowing watercourse enters a relatively flat valley. As water slows down, it deposits sediment (alluvium) that gradually builds the fan shape.

Arroyo: The American Geological Institute Glossary (1972) defines an arroyo as "a deep, flat-floored channel or gully of an ephemeral stream or of an intermittent[3] stream usually with vertical or steeply cut banks of unconsolidated material at least 60 centimeters *(2 feet)* high, that is usually dry, but may be transformed into a temporary water course or short lived torrent after heavy rains." Also called a wash or draw.

Major arroyo means any channel whose watershed exceeds 320 acres in a 100-year design storm, whether the watershed is in its natural or unaltered state or has been altered by development, runoff diversions, or detention facilities.[4]

Natural arroyo is an arroyo that has not been directly altered by human intervention.

Naturalistic arroyo corridor is an arroyo that has been directly altered by human intervention and in which non-continuous or limited erosion protection measures have been installed to prevent damage to infrastructure while maintaining the natural bed and bank materials.

Arroyo boundary: The elevation line on the banks of an arroyo that represents the lateral reach and depth of water calculated from a 100-year flood event.

Arroyo buffer: The area adjacent to an arroyo where development may not occur or may be reduced in intensity. It would be determined starting at the boundary of the 100-year flood zone and measured laterally from that point. Over the arroyo's length, the buffer may vary, depending on

[3] Ephemeral flows carry water only during and immediately after a rain, and intermittent flows carry water for only part of the year.
[4] Las Cruces Municipal Code, Chapter 32 Design Standards

	the hydrology, natural vegetation, wildlife corridors, the slope of the sides of the arroyo, soil type, etc. Buffer distances could be determined using similar computer modeling software that is used to determine flood zone boundaries and buffer widths would be identified on a case by case basis.
Arroyo system:	A major arroyo, its buffers and tributaries that, integrated, form an unaltered, natural drainage area.
Best Management Practices (BMPs):	Management measures or practices used to protect air, soil, or water quality or reduce the potential for pollution associated with storm water runoff. BMPs may be a structural device or non-structural practice, including processes, land use alternatives, activities, or physical structures.
BMPs, structural:	Engineering solutions to stormwater management. Structural BMPs are used to treat stormwater at the point of generation, the point of discharge, or at any point along the stormwater "treatment train." Structural BMPs can serve many different functions based on their design. Common examples of structural BMPs usually found within urban areas include stormwater ponds and open channels (swales).
BMPs, non-structural:	Those BMPs in which there are no physical structures associated. Nonstructural BMPs are designed to limit the amount of pollutants available in the environment that would potentially end up in stormwater runoff, and typically lessen the need for the more costly structural BMPs. Natural elements include floodplains, wetlands, forests and riparian buffers. Nonstructural BMPs may also be achieved through such things as education, management, and development practices.
Buffer:	See “Arroyo buffer”
Channel:	Any arroyo, stream, swale, ditch, diversion, or watercourse that conveys storm runoff, and including structural facilities.
Channel stability:	A condition in which a channel neither degrades to the degree that structures, utilities or private property are endangered, nor aggrades to the degree that flow capacity is significantly diminished as a result of one or more storm runoff events or moves laterally to the degree that adjacent property is endangered.
Channel treatment measure:	A physical alteration of a channel for any purpose.
Climate change:	Any substantial change in measures of climate (such as temperature or precipitation) lasting for an extended

	period (decades or longer). Climate change may result from natural factors and processes or from human activities.
Design storm:	A storm that deposits a stated amount of precipitation within a stated period over a defined area and which is used in calculating storm runoff and in designing drainage control, flood control and erosion control measures.
Detention facility:	Basin whose outlet has been designed to detain stormwater runoff for some minimum time (e.g., 24 hours) to allow soil particles and associated pollutants to settle. Unlike retention ponds, these facilities do not have a large permanent pool of water.
Disturbed area:	Any area in which the soil will be altered by grading, leveling, scraping, cut and fill activities, excavation, brush and timber clearing, grubbing, and unpaved soils on which vehicle operations and/or movement will or has occurred.
Drainage:	Movement of waters through a watershed that is collected from higher elevation or surrounding lands, eventually reaching a lower elevation waterbody like a river or ocean.
Drainage course:	A natural watercourse for the drainage of surface waters.
Drainage plan:	A plan indicating an on-site drainage proposal for developed land, outlining the passage of stormwaters through the development and safe discharge of runoff onto adjacent lands or into storm drainage facilities. Also, a drainage plan provides a comprehensive analysis of (i) the existing storm drainage conditions of a proposed development, and (ii) the detention/retention of the increased runoff which is generated by the development.
Easement:	The right, liberty, advantage or privilege that one individual or entity has in land of another, either express or imputed (utility, grant, or necessity).
Encroachment:	Any man-made obstruction in the floodplain that displaces the natural passage of flood waters.
Erosion:	The transport of soil particles, or mass movement of soil. Caused by water, wind, or mechanical means.
Erosion control:	Treatment measures for the prevention of damages due to erosion and soil deposition from the ten-year design storm runoff.

Escarpment: A long, steep slope, such as a slope at the edge of a plateau or separating areas of land at different heights.

FEMA: Federal Emergency Management Agency. FEMA's primary purpose is to coordinate the response to a disaster that has occurred in the United States, such as flood events.

Finger: A small arroyo or gully that forms a fan-shaped extension at the head of a system of arroyos.

Flood control: Treatment measures necessary to protect life and property from the 100-year design storm runoff.

Flood hazard area: An area inundated by a flood event having a 1-percent chance of being equaled or exceeded in any given year. The 1-percent annual chance flood is also referred to as the base flood or 100-year flood. Flood hazard areas identified on the Flood Insurance Rate Map are identified as a Special Flood Hazard Area (SFHA).

Floodplain: A relatively flat or low land area adjoining a river, stream or watercourse that is subject to partial or complete inundation by floods.

Floodway: The channel of a river or watercourse and adjacent areas that must be reserved from development in order to discharge the 100-year flood without cumulatively increasing the water surface elevation more than one foot (cumulatively one foot for all changes).

Flood zone: Geographic areas that FEMA has defined according to varying levels of flood risk and type of flooding. These zones are depicted on the published Flood Insurance Rate Map (FIRM) or Flood Hazard Boundary Map (FHBM). For the purposes of this document, flood zone is used to describe an area subject to inundation from the 100-year design storm runoff.

Green infrastructure: Infrastructure associated with stormwater management that utilizes low impact development techniques to infiltrate, evapotranspire, capture, and reuse stormwater to maintain or restore pre-development hydrology.

Historic flows: Those flows naturally present in the drainage area prior to any disturbance by development within the upstream watershed.

Hydrology, pre-development: The combination of runoff, infiltration, and evapotranspiration rates and volumes that typically existed on a site before human-induced land disturbance occurred (e.g., construction of

infrastructure on undeveloped land such as meadows or forests).

Las Cruces Municipal Codes (LCMC): Las Cruces Municipal Codes found at: www.municode.com/library/nm/las_cruces

Low impact development (LID): A stormwater management approach that can be used to replicate or restore natural watershed functions and/or address targeted watershed goals and objectives.

Municipal Separate Storm Sewer System (MS4): A conveyance or system of conveyances (including roads and municipal streets with drainage systems) which is used for collecting and conveying storm water and that is owned or operated by a public entity that is a designated and approved management agency under Section 208 of the Clean Water Act. Operators of MS4s can include municipalities, local sewer districts, state and federal departments of transportation, public universities, public hospitals, military bases, and correctional facilities.

Native plants: Plants that are indigenous to the region or are from other places that have become established in wild lands without cultivation.

Natural cover: Vegetation, exposed rock, or barren ground that exists prior to commencement of earth-disturbing activities or vegetation achieved through restoration back to a natural state.

National Pollutant Discharge Elimination System (NPDES): The national permit program for administering and regulating Sections 307, 318, 402, and 405 of the Clean Water Act. The program controls water pollution by regulating point sources that discharge pollutants into waters of the United States. The NPDES General Permit specifies by what conditions construction activities may discharge stormwater.

One hundred-year flood (100-year): A storm whose precipitation within a given period of time and resulting runoff has a one-percent (or one time in a hundred) chance of being equaled or exceeded in any given year. It is also referred to as 100-year design storm.

Open space: The area of a lot, tract, or parcel not devoted to any building or structure, driveway, parking lot or stall, or street. The term generally refers to natural or undeveloped land.

Path: See “Trail”

Retention facility	Constructed basins that have a permanent pool of water throughout the year (or at least throughout the wet season). Ponds treat incoming stormwater runoff by allowing particles to settle and algae to take up nutrients. Also called wet ponds, and are used as a common stormwater management BMP.
Scenic corridor:	A single-loaded street that abuts open space lands such as arroyos, the Organ Mountains, the Rio Grande, or designated protected lands such as an area of critical environmental concern (ACEC) as defined by the U.S. Bureau of Land Management, and provides a scenic view.
Sediment:	Loose particles of sand, clay, silt, and other organic substances that settle at the bottom of a body of water. Sediment can come from the erosion of soil or from the decomposition of plants and animals.
Setback:	The minimum distance from the property line to where a structure may be built, as regulated by zoning statutes or restrictions in the deeds in various locales.
Site planning:	Analysis of a proposed development area to ensure that stormwater management and impact to environmental features are considered early in the development process.
Slope:	An inclined piece of land, three feet or higher vertical rise, with a five horizontal to one vertical incline or greater.
Soil cement:	A mixture of sandy soil excavated on site with Portland cement. The mixture is compacted in place like earth fill and over time hardens to the consistency of sandstone.
Trail:	A paved or unpaved right-of-way or grade-separated right-of-way for which primary purposes are to provide a place to walk, cycle or horseback ride, and to provide access to other areas, such as recreational facilities, neighborhoods, schools, commercial areas, etc.
Transect:	A geographical cross-section of a selected environment and a master planning tool that guides the placement and form of buildings and landscape, allocate uses and densities, and may detail civic spaces. The result is a natural gradient of development that moves from large, rural lots to more compact mixed-use main streets.
Viewshed:	The natural environment that is visible from one or more viewing points.
Wash:	Another term for arroyo or gully.

Watershed: A basin-like landform defined by upper elevation ridgelines that descend into lower elevations and stream valleys. A watershed acts as a drainage basin and carries precipitation (either from rainfall or snowmelt) to stream tributaries making its way to larger rivers and groundwater aquifers.

Wetland: An area that is inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support a prevalence of vegetation typically adapted for life in saturated soil conditions, including swamps, marshes, bogs, and similar areas.

CHAPTER 3. REGIONAL CHARACTERIZATION

Las Cruces is situated in the central portion of Doña Ana County in south central New Mexico. The Organ Mountains flank the eastern part of the city, and on the north, south, and west, agriculture and open space. The area is located within the northern reaches of the Chihuahuan Desert which extends north from approximately Zacatecas, Mexico to Socorro, New Mexico, about 220,000 square miles in total area. The Chihuahuan Desert is described as a high-elevation desert because a large portion lies above 4000 feet in elevation.[5] Further west, the Rio Grande flows through the Mesilla Valley. Agriculture is one of the historical foundations of the area's culture and is one of the major sources of groundwater recharge in the region.

The Organ Mountains are the scenic backdrop to Las Cruces and are Doña Ana County's most recognizable feature. The Organ Needle is the high point in the county, at about 8,990 feet in elevation.[6] Just three miles to the west the elevation drops to about 4,000 feet, making the Organ Mountains one of the steepest mountain ranges in the western United States.

It is not uncommon to see snow in the Organs as late as May while the rest of the area enjoys milder weather. Photo: http://lascrucesblog.com/.

Dripping Springs Natural Area has over four miles of easy hiking trails that display desert scrub and low elevation pinon-juniper and oak woodlands. The area also provides wildlife viewing opportunities. Photo: www.elpasotimes.com/ living/ci_21498935.

[5] Chihuahuan Desert Nature Center, http://cdri.org

[6] Organ Mountains Desert Peaks National Monument, http://www.organmountains.org

Climate

The climate around Las Cruces is considered mild and arid or semi-arid, which is characterized by fairly hot summers and mild winters with warm spring and fall seasons. The average minimum and maximum daily temperatures in January are 21°F and 57°F, respectively, increasing to 62°F and 96°F in July. Average annual precipitation in Las Cruces is 9.23 inches and over 11 inches in the Organ Mountains. August is the wettest month with an average of 2.12 inches of precipitation and April is the driest month with an average of 0.21 inches of precipitation. The average annual snowfall in the area is 3.7 inches, typically in December, January, and February.[7]

Unlike the Sonoran and Mojave Deserts, the Chihuahuan Desert does not have a winter rainy season. Instead, over 90% of the annual rainfall occurs between the months of July and October, the period of "monsoonal" activity. Locally, "monsoons" are thought of as heavy and continuous storms, but the term refers to a system of alternating winds that shift direction because of differential heating between land and water.[8] The North American Monsoon (NAM) is characterized by shifts in summer wind patterns that occur as Mexico and the southwestern U.S. become hotter. When this happens, the prevailing winds start to flow from moist ocean areas into dry land areas, bringing moist air into Mexico in May then north to Arizona and New Mexico as summer begins.[9] These wind patterns can be erratic which then results in erratic storm activity.

El Niño and La Niña events further influence storms in the Southwest. El Niño occurs when warm water builds up along the equator in the eastern Pacific Ocean. The warm ocean surface warms the atmosphere, allowing moisture-rich air to rise and develop into rainstorms.[10] La Niña occurs when cooler than normal sea surface temperatures form along the equator, slowing cloud growth overhead. The result is usually drier than normal weather in the Southwest.[11]

Within Doña Ana County, storms are usually brief yet deliver an abundance of rain. This results in a high amount of runoff that naturally collects n arroyos and is transported or drained to the Rio Grande. The arroyos are made up of multiple intertwining channels that result from the unpredictable nature of stormwater runoff. Waters flow downhill through the watershed, collecting into larger and fewer channels until they converge in what is referred to as a "major arroyo".

Watersheds

Healthy watersheds provide three major functions. First, they transport and store water, sediment, pollutants, and organisms. Second, watersheds cycle and transform elements such as carbon, nitrogen, and phosphorus. And finally, they provide ecological succession through changes in vegetation due to movement of a watershed's energy, water, and materials. Through these functions, a watershed can provide habitats for aquatic and terrestrial organisms, and convey runoff and sediment loads out of each stream's watershed. The complex system of streams within a watershed is commonly referred to as the drainage net. Within drainage nets, small streams join or come together to form successively larger ones. This relationship, although variable in detail, holds true for watersheds of any size or extent.

[7] National Weather Service: www.weather.gov
[8] Arizona Cooperative Extension: http://cals.arizona.edu/pubs/natresources/az1417.pdf
[9] University of Arizona Climate Assessment for the Southwest: www.climas.arizona.edu/sw-climate
[10] NASA Earth Observatory: http://earthobservatory.nasa.gov/Features/WorldOfChange/enso.php
[11] www.climas.arizona.edu/sw-climate

A watershed acts as a drainage basin and carries precipitation (either from rainfall or snowmelt), which is then channeled to stream tributaries making its way to larger rivers and groundwater aquifers. Watersheds also transport sediment, pollutants (both natural and anthropogenic), and aquatic organisms. The structure of a watershed can change over time due to shifts in soils and alluvial fans depending on hydrologic forces, land cover, and surface characteristics. In the Las Cruces area, the receiving surface water body is the Rio Grande; groundwater aquifers also receive water through seepage and infiltration. [12]

The Southwest has experienced severe drought since 2002, and questions regarding how much water is available in the region and how it will be used influence development, economic growth and every other aspect of community life. In Doña Ana County, water is strictly controlled for agricultural, domestic and industrial use, and many agencies are involved in its management. They are primarily the United States Section of the International Boundary and Water Commission (USIBWC), U.S. Bureau of Reclamation (BOR), the New Mexico Office of the State Engineer (OSE), and Elephant Butte Irrigation District (EBID). Other entities involved in water management include the New Mexico Interstate Stream Commission, the Lower Rio Grande Water Users Organization (LRGWUO), the Paso del Norte Watershed Council (PdNWC), and the South-Central New Mexico Stormwater Management Coalition.[13]

Characteristics such as land use, geology, soil type, amounts of deposited sediment and debris, and hydrologic interactions, all play a role in how a watershed drains to major rivers and aquifers. Channels can be altered considerably over time depending on hydrologic conditions. The relationship between alluvial fans and the greater watershed is significant, because extreme stormwater events can alter channel formation.

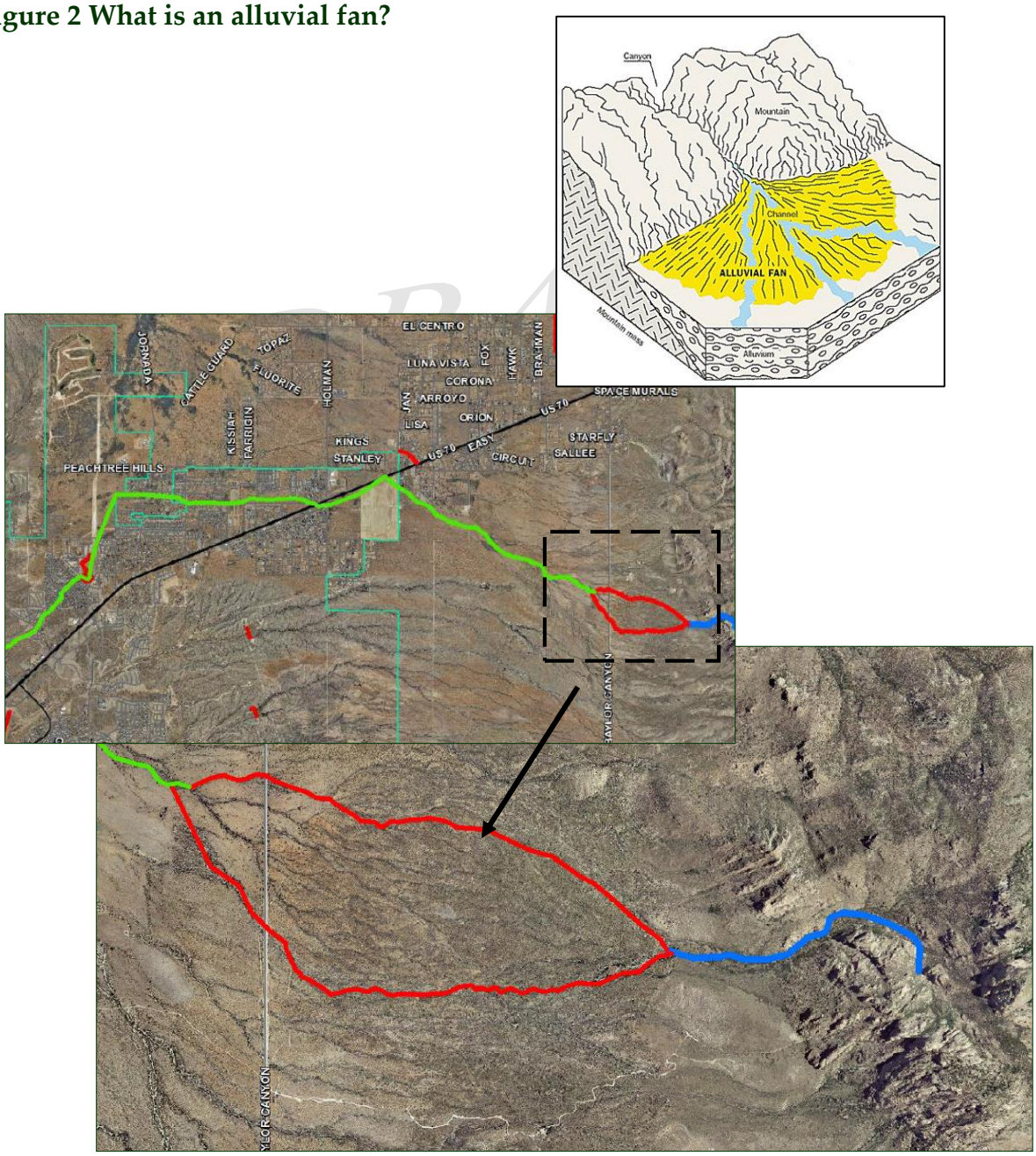
Alluvial fans are gently sloping, fan-shaped landforms common at the base of mountain ranges in arid and semiarid regions. Alluvial fans develop where streams or debris flows emerge from steep reaches to relatively straight, narrow channels then to zones that are wider and flatter. These conditions develop where there are major breaks in gradient or channel confinement, allowing both deposition of sediment and the lateral movement of channels to spread the sediment into fan-shaped landforms. An undisturbed upstream alluvial fan is important to the health of the entire arroyo system. Proper infiltration and drainage within the alluvial fan can lead to more natural and consistent downstream tributary flows.

Alluvial fans are made of sediments that are deposited where a stream or river leaves a defined channel and enters a broader and flatter floodplain. As the flow path spreads out, conveyance is reduced and active erosion, sedimentation, deposition and unpredictable flow paths can inundate the low-lying areas. Alluvial fans can convey high flood risk and be even more dangerous than the upstream canyons that feed them. Their slightly convex perpendicular surfaces cause water to spread widely until there is no zone of refuge. [14] If the gradient is steep, active transport of materials down the fan creates a moving substrate that is inhospitable to travel on foot or wheels. But as the gradient diminishes downslope, water comes down from above faster than it can flow away downstream, and may pond to hazardous depths. When the stream repeatedly deposits sediment into its floodway and channel bed, the conveyance capacity of the channel is quickly exceeded resulting in overbank flooding, erosion and the

[12] Paso del Norte Watershed Council, www.pdnwc.org
[13] *One Valley One Vision 2040* Regional Plan
[14] Alluvial Fan Flooding. National Research Council Committee on Alluvial Fan Flooding, Washington DC. 1996.

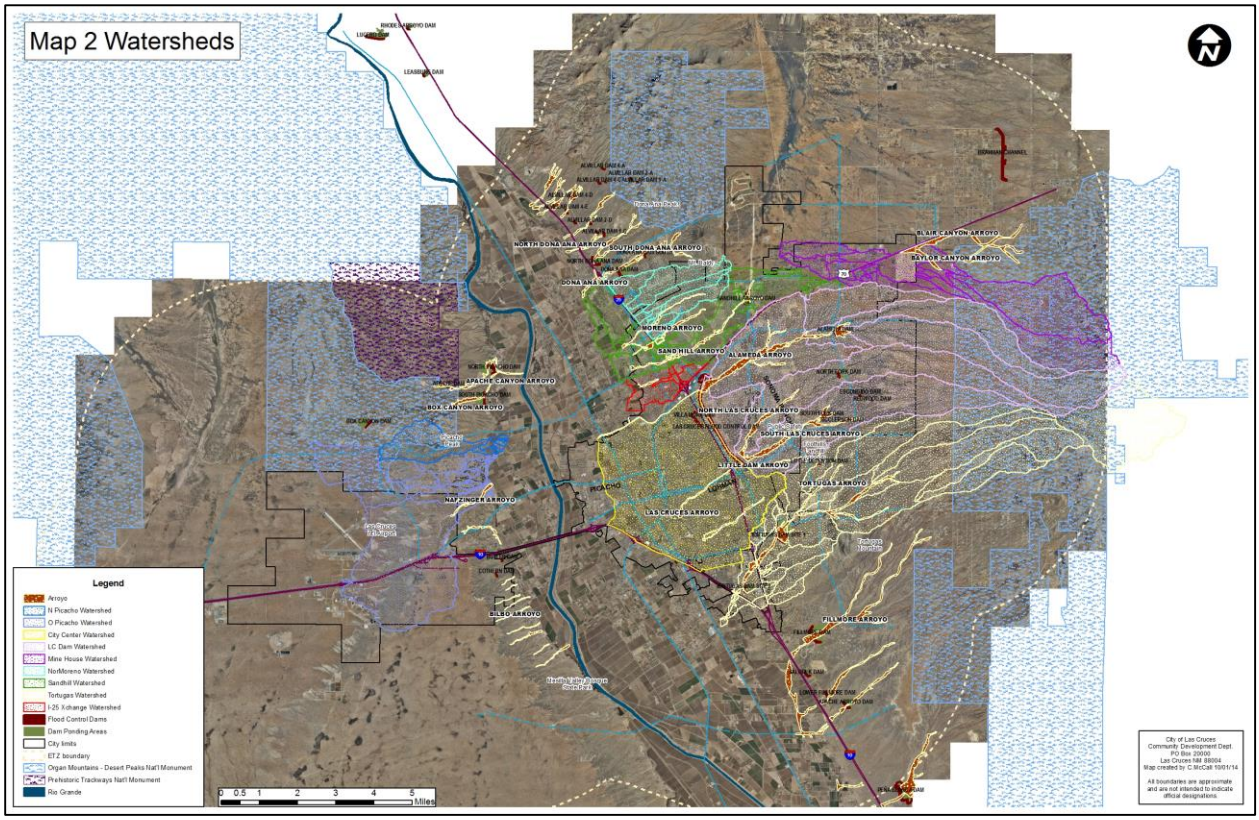
formation of a new channel. Alluvial fans are also dangerous because the stream channel will slowly erode the soft sediments and meander outside of the mapped 100-year flood zone.

Figure 2 What is an alluvial fan?



These images show the general path of the Sandhill Arroyo in 2010. The well-defined portion of the flow path within the Organ Mountains is delineated in blue. As the arroyo drops out of the mountains into the relatively flatter alluvial plain below many fingers begin to form as the flow fans out. This area is roughly indicated in red. As flows continue to the valley floor, these smaller fingers generally come back together again into a well-defined channel. The well-defined downstream portion is indicated in green. Graphic by Mary Evans

Map 2 Watersheds in the Planning Area



East Mesa

On the East Mesa, there are several major arroyos that cross Las Cruces from east to west. All of the major arroyos are well defined from the Organs but as the arroyos cross into flatter alluvial fans and urban and agricultural areas, they become more poorly defined.[15] Many of the larger arroyo systems on the East Mesa were dammed because they were the source of damaging flooding and sediment deposition on the valley floor where agriculture and older development were located. The Alameda and Las Cruces (north and south forks) Arroyos caused flooding in the city center prompting the construction of the Las Cruces Dam in the early 1970s. The City of Las Cruces manages these and the Sandhill Arroyo, which play an integral part in flood control and public safety in the community.

Under natural conditions, arroyo channels meander within their floodplains, shifting locations in response to unpredictable storms and their runoff. Severe summer storms sometimes produce high flows that erode the channels, dramatically changing the slope and paths of the arroyos. Development impacts to the natural drainage system have increased the likelihood of flooding within an arroyo because the rain falls on impervious surfaces such as rooftops, driveways, parking lots, sidewalks and streets. This runoff is more rapid and concentrated, adding more water in a shorter time to the arroyo than would be the case under historic flows. This rapid surge increases the quantity of water in the arroyo making it capable of forcing changes to its channel and to the surrounding land. When the

[15] City of Las Cruces Storm Drain Master Plan, 2006. Bohannan Huston, Inc.

existing channels cannot accommodate the flow by cutting wider and deeper, the stream overflows its banks, flooding the surrounding area and sometimes changing its boundaries.

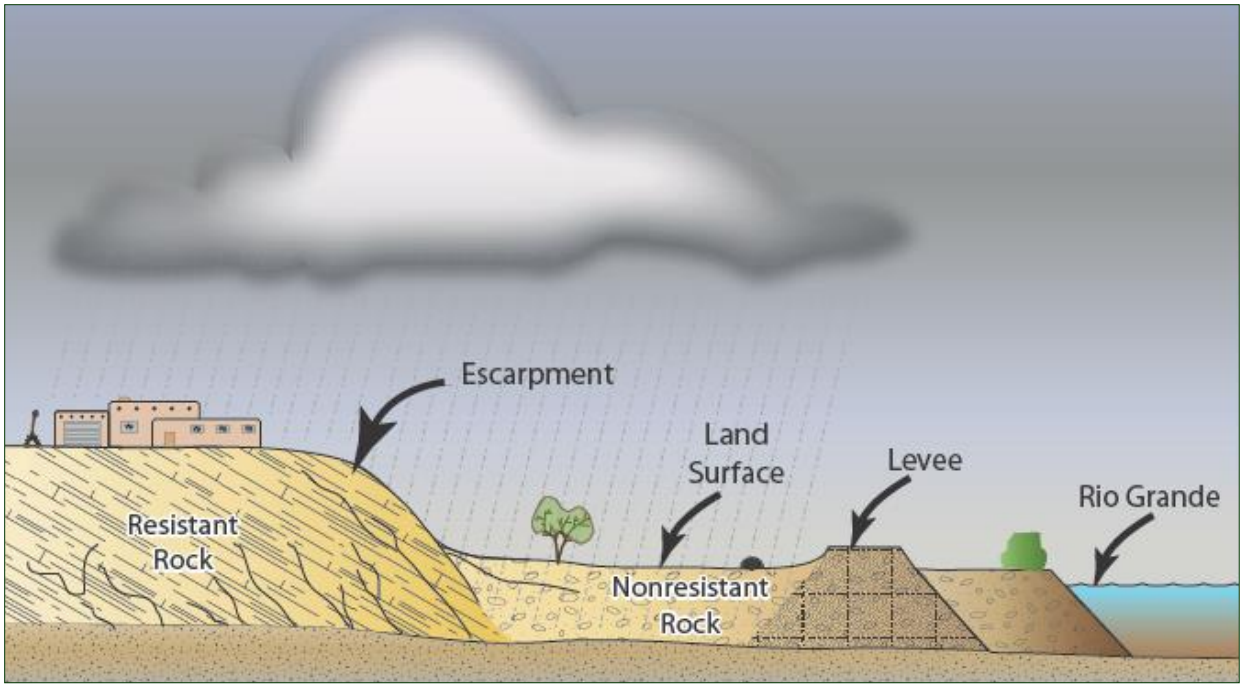
Other intrusions by development within the floodplain of an arroyo also impact the balanced relationships between the flow of flood waters and their erosion of the channel soils. Historically such changes to the channel increase the velocity of the drainage water, increasing erosion, which transports sediment and causes downstream deposition that alters the natural channel. These impacts start a series of adjustments in which a new equilibrium within the channel is sought. Such adjustments, once started, may require tens or hundreds of years to reach a new equilibrium. Conversely, to slow the drainage water down in an arroyo channel to a velocity below its historic equilibrium velocity could lead to an early deposition of sediment that would start the formation of a sandbar, further restricting or deflecting the flow of the captured water. The least impact to the arroyo drainage is to maintain the naturally established system that forms the arroyo flood zone and its channel.

West Mesa

On the West Mesa, Picacho Hills and Picacho Mountain developments have added several hundred residences in recent years, but with the exception of these neighborhoods, there is very little development to date that impacts arroyo function. The West Mesa continues along the valley much further south than the East Mesa with few flood protection structures and affords much greater opportunity for natural flood protection without dams if development is planned properly.

On the West Mesa, rather than gradually sloping from the mountains, the Apache Canyon, Box Canyon, Nafzinger, and Bilbo Arroyos drop down an escarpment then flow to the Rio Grande. An escarpment is an area where elevation changes suddenly; it usually refers to the bottom of a cliff or a steep slope (see Figure 3). On the West Mesa, elevation can drop 200-500 feet in as little as a mile, depending on location. Escarpments and hillsides present unique challenges to arroyo protection as well as to development, including extreme slopes, lack of soil stability, infrastructure and roadway development impediments, and wildlife habitat protection. These unprotected arroyos are very dynamic in nature and it will prove difficult to avoid engineer solutions unless development is planned to avoid the need to control the numerous arroyos. While this area is largely outside of the city, it is important to maintain a watershed-based perspective. In these instances, increased focus needs to be provided to protect views, surface integrity, and other issues related to constructing along hillsides and escarpments.

Figure 3 Escarpment diagram[16]



Issues on the West Mesa escarpment include roadway development impediments and unstable soils due to steep slopes and erosion.

[16] Graphic by Peter Bennett, after: Guidebook to the Geology of Travis County, University of Texas-Austin, 1977.

Geology and Soils

The geology of the Las Cruces area is extraordinary and diverse. Las Cruces is located in the Mexican Highland Section of the Basin and Range Physiographic Province.[17] Landforms consist of alluvial and terrace deposits that occur along the Rio Grande Valley west of the Organ Mountains. Geologic formations in Las Cruces are Quaternary piedmont and the Upper Santa Fe Group.[18] The underlying geology of an area determines the soil types found toward the surface.

Doña Ana County is characterized by 70 different soil types.[19] For the most part, the soils of the arroyos and surrounding areas are gravelly sand with some cobblestones, boulders and un-weathered bedrock. The sandy soils extending east from the Las Cruces Dam to the Organ Mountains generally become more gravely closer to the mountains. The terrain on the East Mesa is nearly level, then slopes gradually upward, becoming very steep on the approach to the Organ Mountains.

Closer to Las Cruces the gradation of the soils gradually increase in their small particle contents in both silt and clay size. Within the intervening areas various alluvial deposits can be found which typically exist as thin beds of horizontally stratified sands or other soils probably deposited during historic storm or tectonic events. Further west into the middle of Las Cruces, the soils also start showing past sorting by the Rio Grande historic flood events. In these locations, and extending to the Rio Grande, an increased content of clay-like soils are found. There is also a decreased aggregate content.

Soils located in arid and semi-arid regions are subject to more extreme cycles of expansion and contraction than those located in more consistently moist areas, and great differences in soil properties can occur even within short distances. Soils may be seasonally wet or subject to flooding; they may be shallow to bedrock; or they may be too unstable to be used as a foundation for buildings or roads. Very claylike soils have a high water-holding capacity and do not promote infiltration or movement to groundwater. Conversely, very sandy soils provide a porous environment which provides better infiltration but are more susceptible to erosion.

Whether soils expand or collapse under varying conditions also impacts infrastructure. Collapsible soils consist of loose, dry, low-density materials that collapse and compact under the addition of water or excessive loading. These soils are distributed throughout the southwestern United States, specifically in areas of young alluvial fans, debris flow sediments, and wind-blown sand/silt sediment deposits. Collapsible soils are most often encountered in arid climates, where wind and intermittent streams deposit loose sediment. Expansive soil and rock are characterized by clayey material that shrinks and swells as it dries or becomes wet, respectively. Problems often associated with expansive soils include foundation cracks, ruptured pipelines and heaving or cracking of sidewalks and roads. Similar to expansive soils, collapsible soils result in structural damage such as cracking of the foundation, floors, and walls in response to settlement. But human activities can sometimes facilitate soil collapse, notably water impoundment, irrigation or changing the natural drainage of a site. [20]

[17] Williams, J. L. 1986. *New Mexico in Maps, Second Edition.* Albuquerque, NM: University of New Mexico Press.
[18] New Mexico Bureau of Geology and Mineral Resources. 2003. *Geologic Map of New Mexico.* Socorro, NM: New Mexico Institute of Technology and USGS.
[19] Ibid
[20] Association of Environmental and Engineering Geologists, http://www.aegweb.org/

The level of the water table is also a factor for infrastructure placement and design. A high water table is not suitable for subsurface installations and erosion must be accounted and managed for. Soil type analysis is an important step in the design and placement of any infrastructure in our desert environment.

Soil formation is largely controlled by five major factors:

1. The physical and mineralogical nature of the parent material (underlying bedrock),
2. Plant and animal life,
3. Topography,
4. Present and past climatic conditions, and
5. Time.

Dynamic factors like climate and organisms alter soil's parent material over time, resulting in more or less distinct soil layers. No single factor dominates the soil-forming process except in extreme cases. Rather, the effect of any one factor is either enhanced or hindered by the others. For example, topography can modify the effect of rainfall by influencing drainage and surface runoff. Likewise, rainfall and temperature together can stimulate the effect of vegetation in soil formation. These and other interactions give rise to the different soil characteristics found within any given landscape.[21] Soil type is a primary factor in determining drainage and surface runoff, and often a main factor for a site's topography.

Vegetation

Although much of this area was at one time covered in Chihuahuan Desert grasses such as sideoats grama, black grama, fluffgrass, vine mesquite, tobosa, burro grass, alkali mallow and cane bluestem, desertification has caused a transition to scrubland.[22] The East Mesa holds relatively sparse vegetation in the overland areas and larger, denser vegetation along the beds of the arroyos. An arroyo is technically an ephemeral stream, but the vegetation is basically upland desert vegetation. Shrubs, stem succulents, cacti, and grasses; creosote bush and tarbush are dominant.[23] On much of the East Mesa, desert willow, little-leaf sumac, Apache plume, and cut-leaf bricklebush are good indicator species for significant arroyo corridors since these plants require the additional water carried by arroyos. In the upper reaches of the major arroyos on the East Mesa dense stands of the small tree known as Western Soapberry can also be found. Many of these plants, especially the Apache plume, bricklebush, and soapberry reproduce readily through root-sprouting, creating dense stands with tightly packed stems and underlying root systems that are very good at stabilizing soils. The dense growth forms and low overhanging branches of desert willows and little-leaf sumac also result in thick vegetation at ground level, allowing these plants to reduce the erosive force of floods by slowing the flow of stormwater and capturing sediment and other debris carried by floods.[24]

Other typical plant species found in this area include snakeweed, whitethorn acacia, Mormon tea, Sand sagebrush, Soaptree Yucca, Giant and Mesa Dropseed, Fourwing Saltbush, lechuguilla, sotol, and various types of yuccas. Other common shrubs include mimosa, acacia, mariola, tarbush, javelina bush, skeleton

[21] Soil Survey of Doña Ana County Area, New Mexico, 2007. www.nrcs.usda.gov
[22] USACE East Mesa Watershed Study
[23] Asombro Institute for Science Education: http://asombro.org
[24] Nancy Stotz memo, April 29, 2014

leaf goldeneye, allthorn, and ocotillo.[25] Perhaps one-fifth of all the world's cacti – as many as 350 of the 1,500 known species – occur in the Chihuahuan Desert.[26] Common cacti include the prickly pear, hedgehog, living rock, nipple cacti, and cory cacti. The night blooming cereus, a cactus, has been observed and is state endangered. Other species of concern and State-endangered species include various pincushion cacti.[27]

Vegetation has a direct impact on the health of arroyos. In addition to root systems that hold water and prevent erosion, the plants themselves provide habitat and protection for wildlife. It takes many years for vegetative species to establish and stabilize in the Chihuahuan Desert, furthering the need for protecting the arroyo systems from disturbance.

Wildlife

There are approximately 80 species of mammals, 185 species of birds and 60 species of reptiles and amphibians that inhabit this area.[28] But according to the Army Corps of Engineers East Mesa Watershed Study (2007), mammalian wildlife is somewhat limited in the more urbanized areas and animal diversity may be further limited by the lack of permanent or perennial sources of surface water.[29]

No federally listed wildlife species are believed to occur in the Las Cruces desert arroyo areas. In 2007, one state-threatened species, the peregrine falcon, and one USFWS species of concern, the burrowing owl, were observed on the East Mesa.[30] However, according to the U.S. Fish and Wildlife Service and the New Mexico Department of Game and Fish websites, these birds are no longer listed as vulnerable species.[31]

This region is home to several plant and animal species found nowhere else on earth.[32] Military lands to the east and north prohibit public access, which helps protect many sensitive native species. In addition, military land north of Highway 70 protects a critical wildlife corridor between the Organ Mountains and the San Andres National Wildlife Refuge, home to the New Mexico's largest herd of Desert Bighorn Sheep, which are listed as endangered by the state of New Mexico.[33]

Flood Control Dams

There are 37 earthen flood control dams within the Extra-Territorial Zone (ETZ) all varying in size, condition, age and original purpose (see Map 3 and Table 1 below); nine of them are believed to have been constructed by the Civilian Conservation Corps during the years 1936 to 1939. Twelve of these are within the Las Cruces city limits. Most of the dams on the East Mesa were constructed on alluvial fan deposits that originated from the Organ Mountains to the east. There are also several flood control

[25] University of Texas at El Paso Centennial Museum: http://museum2.utep.edu/chih/chihdes.htm
[26] World Wildlife Fund: http://worldwildlife.org/ecoregions/na1303
[27] U.S. Fish & Wildlife Service: www.fws.gov/endangered
[28] U.S. Army Corps of Engineers East Mesa Watershed Study, 2007
[29] Ibid
[30] Ibid
[31] NM Department of Game & Fish: www.wildlife.state.nm.us/conservation; and www.fws.gov/endangered.
[32] Citizens' Task Force for Open Space Preservation (CTFOSP) *A Vision: Open Space and Trail System*
[33] Ibid

dams on the West Mesa. These structures were built to protect agricultural lands within the Mesilla Valley and were intended as low hazard structures providing protection from a 50-year storm event.[34]

As areas downstream of these structures became urbanized, the hazards and required protection of the structures changed without upgrades or rehabilitation of the structures themselves. Currently a significant number of the dams are approaching or have met the end of their design life, but still protect downstream developments to a small degree. The Las Cruces Dam, which is a flood control pass-through dam, was constructed by the U.S. Army Corps of Engineers (Corps) in 1975 to protect development in Las Cruces by controlling flood flows from the Alameda and Las Cruces Arroyos.

Most dams in Doña Ana County are dry dams and have ungated outlets positioned so that essentially all stored water will drain from the reservoir by gravity, resulting in a normally dry reservoir area. The intent of a dry dam is to capture and slowly release storm water in order to lessen the velocity, flow rate, and sediment load that result from major storms. These dams are currently required by state law to drain their impounded water within 96 hours from the end of the storm. They also allow groundwater recharge by ponding runoff and allowing it to slowly infiltrate into the aquifer. In addition, through cooperative planning, these dams can fulfill other purposes such as habitat restoration, open space preservation, and public recreation.

Flood of August 29-30, 1935.
Boat of International Boundary Commission on Alameda Boulevard. This boat carried several people and personal property to safety.

Flood of August 29-30, 1935.
Professor D.B. Jett standing near Alameda Boulevard and Greening Avenue. Both photos: NMSU Library, Archives and Special Collections, 00941776/00941777. Used with permission.

[34] A 50-year storm is an event having a 2 percent chance (or one in fifty) of being equaled or exceeded during any given year.

The New Mexico Office of the State Engineer Dam Safety Bureau requires dam owners to prepare Emergency Action Plans (EAP) for some of these dams (non-Significant Hazard Dams do not require an EAP.) An EAP is critical for protecting the dam and downstream development. It should be noted that the Hazard class will change if development is allowed below the dam. The EAP assists a dam owner in recognizing emergency and non-emergency events and to respond appropriately. It also provides local emergency officials with an inundation map to assist in developing an evacuation map.[35] The dams are owned and operated by a number of entities, including the City of Las Cruces, Dona Ana County, Elephant Butte Irrigation District, New Mexico State University and some private owners.

Table 1 Flood Control Dams

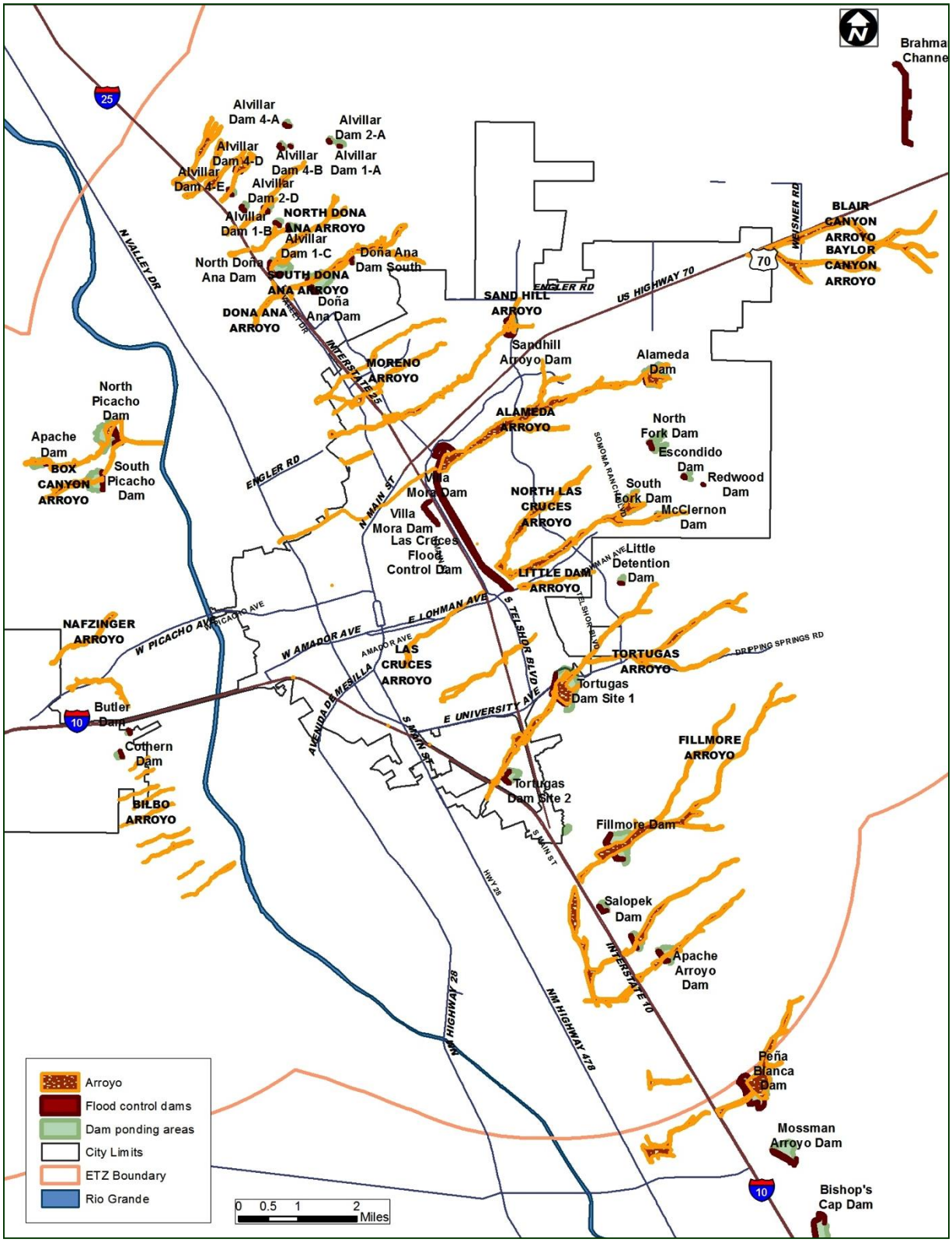
Dams within Las Cruces	Dams within the ETZ but outside the Las Cruces city limits	
Tortugas Site 1 Dam	South Picacho Dam	Alvillar 1-A Dam
Alameda Dam	North Picacho Dam	Alvillar 1-B Dam
North Fork Dam	Apache Dam	Alvillar 1-C Dam
Escondido Dam	Box Canyon Dam	Alvillar 2-A Dam
Redwood Dam	Brahman Channel	Alvillar 2-D Dam
South Fork Dam	North Doña Ana Dam	Alvillar 3-A Dam
McClernon Dam	Doña Ana Dam	Alvillar 4-A Dam
Butler Dam	Doña Ana South Dam	Alvillar 4-B Dam
Cothern Dam	Tortugas Site 2 Dam	Alvillar 4-C Dam
Fairbanks Dam	Fillmore Dam	Alvillar 4-D Dam
Sandhill Arroyo Dam*	Salopek Dam	Alvillar 4-E Dam
Las Cruces Dam*	Lower Fillmore Dam	
Villa Mora Dam*	Apache Arroyo Dam	
	Little Detention Dam	
*City of Las Cruces has management authority for these three dams		

For more detailed descriptions of these flood control dams, including owners and Hazard class, see Appendix 3.

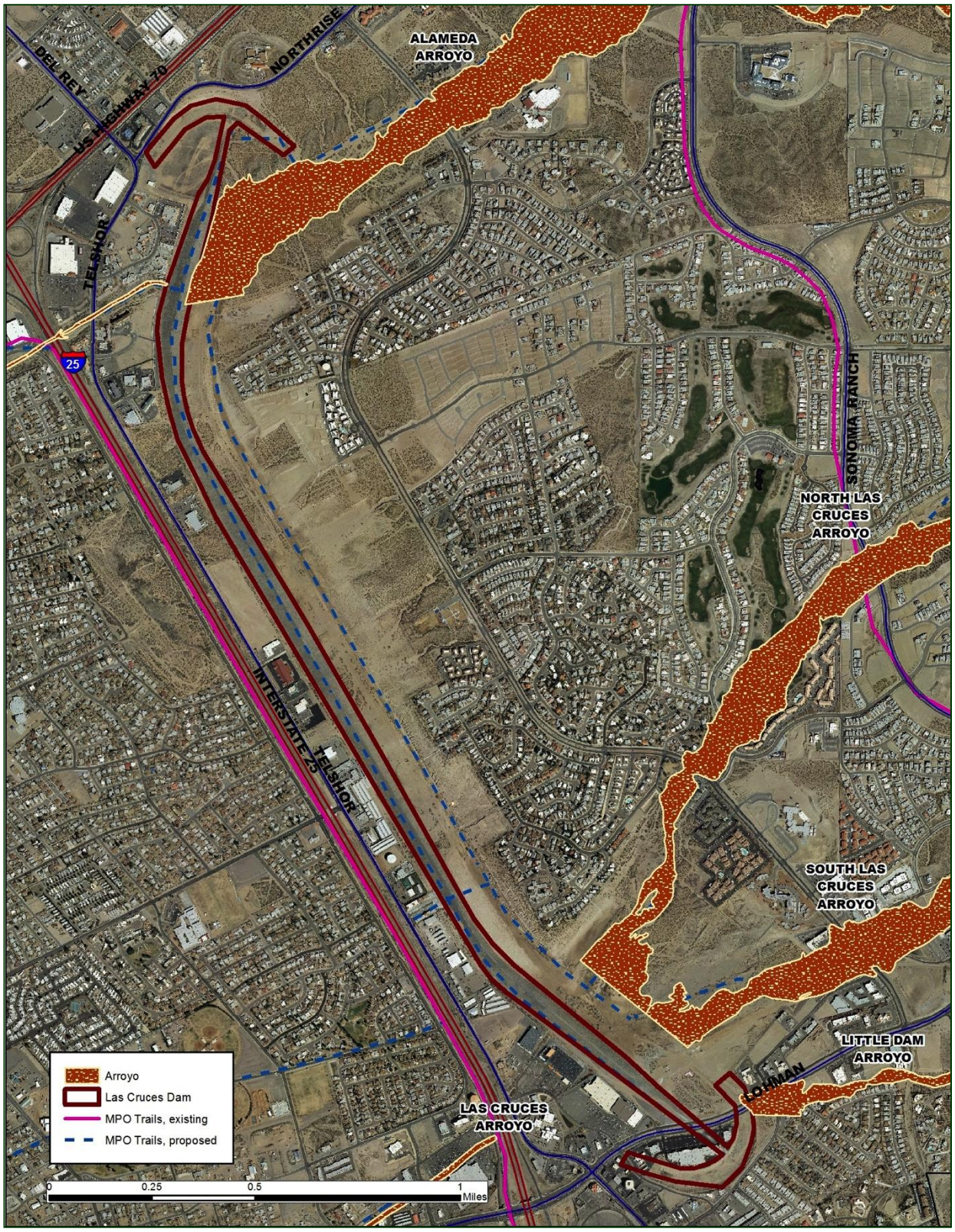
Looking upstream across the flood pool upstream from McClernon Dam. Pooling presents an opportunity for vegetative growth and habitat restoration. Photo: USACE Sediment Transport Analysis Report.

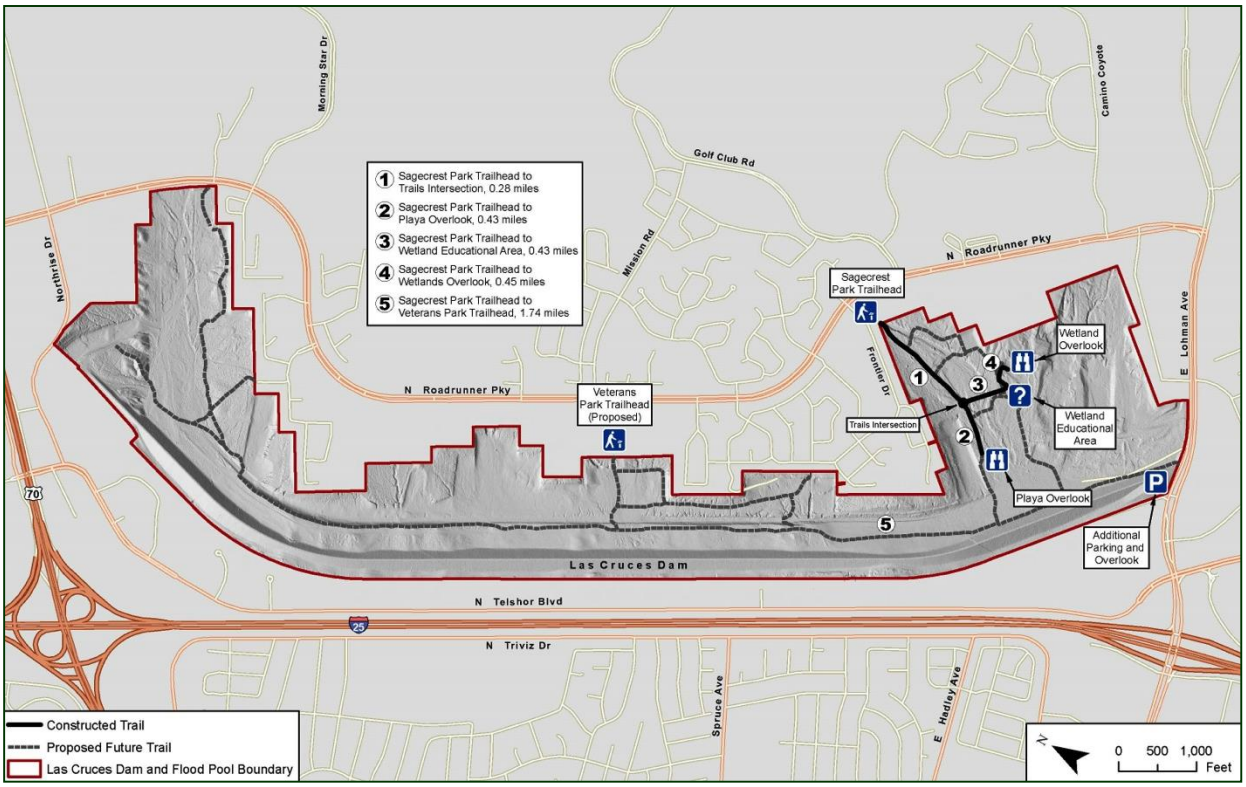
[35] New Mexico Office of the State Engineer http://www.ose.state.nm.us/water_info_dam_safety_info.html

Map 3 Flood Control Dam Locations



Map 4 Las Cruces Flood Control Dam





A partnership between the City of Las Cruces and the U.S. Army Corps of Engineers is sponsoring an environmental restoration project behind Las Cruces Dam. The project includes the creation of trails, viewing blinds, benches, shade structures, pond, a wetland meadow and a variety of riparian vegetation such as Cottonwood trees, grasses and shrubs.

Stormwater Management and Drainage

Floodwater that does not absorb into the ground flows into an arroyo carrying sediment with it until it eventually dissipates into the bed of the arroyo or continues on to the Río Grande. Because of the high sediment load in the floodwater and the amount of erosion and deposition, arroyos often change flow paths creating flooding concerns where none existed previously. Manmade changes to an arroyo system, such as road construction, may also result in unpredictable changes to the arroyo's path.

Stormwater management in Las Cruces is accomplished through a storm drain network, which consists of storm drain pipes, inlets/outlets, detention ponds as well as roadways and natural arroyos. There are 17 major detention ponds within the city limits. The stormwater collected through the natural arroyos and in the detention ponds is transported and discharged to the Rio Grande at several locations. In addition to the larger scale detention ponds, individual commercial lots also require their own on-lot ponding to handle storm water runoff. The runoff collected in these smaller on-lot ponds either evaporates, percolates down into the groundwater or adds to the controlled downstream runoff of the area.[36]

The City prepared a Storm Water Management Plan in April 2009 that serves to develop, implement and enforce its stormwater management program. In addition, the City also has a Storm Water Management

[36] City of Las Cruces Storm Drain Master Plan, 2006, Bohannan Huston Inc.

Ordinance in effect (Chapter 34 of the LCMC), which defines means of reducing pollutants from entering the City's municipal storm sewer system. Together with LCMC Chapter 32 Design Standards, the City ensures that its own projects and those of private developers comply with the EPA's NPDES permit program.[37]

As authorized by the Clean Water Act, the NPDES permit program controls water pollution by regulating point and non-point sources that discharge pollutants into waters of the United States. Most stormwater discharges are regulated under this permit. The program regulates stormwater discharges from three potential sources: municipal separate storm sewer systems (MS4s), construction activities, and industrial activities. This permitting mechanism is designed to prevent stormwater runoff from washing harmful pollutants into local surface waters such as arroyos and the Rio Grande.

Looking downstream in typical portion of the incised reach of the Alameda Arroyo about 0.4 miles downstream from Alameda Dam where the left bank is being cut into an alluvial terrace.
Photo: USACE Sediment Transport Analysis Report.

[37] Ibid

Utilities

The majority of City utilities are located in public right-of-way for the purposes of serving customers. Since arroyos are situated in low-lying areas, they naturally become main drainage ways and create ideal spots for locating gravity-driven sewer interceptors (collection lines of ten inches or more in diameter). It is necessary in some instances to place utility lines adjacent to or along the floors of the arroyos, or across arroyos in a perpendicular manner.

According to the City's Utility Standards, City utilities have been buried at minimums of six feet for sewer and five feet deep for water and gas under the arroyo bottom. To avoid erosion after installation, the soil is compacted to 90% of original compaction,[38] which is slightly less than soil compaction required for street construction. With proper design and protection of gravity-driven sewer collection systems within and around arroyos, the need for lift stations is eliminated, therefore reducing operations and maintenance costs.

Parks and Open Space

The City's current park inventory includes numerous parks and trails on the East Mesa that include arroyos in their design. There are three trails that are part of an arroyo trail network shown on the MPO Trail Plan: the Alameda Arroyo Trail (0.78 mi.), the Engler Road Trail (1 mi.), and the Sonoma Ranch Trail (3.64 mi.). In addition, there are several neighborhood and community parks in close proximity to arroyos: Desert Trails Park (34.42 ac.), Sam Graft Park (2.8 ac.), Veterans Memorial Park (8.99 ac.), Sagecrest Park (2.2 ac.), Paseo de Onate (2.5 ac.), Oro Vista Park (18.85 ac.), and Vista de la Montana Park (2.11 ac.). There are also two privately-owned golf courses that include arroyos in their designs: the Red Hawk Golf Course in the Metro Verde development and the Sonoma Ranch Golf Course west of Roadrunner Parkway.

These facilities provide outdoor recreation opportunities. The Parks & Recreation Master Plan (PRMP), updated in 2013, envisions a City park and trail system that will continue to provide high-quality recreational opportunities for residents and visitors during the next decade and beyond. And according to the PRMP, Las Cruces residents would like more of these. During May and June of 2011, the City of Las Cruces Parks and Recreation Department conducted a Community Interest and Opinion Survey. The purpose of the survey was to gather input to help determine parks, trails, open space and recreation priorities for the community.

According to the survey, 42% of respondents said they had used or visited walking, hiking, and biking trails over the past 12 months, 65% said they have a need for walking and biking trails, and 43% said their most important parks and recreation facilities are walking and biking trails. In addition, 64% of respondents indicated that they would be willing to pay at least $10-$19 per year in additional property taxes to build and operate the types of parks, trails, aquatics, sports and recreation facilities most important to their household. Fifty-nine percent (59%) of respondents indicated that they would either "vote in favor" (37%) or "might vote in favor" (22%) if an election were held for a bond issue to be used only for open space and parkland acquisition, construction of amenities and trails development in Las Cruces.[39]

[38] http://www.las-cruces.org/Departments/Utilities

[39] Parks & Recreation Master Plan & Park Impact Fee Update, May 2012.

Desert Trails Community Park

Alameda Arroyo Trail

Paseo de Oñate Park

CHAPTER 4. ISSUES, CHALLENGES AND OPPORTUNITIES

There have been many area flood events in recent memory, and in the last decade, severe flooding in 2006 and 2013 are notable. Over 400 homes were affected by flooding in Hatch in September 2006.[40] Four foot-deep waters flooded downtown Hatch damaging homes, businesses and motor vehicles and almost all of Hatch's 1600 residents were forced to evacuate. In addition, the same storm delivered golf ball-sized hail and heavy rains along Interstate 10 and over Las Cruces and Mesilla. Total storm damage was estimated at over $10 million.[41] In September 2013, New Mexico experienced an estimated $6.87 million worth of road and highway repairs alone from heavy rains and floods that hit the state.[42] Two major storms within days of each other delivered more than 8 inches of rain in Doña Ana County, nearly as much as the region usually receives in a year. There are cumulative impacts of multiple storm events that can increase the chance of flooding, risk, and damages

In his 1969 text, *Design with Nature*, Ian McHarg proposed that development plans be based on maps that identified natural resource and landscape constraints. He promoted an ecological view in which the developer analyzed soil, climate, hydrology, etc. and designed the project in concert with the conditions of setting, climate and environment. Harg advocated that the first stage in the planning process is mapping the resources then building where there were the fewest constraining features (either by avoidance or minimization). By definition, mitigation recognizes that something has been built in a dangerous area and seeks to protect against subsequent events. But there is always the chance that mitigation is under-designed, will deteriorate, and fail. As Harg points out, a more appropriate strategy is often avoidance.

The previous chapter, Regional Characterization, described some of the existing conditions in our area – flood control dams, utilities infrastructure, vegetation and wildlife, recreation facilities, stormwater management, and how the general climate of the area impacts arroyo health. This chapter focuses more closely on problems associated with all of these elements and in some cases, offers suggestions for preventing or mitigating them.

[40] "Governor seeks presidential disaster declaration for Hatch, NM," USA Today, August 21, 2006.
[41] "Heavy Rains and Flash Floods Devastate Western Texas and Southern New Mexico," Southwest Weather Bulletin, Autumn-Winter 2006-2007 Edition, National Weather Service El Paso/Santa Teresa.
[42] "Final Cost of New Mexico Flood Repairs Still Unclear," John Guzzon, October 2, 2013. ENR Southwest, http://southwest.construction.com/.

Flooding near New Mexico State University as a result of the September 13, 2006 thunderstorm.
Photo: Dr. Deborah Bathke/NMSU.

High waters from heavy rains breached the Las Placitas Arroyo 3 times during the summer of 2006 resulting in widespread flooding and damage in Hatch and surrounding areas.
Photo: Southwest Weather Bulletin, Autumn-Winter 2006-2007 Edition.

Flooding in La Union, September 13, 2013.
Photo: Shari V. Hill, Las Cruces Sun-News.
www.lcsun-news.com/ci_24087689/rain-continues-soak-southern-new-mexico.

Arroyo Modeling

Most often, development occurs up to the 100-year flood zone boundary. The course of an arroyo changes with time and, as described previously, runoff can migrate out of the existing flowpath simply with sheer force. Development may restrict natural channels for flowpath, which can lead to erosion, landslides and flooding along the bank of the channel. This can ultimately put adjacent development at greater risk. Therefore, it is critical that the City direct growth away from the arroyos and adopt plans and ordinances that will accommodate dynamic arroyo systems.

Several strategies would be effective in this regard. Some would rely on a detailed science-based characterization of the each major arroyo using in-depth modeling that evaluates proposed land uses against arroyo characteristics. Models that have been used for this purpose in Las Cruces are the U.S. Army Corps of Engineers Hydrologic Engineering Center (HEC) Hydrologic Modeling System (referred to as HEC-HMS) and the River Analysis System (HEC-RAS). Some modeling of the arroyos has already been completed as part of the Federal Emergency Management Agency's (FEMA) National Flood Insurance Program (NFIP).

Modeling proposed under the AMP would not replace the floodplain designations show on the NFIP's Flood Insurance Rate Map (FIRM), but would add to this information base by modeling further upstream and determining flood zones there. These are free software tools that are publically available and are frequently used in this type of work.

This can then serve as a baseline for further analysis of major arroyos. Additional data sets that may be needed include, but are not limited to, land use, vegetation and wildlife, rainfall, and soil type. Using GIS mapping software, the aerial extent of water at the 100-year and 500-year storm could also be evaluated for the presence of wildlife, proximity of a parcel to other identified open space, existing infrastructure like roads, power lines, water lines, gas, etc., and proximity to existing developments and privately owned parcels within the 100-year flood zone.

Once the models are in place and functioning, they could be used to determine areas where upper watershed flood control improvements may provide additional downstream benefits. For instance, upper watershed improvement may help to slow flowpath and increase infiltration, reducing the chance for high velocity flowpaths downstream. Also, a model could help identify areas suitable for buffers or areas that may be appropriate for development with fewer constraints.

A buffer is an area adjacent to an arroyo where development would not occur or where development would be of lesser intensity. It would be determined starting at the boundary of the 100-year flood zone and measured laterally from that point. Over the arroyo's length, the buffer may vary, depending on results from the modeling discussed above. Identified buffer acreage could be dedicated to the City or withdrawn by the New Mexico State Land Office or U.S. Bureau of Land Management prior to selling acreage for development. If privately held, a buffer could take the form of a linear park, trail, or conservation easement, all of which could be offset by various incentives such as higher density farther away from the arroyo, federal tax break, or park credits.

Just as the NFIP maps are intended to help protect the public from the potential negative impacts of flooding, buffers are proposed as part of the AMP to further protect the health, safety and welfare of the public. The use of buffers would be determined by a need for further erosion control, for example by protecting pockets of natural vegetation outside the 100-yar flood zone. An ancillary benefit would be their use for open space, trails, and parks.

Development

According to the *One Valley One Vision 2040 Regional Plan*, a great deal of new growth is expected east of Interstate 25, bringing with it not only residential development but new activity centers and employment opportunities.[43] As we look to the future, the city and county are expected to increase in population by over 50% and 40% by 2040, respectively.[44] Due to an increase in impervious surfaces in these areas, storms that occur as short duration high intensity events are no longer lessened by soil and vegetation but are rapidly discharged into arroyos. The increase in runoff rate and volume from developed areas can overwhelm structures designed to convey a storm with a lower peak discharge. The

[43] One Valley One Vision 2040

[44] The city's population is estimated to increase from its 97,618 Census 2010 population to 150,000 by 2040. The overall population of the county is projected to increase from 210,000 people in Doña Ana County to about 300,000 by 2040. Source: U.S. Census Bureau; University of New Mexico Bureau of Business & Economic Research, 2013 Doña Ana County Snapshot Report.

tremendous growth in the area since the 1980s has put many more people in the path of potential flooding.[45] As Las Cruces has grown, development intensity has increased on the East and West Mesas, areas that historically have been open land or occupied by larger lots and fewer structures.

Arroyo modeling described above may provide additional insight when considering areas suitable for development. Land acquisition and buffer distances could be prioritized in relation to each parcel's function and importance, as well as the measure of likelihood and immediacy of development projects. It is important to note that a buffer is only one of several strategies for arroyo protection and management, and that a buffer may not be needed for all arroyos or for an entire arroyo. If a buffer is found to be needed for erosion control purposes in privately-owned areas, eliminating developable land could come at a high cost to the City. In some cases it may be necessary to purchase the land outright. Alternatively, incentives could play a major role in encouraging private land owners to participate in these strategies. For instance, it may be practical to use buffers as utility easements for access to infrastructure where necessary.

A similar process for protecting natural stormwater conveyances has been successfully used for many years by other entities in New Mexico, including Southern Sandoval County Area Flood Control Authority (SSCAFCA) and Albuquerque Metropolitan Arroyo Flood Control Authority (AMAFCA). SSCAFA's use of the Lateral Erosion Envelope (LEE) identifies areas that are susceptible to erosion and protects them from development, allowing them to continue serving their stormwater conveyance functions. AMAFCA's use of the prudent line serves a similar purpose, facilitating development while protecting natural water courses.

As arroyos form at the base of the Organ Mountains, they typically form a single channel but fan out into a larger number of small tributary channels as they move westward over the terrain. These tributary systems take up more square footage of the land, which becomes less suitable for traditional developments that require filling, flattening and clearing of vegetation. Development must be sensitive to existing landforms, and arroyo modeling can assist in this when using detailed information and analysis. Major arroyos that are in city limits have relationships with alluvial fan tributary systems that originate in the upper watershed, outside of the 100-year flood zone. Incorporating upper watershed data such as 2-foot contour lines can increase the precision and clarity in which development and arroyo management decisions are made. Directing development toward relatively flat areas would reduce land disturbance and destruction of vegetation in the uneven terrain of these small channel tributary systems. Another strategy may be to propose a density gradient in a development that would include larger rural lots close to the arroyo and denser, compact mixed-use streets further away from the arroyo (see Figure 4).

There may be other strategies for development to further incorporate arroyo preservation and management, and to address the financial obligations of land acquisition if the City were to purchase privately-owned land. Some of these options are described below. It is also important to note the relationship between improved arroyo management and costs that are passed on to the home owner, thus directly affect overall housing costs in Doña Ana County. A significant portion of county residents lives at or below the poverty line. Costs for land acquisition and/or maintenance of open spaces are passed onto property owners and in some cases the renters of the property. Policy would need to address incentives, compensation or other means (such as acquisition by the City) to preserve arroyos

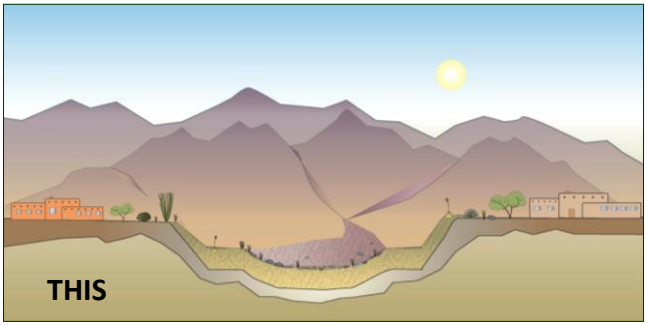
[45] "Recovering from New Mexico's Floods," October 3 2013, New Mexico State University Frontera NorteSur. http://fnsnews.nmsu.edu/recovering-from-new-mexicos-floods.

and other open spaces. Policy would also need to address affordable housing in the land preservation context.

Land trusts are widely recognized as an effective means of conserving natural land and open spaces. Not to be confused with a *land bank*, which seeks to repurpose underused, abandoned, or foreclosed property, a land trust normally has a singular purpose to preserve sensitive natural areas, farmland, ranchland, water sources, cultural resources or notable landmarks. Many different strategies are used to provide this protection, including outright acquisition of the land by the trust. In other cases, the land remains in private hands, but the trust purchases a conservation easement on the property so that it won't be developed.

Conservation easements are not frequently used in this region, but they offer an effective means of protecting sensitive environmental areas. A conservation easement is a legal agreement between a landowner and a land trust or government agency that permanently limits uses of the land in order to protect its conservation values. It allows landowners to continue to own and use their land, and they can also sell it or pass it on to heirs. A landowner who donates a conservation easement to a land trust gives up some of the rights associated with the land but it offers great flexibility for the landowner for watershed improvements to be planned, designed and installed. An easement may apply to all or a portion of the property, and need not require public access. Each conservation easement is crafted to meet the needs of the landowner while not jeopardizing the conservation values of the land. The size of the parcel can range from just a few acres, such as a pocket nature preserve, to hundreds or even thousands of acres.

Land protection measures could be used effectively to designate privately-owned buffers as linear parks, buffers or protected open space. Building on only one side of the street (referred to as a "single-loaded" street) allows enhanced views for those purchasing homes across from an arroyo. It also provides opportunities for linear parks and trails, both of which could be credited toward park impact fees. Single-loaded roads increase safety for open space users and nearby property owners by providing visibility for surveillance and monitoring, as well as improving accessibility for park users and improving access for emergency response. Since a developer would be choosing to leave developable land open, the overall costs of developing that area would inevitably be higher. If an arroyo buffer has not already been withdrawn from development and is privately owned, a tax deduction through a conservation easement or some other incentive would have to be determined.



Buffers would allow arroyos to shift and move naturally and would provide many positive outcomes, including: added soil stability; less structural loss due to erosion/flooding; more desirable open space; more wildlife corridors and wildlife viewing opportunities; and preservation of native vegetation.
Graphics: Peter Bennett

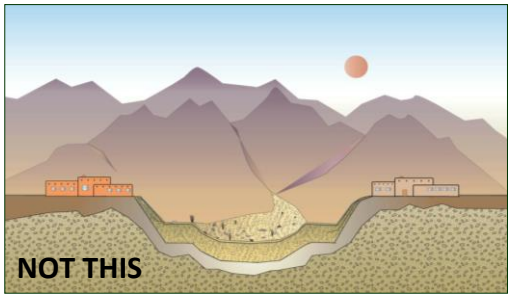
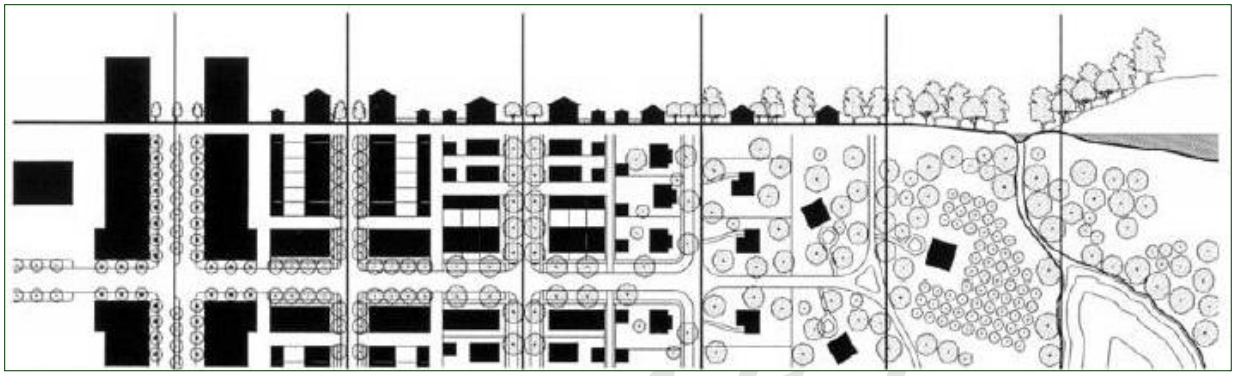
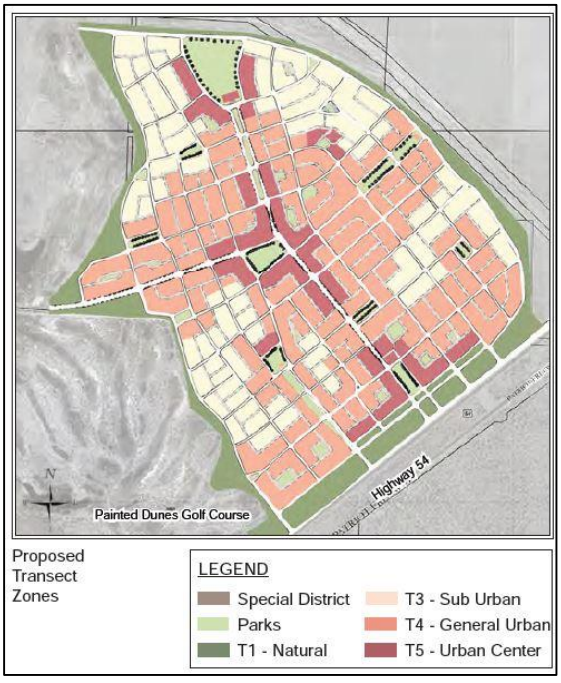


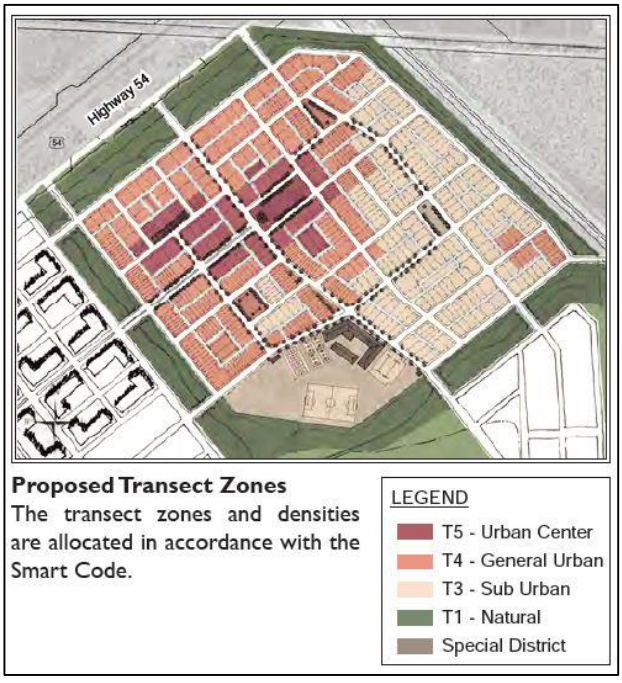
Figure 4 Rural-to-urban transect



The transect is a geographical cross-section of a selected environment and an effective master planning tool that guides the placement and form of buildings and landscape and allocate uses and densities. Many communities are organized this way, providing a natural gradient of development from urban center to natural edge.
Graphic: www.planetizen.com.

Linear parks and trails adjacent to development enhance the views for property owners. A conservation easement could provide a tax break for the owner, a different incentive could be devised, or the acreage could be purchased by the City. This is Pinnacle View Drive adjacent to the Little Dam Arroyo. Photo: Peter Bennett.





These illustrations, from the El Paso Comprehensive Plan (2012), show how transect zones that included protected open space and parks can be applied to individual neighborhoods and sections of the city. Graphic: *Plan El Paso*, volume I.

On the West Mesa, hillside and escarpment developments present several issues that are more complicated than developments on relatively flat land. These include topography and geometry, slope stability, velocity of stormwater runoff, erosion, and access (emergency and non-emergency). Hillsides, mountain terrain, and escarpments are generally unstable landforms to begin with, and disturbance can increase their instability and potentially require additional structural support to ensure infrastructure and slope stability. With many shifts in grade and elevation, density gradients could be used successfully here with denser development to the west on flatter terrain.

The City's *Comprehensive Plan 2040* proposes a 'Future Concept Map' which includes conservation areas consisting of areas with historical, cultural, environmental value or open areas that could become community assets and are worth preserving, such as arroyos and hillsides (Goal 35, Policy 35.1). At present, the 2001 Zoning Code as amended has three zoning districts related to open space and arroyos: Flood Control (FC); Open Space-Recreation (OS-R); and Open Space-Natural/Conservation (OS-NC). However, these are not frequently used as a means to permanently preserve natural environments because they are voluntary options. Providing incentives to expand the use of the OS zoning districts in developments would further accomplish the protection of sensitive areas that have been identified by the public as valuable resources.

Low impact development (LID) and green infrastructure (GI) techniques can reduce the volume of runoff that reaches arroyos. Traditional stormwater management design has been focused on collecting stormwater in piped networks and transporting it off site as quickly as possible, to an arroyo, a constructed channel, a large stormwater management facility (basin), or a combined sewer system flowing to a wastewater treatment plant. LID and GI techniques are newer practices intended to lessen runoff at its source. They address these concerns through a variety of techniques, including strategic site design, measures to control sources of runoff, and thoughtful landscape planning. LID aims to restore natural watershed functions through small-scale treatment by designing hydrologically-functional sites that mimic predevelopment conditions. GI includes approaches and technologies to infiltrate, evapotranspire, harvest, and reuse stormwater to maintain or restore natural hydrologies.[46]

However, some GI/LID practices aren't appropriate in all cases. At times, residential on-lot ponding can be an ineffective strategy. This is because ponds are often filled in or not maintained properly so their water retention and infiltration properties diminish. Increasing education and awareness of the importance of these structures and other GI/LID techniques could improve overall management of arroyo systems by reducing runoff in some cases.

Other communities in the southwestern U.S. have successfully integrated land conservation, water harvesting and other GI/LID techniques, and preservation of the natural terrain into attractive, functional and affordable developments:

- Mesa del Sol in Albuquerque, NM includes parks and other public landscaped areas that have been designed using native, drought-resistant plants and a reclaimed water system that is used for non-potable uses like outside landscaping. Homes include rainwater harvesting and other water-saving features.

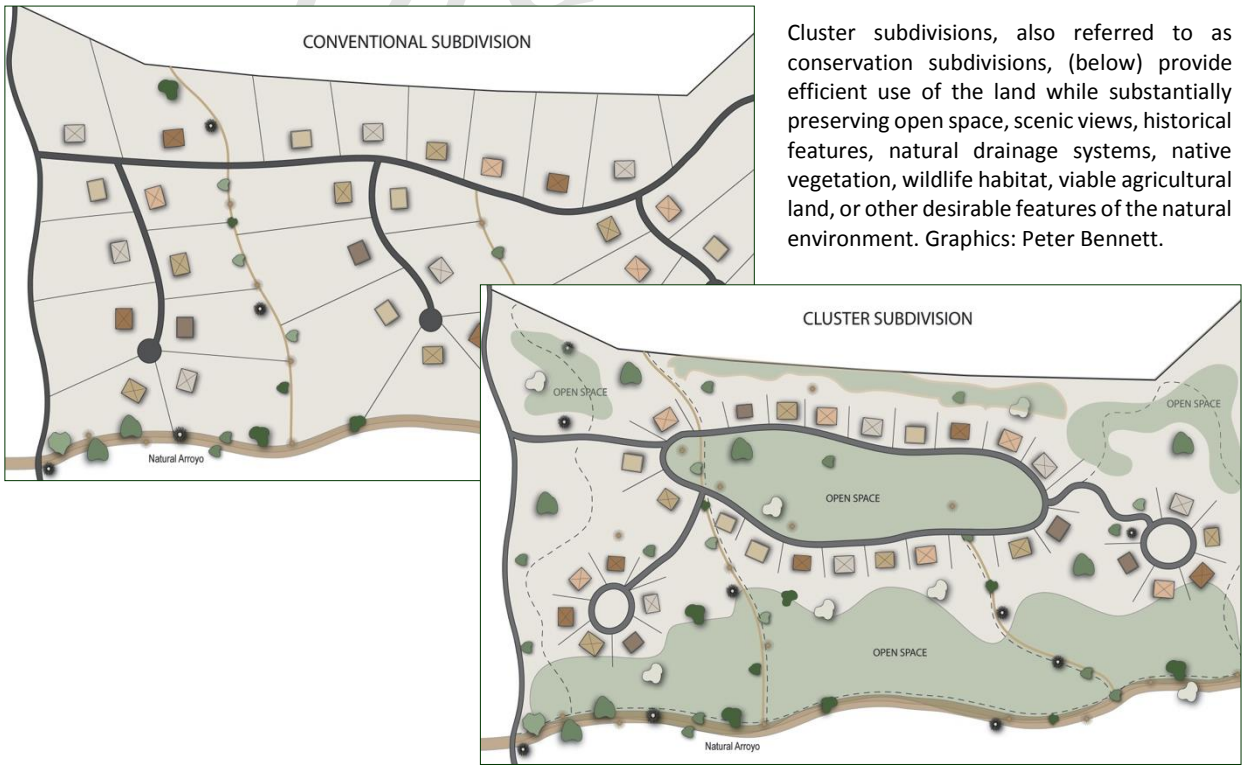
- Village Homes in Davis, CA utilize a natural drainage system that includes a network of creek beds, swales and pond areas to allow rainwater to be absorbed into the ground rather than

[46] EPA NPDES Stormwater Program Overview: http://cfpub.epa.gov/npdes/home.cfm?program_id=6

carried away through storm drains or detention ponds. Besides helping to store moisture in the soil, this system provides a visually enhancing backdrop for landscape design.

- The Civano development near Tucson, AZ is based on a tenet for development to tread lighter on the land through innovative design. Civano began by setting aside 35% of the land area for natural or enhanced open space. Community orchards, linear parks, pedestrian trails, bike paths, environmentally friendly recreational facilities, and preserved desert wild lands are all integral to the community's design.

It is important that our community balance the costs, types and quality of development against the long term value gained by preserving landscape views and open spaces associated with arroyo systems. The impact that open space can have on property values may actually underestimate the value of open space, by excluding the nonmarket values associated with passive uses, such as recreation or just knowing that open space exists.[47]



Cluster subdivisions, also referred to as conservation subdivisions, (below) provide efficient use of the land while substantially preserving open space, scenic views, historical features, natural drainage systems, native vegetation, wildlife habitat, viable agricultural land, or other desirable features of the natural environment. Graphics: Peter Bennett.

Watersheds

As a community expands and grows, the amount of impervious surfaces from development changes the nature of watersheds and how they function. Over time, a stream becomes graded, which means that an equilibrium was reached between channel slope (gradient), channel characteristics, available discharge, and load (debris). Stream banks and channels are relatively stable under graded conditions. But this balance can be upset by changes to land cover and surface characteristics of the watershed.

[47] The Economic Benefits of Open Space, Recreation Facilities and Walkable Community Design, Active Living Research, Robert Wood Johnson Foundation, May 2010. www.activelivingresearch.org