Attachment “A”

CITY OF LAS CRUCES
ARROYO MANAGEMENT PLAN

Adopted

October 5, 2015

ACKNOWLEDGEMENTS

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District 2: Councillor Greg Smith, Mayor Pro-Tem
District 3: Councillor Olga Pedroza
District 4: Councillor Nathan Small
District 5: Councillor Gill Sorg
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TABLE OF CONTENTS

ILLUSTRATIONS

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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.

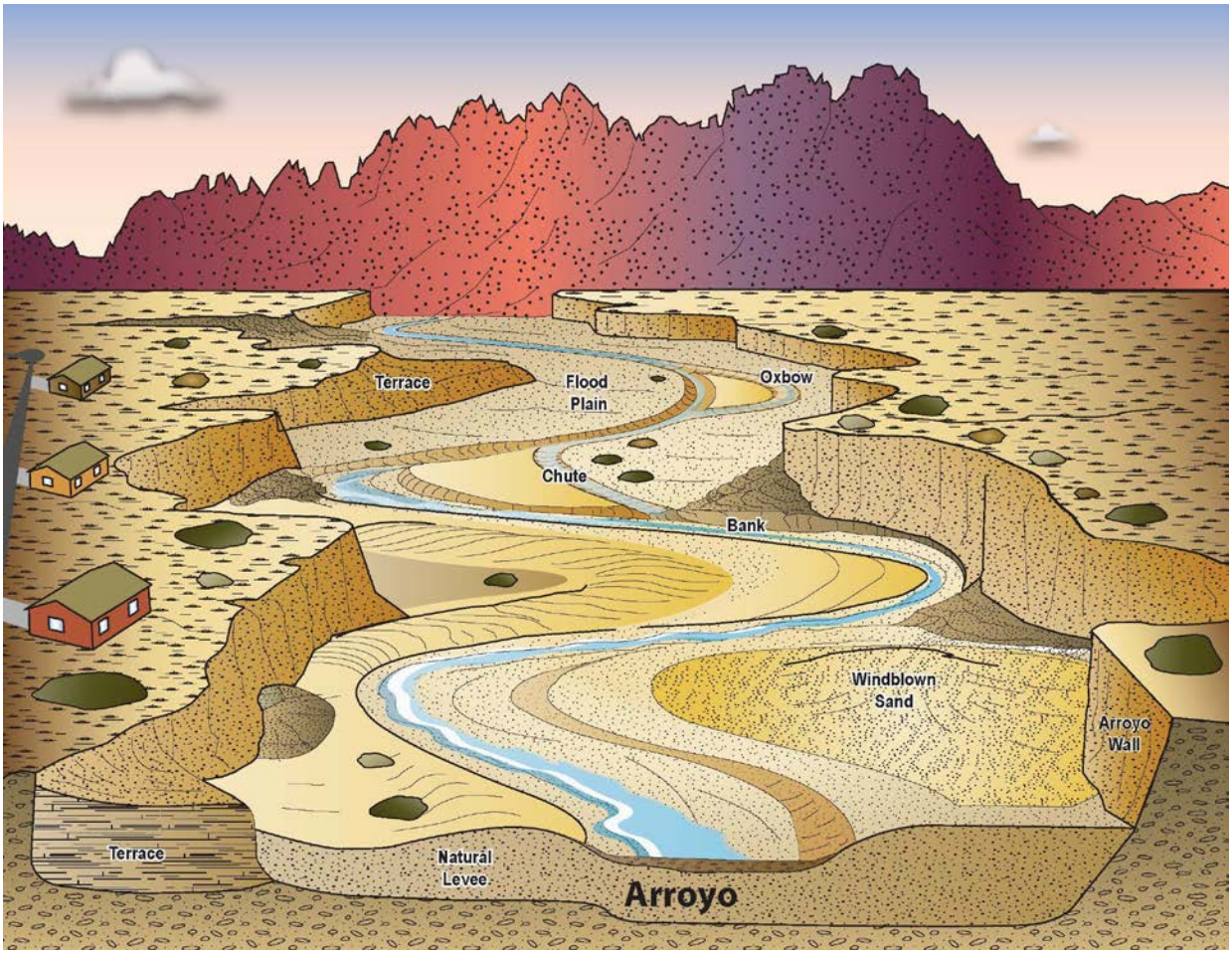
The City of Las Cruces Arroyo Management Plan will be used by the City to help guide regulations in the Development Standards, Subdivision Code (Chapters 32 and 37 respectively of the Las Cruces Municipal Code) and all other relevant codes as amended. It will guide design and development adjacent to 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.

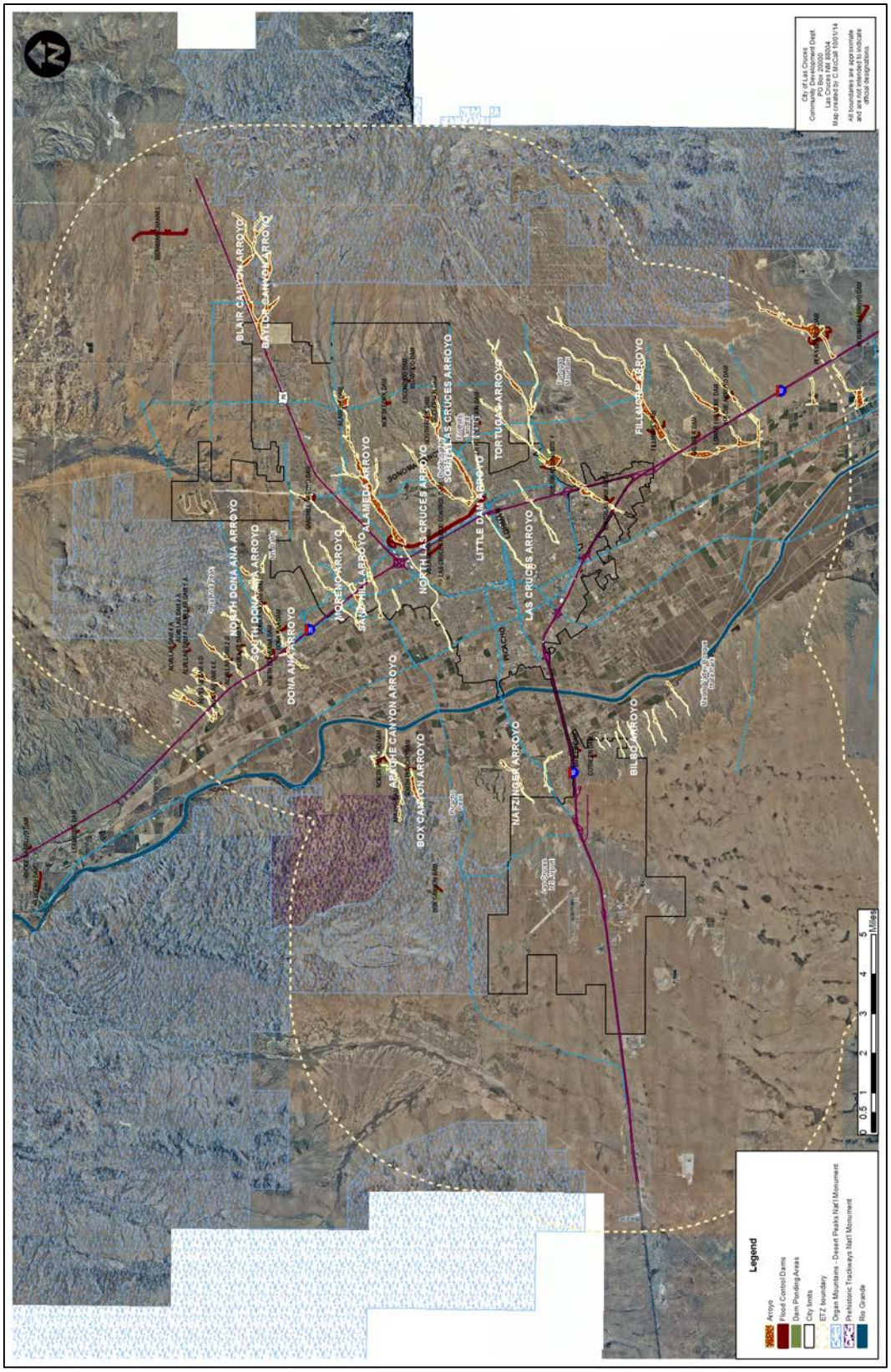
Figure 1 Arroyo Characteristics



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."

[The following revision, including the strikethrough and footnote, have been recommended by the City's Legal Department.]
In 1965 the New Mexico legislature enacted NMSA Sections 3-41-1 through 3-41-5, entitled "Flood Control." This legislation allows all New Mexico cities to tax property within their city limits to pay for authorized flood control structures within and without the municipal boundaries up to $5 per $1000 net taxable value (5 mill) with voter approval. Then in 1967, for unknown reasons, the New Mexico legislature cloned the Albuquerque Metropolitan Arroyo Flood Control Act and enacted NMSA Sections 72-17-1 through 72-17-103, entitled the "Las Cruces Metropolitan Arroyo Flood Control Authority," which created an independent Authority to operate a flood control system throughout the Las Cruces area. The Authority had less taxing authority than provided in the 1965 municipal Flood Control statute and there is some uncertainty as to the historical status of the Authority. Some individuals remember there being an Authority Board created but eventually it ceased meeting.[3]

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.

[3] The 1965 legislation provides up to $5 per $1000 (5 mill) taxing authority. Currently, the City of Las Cruces is collecting $2 per $1000 (2 mill) net taxable value for flood control purposes. By comparison, the 1967 Authority legislation enables the City of Las Cruces to tax properties within the boundaries of the authority only up to $0.50 per $1000 (0.5 mil) of net taxable value per NMSA Section 72-17-22(J) as indicated by the City Attorney's office.

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[4] 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.[5]

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

[4] Ephemeral flows carry water only during and immediately after a rain, and intermittent flows carry water for only part of the year.

[5] 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.[6] 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.[7] 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.

[6] Chihuahuan Desert Nature Center, http://cdri.org
[7] 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.[8]

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.[9] 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.[10] 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.[11] 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.[12]

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.

[8] National Weather Service: www.weather.gov
[9] Arizona Cooperative Extension: http://cals.arizona.edu/pubs/natresources/az1417.pdf
[10] University of Arizona Climate Assessment for the Southwest: www.climas.arizona.edu/sw-climate
[11] NASA Earth Observatory: http://earthobservatory.nasa.gov/Features/WorldOfChange/enso.php
[12] 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. [13]

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.[14]

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.

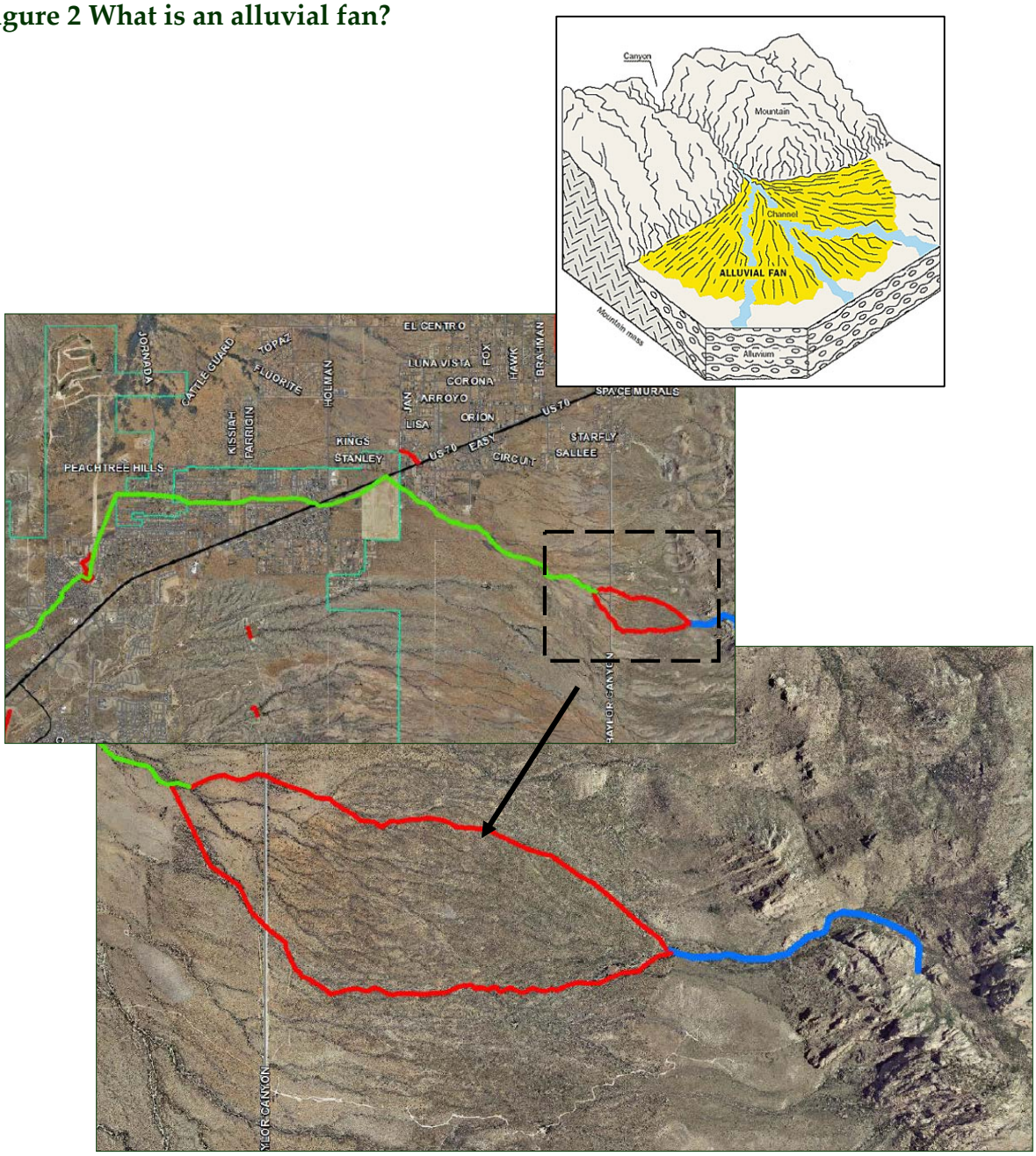
Alluvial fans are gently sloping, fan-shaped landforms common at the base of mountain ranges in arid and semiarid regions. Alluvial fans develop where streams or debris flows emerge from steep reaches to relatively straight, narrow channels then to zones that are wider and flatter. These conditions develop 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. [15] 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

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

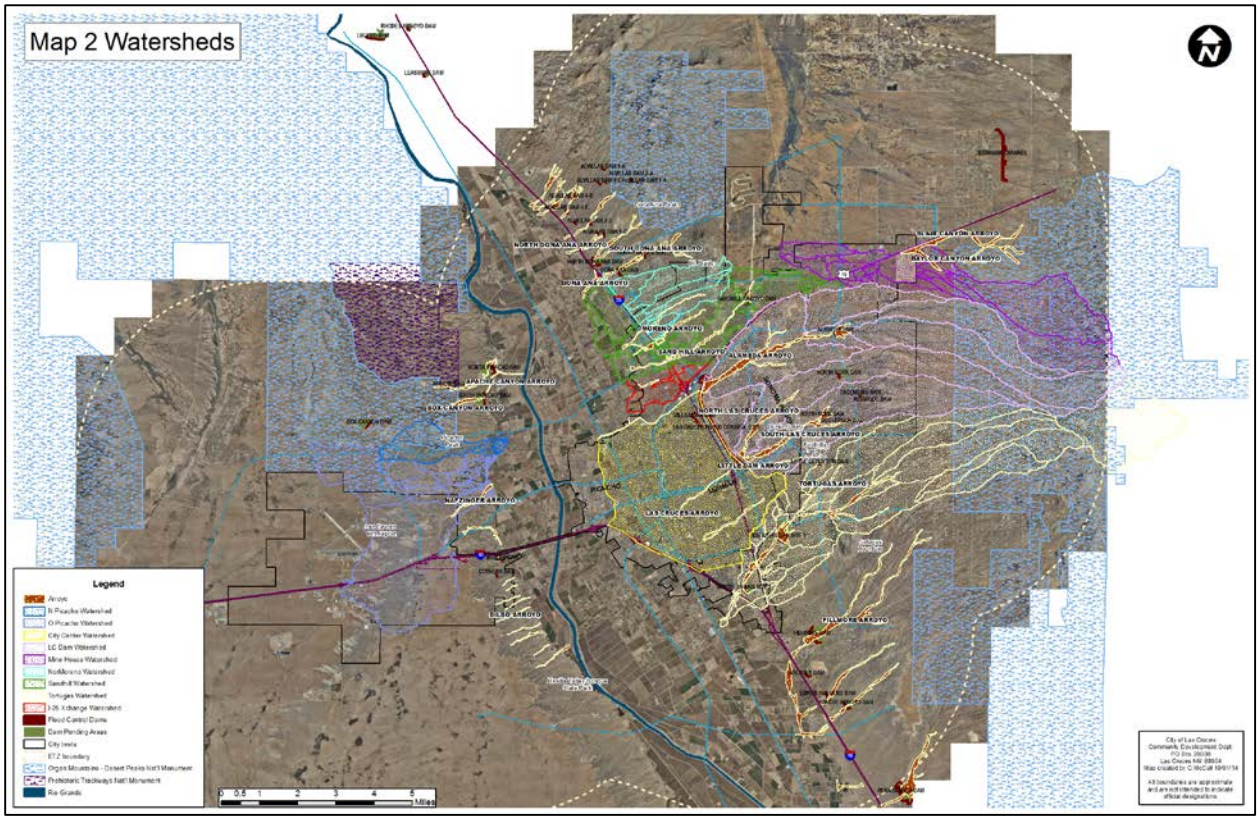
the formation of a new channel. Alluvial fans are also dangerous because the stream channel will slowly erode the soft sediments and meander outside of the mapped 100-year flood zone.

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.[16] 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

[16] 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.

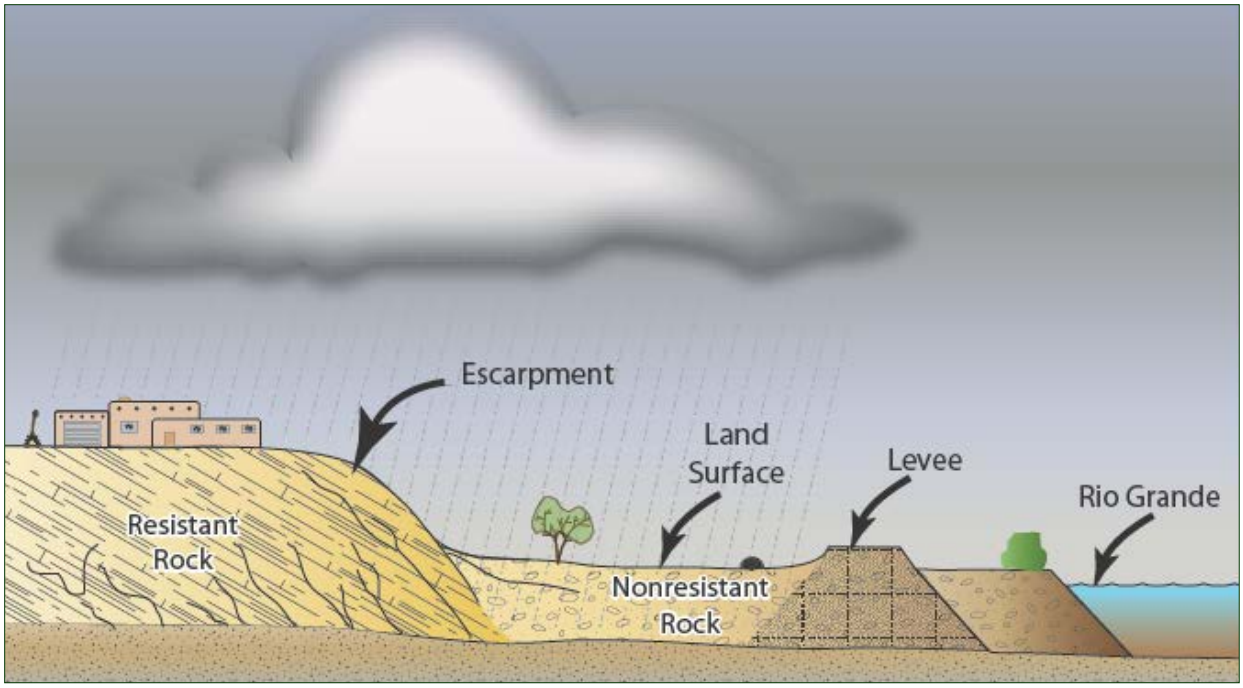
Other intrusions by development within the floodplain of an arroyo also impact the balanced relationships between the flow of flood waters and their erosion of the channel soils. Historically such changes to the channel increase the velocity of the drainage water, increasing erosion, which transports 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[17]



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

[17] 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.[18] 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.[19] The underlying geology of an area determines the soil types found toward the surface.

Doña Ana County is characterized by 70 different soil types.[20] 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. [21]

[18] Williams, J. L. 1986. *New Mexico in Maps, Second Edition.* Albuquerque, NM: University of New Mexico Press.
[19] New Mexico Bureau of Geology and Mineral Resources. 2003. *Geologic Map of New Mexico.* Socorro, NM: New Mexico Institute of Technology and USGS.
[20] Ibid
[21] 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.[22] 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.[23] 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.[24] 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.[25]

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

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

leaf goldeneye, allthorn, and ocotillo.[26] Perhaps one-fifth of all the world's cacti – as many as 350 of the 1,500 known species – occur in the Chihuahuan Desert.[27] 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.[28]

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.[29] 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.[30]

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.[31] 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.[32]

This region is home to several plant and animal species found nowhere else on earth.[33] 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.[34]

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

[26] University of Texas at El Paso Centennial Museum: http://museum2.utep.edu/chih/chihdes.htm
[27] World Wildlife Fund: http://worldwildlife.org/ecoregions/na1303
[28] U.S. Fish & Wildlife Service: www.fws.gov/endangered
[29] U.S. Army Corps of Engineers East Mesa Watershed Study, 2007
[30] Ibid
[31] Ibid
[32] NM Department of Game & Fish: www.wildlife.state.nm.us/conservation; and www.fws.gov/endangered.
[33] Citizens' Task Force for Open Space Preservation (CTFOSP) *A Vision: Open Space and Trail System*
[34] 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.[35]

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.

[35] 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.[36] 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

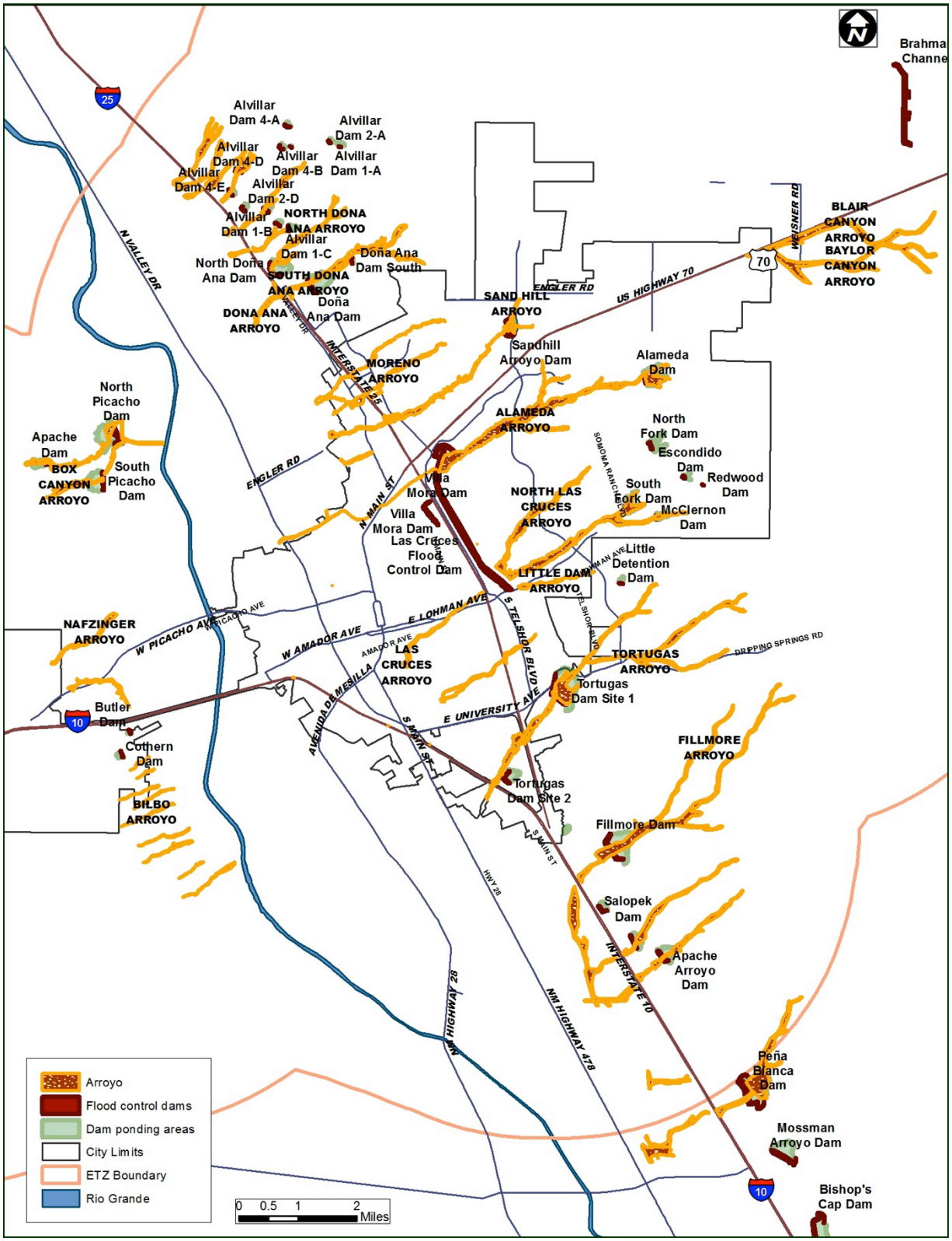
Dams within Las Cruces	Dams within the ETZ but outside the Las Cruces city limits	
Tortugas Site 1 Dam	South Picacho Dam	Alvillar 1-A Dam
Alameda Dam	North Picacho Dam	Alvillar 1-B Dam
North Fork Dam	Apache Dam	Alvillar 1-C Dam
Escondido Dam	Box Canyon Dam	Alvillar 2-A Dam
Redwood Dam	Brahman Channel	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.

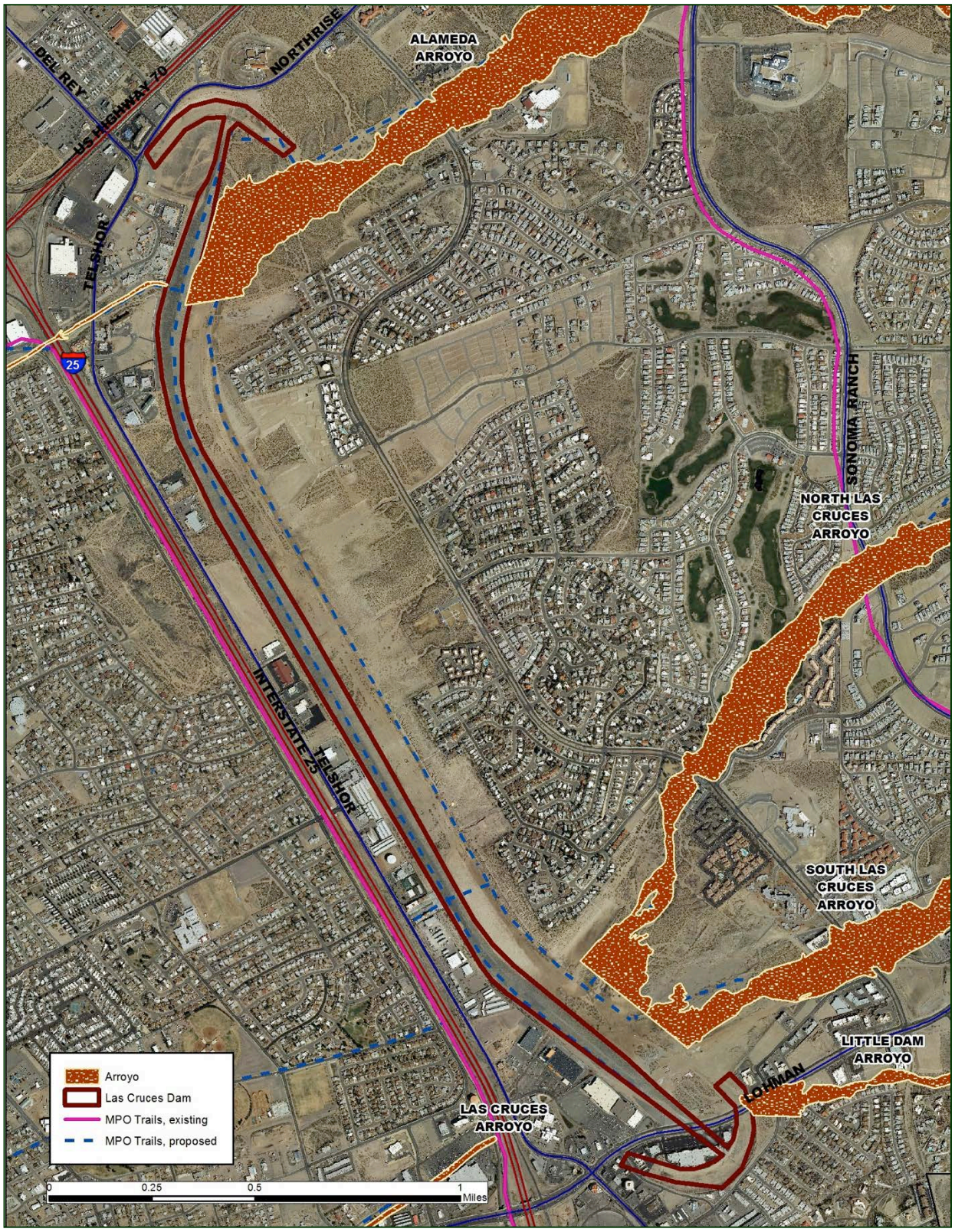
Looking upstream across the flood pool upstream from McClernon Dam. Pooling presents an opportunity for vegetative growth and habitat restoration. Photo: USACE Sediment Transport Analysis Report.

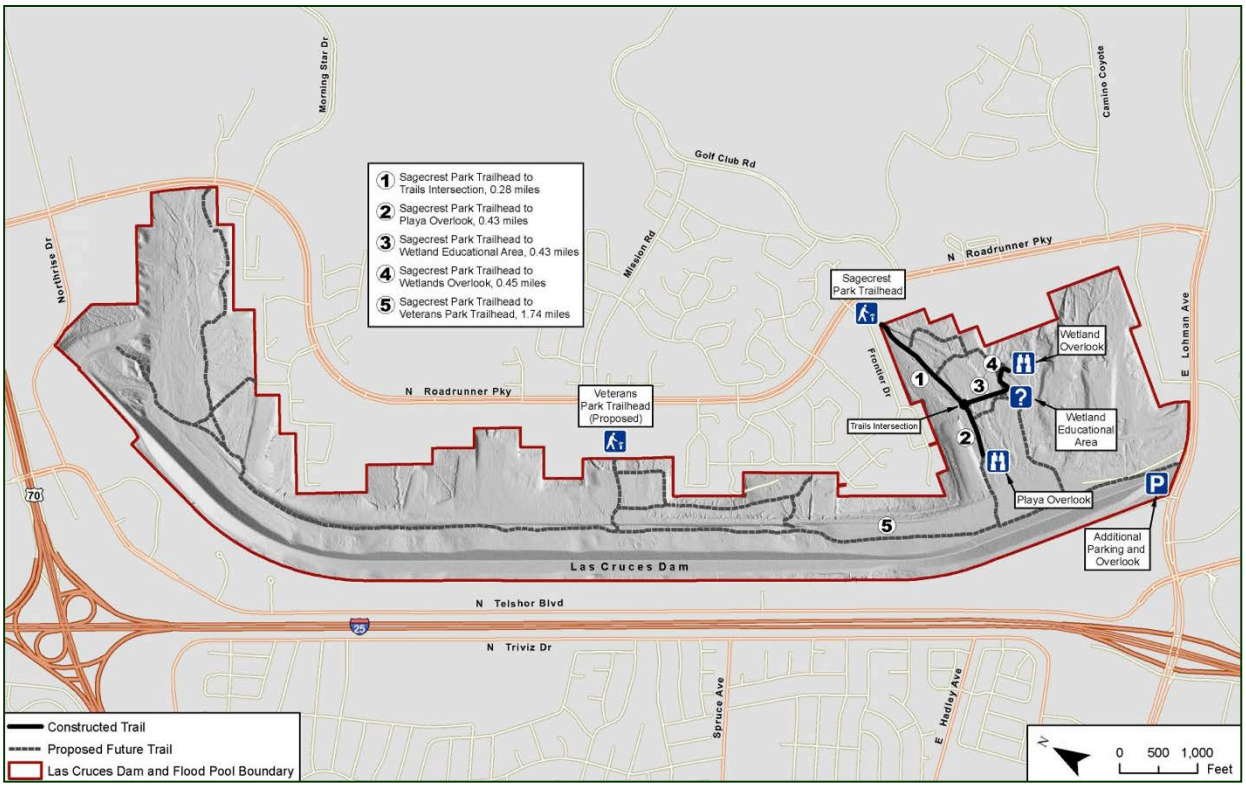
[36] New Mexico Office of the State Engineer http://www.ose.state.nm.us/water_info_dam_safety_info.html

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.[37]

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

[37] 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.[38]

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.

[38] 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,[39] 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.

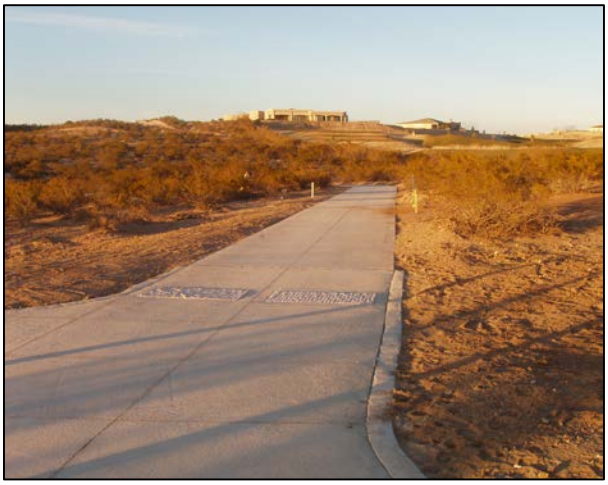
Parks and Open Space

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.[40]

[39] http://www.las-cruces.org/Departments/Utilities
[40] 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.[41] 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.[42] 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.[43] 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.

[41] "Governor seeks presidential disaster declaration for Hatch, NM," USA Today, August 21, 2006.
[42] "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.
[43] "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.[44] As we look to the future, the city and county are expected to increase in population by over 50% and 40% by 2040, respectively.[45] 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

[44] One Valley One Vision 2040

[45] 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.[46] 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

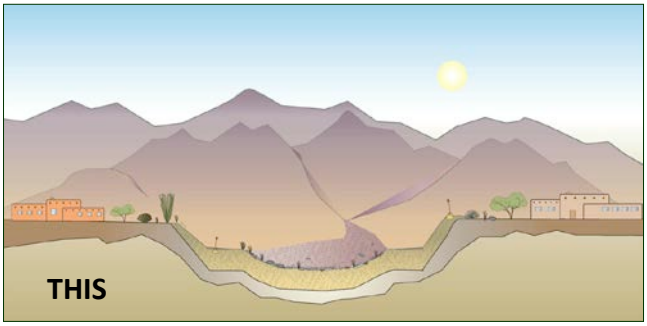
[46] "Recovering from New Mexico's Floods," October 3 2013, New Mexico State University Frontera NorteSur. http://fnsnews.nmsu.edu/recovering-from-new-mexicos-floods.

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

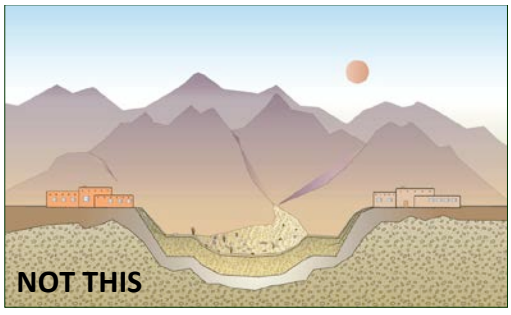
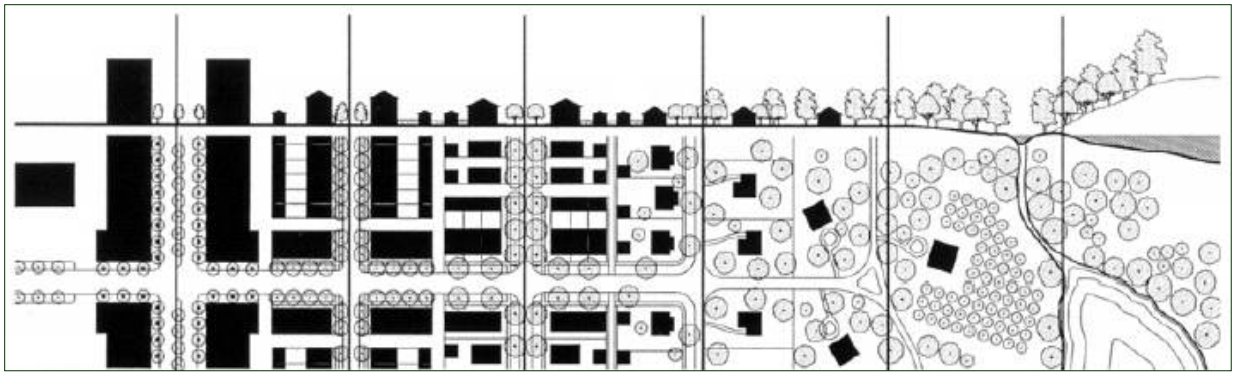
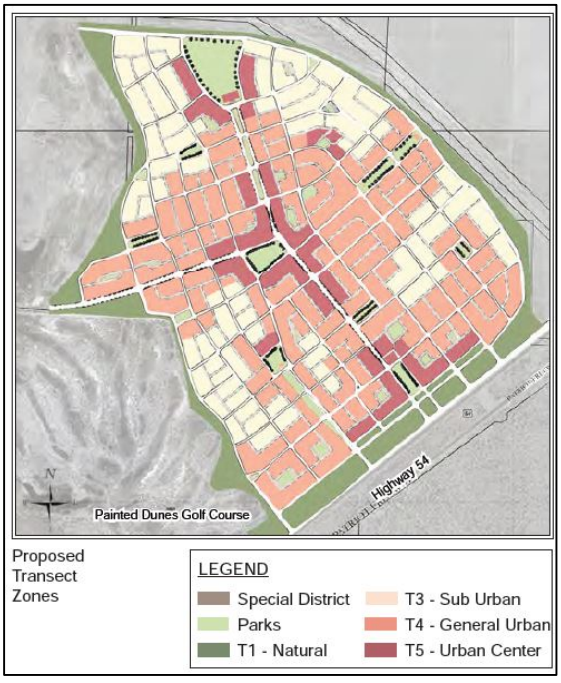


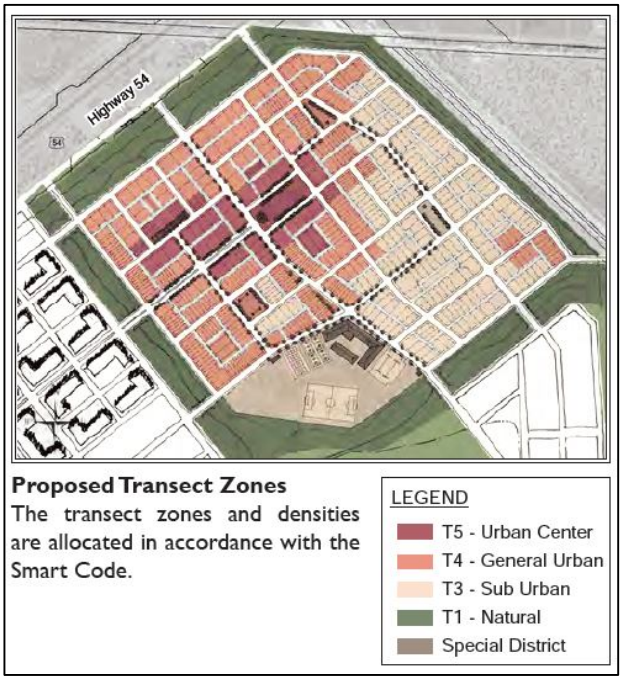
Figure 4 Rural-to-urban transect



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.[47]

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.

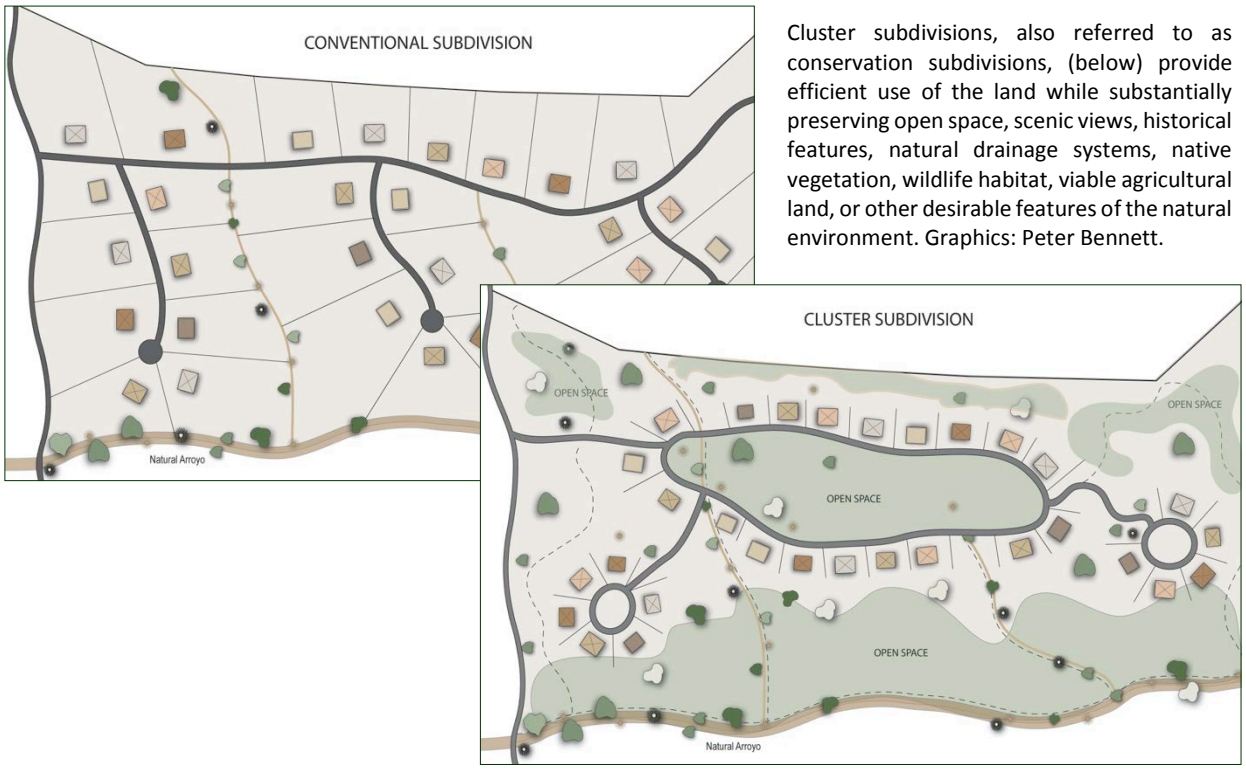
- Village Homes in Davis, CA utilize a natural drainage system that includes a network of creek beds, swales and pond areas to allow rainwater to be absorbed into the ground rather than

[47] 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.[48]



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.

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

Development and other changes to land cover can increase the amount of impervious surfaces, alter the density of arroyo channels, increase the volume and velocity of stormwater, and change the amount and type of material that arroyos convey. Ultimately, these changes can divert much of the surface drainage to underground storm sewers. Stormwater events and resulting floods can strike with little warning, can travel at extremely high velocities, and carry a tremendous amount of sediment and debris. Changes in land cover can also alters the physical configuration and stability of stream channels, changing vegetation patterns and potentially reducing their value as wildlife habitats.

Enhancing and improving existing channels and arroyo systems can allow them to withstand erosion caused by turbulent flood and debris flows. Such enhancements and improvements require careful design, proper implementation and sufficient maintenance in some cases. Development on or near an arroyo should not increase downstream peak flows. Studies can be performed for such development to ensure it does not change the direction of an arroyo or have negative downstream effects. Erosion control techniques like culverts and arches can maintain flow path and protect from erosion. The location of erosion control structures is important: constructing them where a flow path has been or is likely to be altered, or downstream of a road crossing (where increased flow velocity is likely) can assist in maintaining a healthy arroyo system where development has already occurred.

Floodwaters may pass safely through an alluvial fan system if the existing channels and banks are protected. Because alluvial fans represent critical sites of sediment routing in mountainous watersheds, including a fan analysis in an arroyo characterization model may provide a fundamental tool for assessment. In addition, mapping alluvial fans could provide quality risk assessment data and suggest additional mitigation actions that assessing arroyo characteristics may not provide alone.

Stormwater Management, Impacts and Risks

When stormwater is absorbed into the ground, it is filtered and ultimately replenishes aquifers or flows into streams and rivers. In developed areas, however, impervious surfaces such as pavement and roofs prevent precipitation from naturally soaking into the ground in an evenly displaced manner. Instead, water collected from impervious surfaces gathers and flows more rapidly into storm drains, sewer systems, and drainage ditches and can cause:

- Downstream flooding
- Stream bank erosion
- Increased turbidity (muddiness created by stirred up sediment) from erosion
- Habitat destruction
- Changes in the stream flow hydrograph (a graph that displays the flow rate of a stream over a period of time)
- Combined sewer overflows
- Infrastructure damage
- Contaminated water

As runoff flows over the land or impervious surfaces, it accumulates debris, chemicals, sediment or other pollutants that could adversely affect water quality if the runoff is discharged untreated. In addition, most stormwater discharges are considered non-point sources (NPS) and require coverage under the U.S. Environmental Protection Agency's (EPA) National Pollutant Discharge Elimination System (NPDES) permit. Stormwater discharges from construction activities (such as clearing, grading,

excavating, and stockpiling) that disturb one or more acres, or smaller sites that are part of a larger common plan of development or sale, are regulated under the NPDES stormwater program. The NPDES program requires the City to have a Small Municipal Separate Storm Sewer Systems (MS4s) permit for such construction activities. This includes a USEPA Construction General Permit requirement, where BMPs are mandatory during construction in order to control stormwater discharges; post-construction activities require runoff containment, revegetation or ponding are two ways to accomplish this.

Mitigating stormwater pollution by reducing impervious surface and preserving open space for drainage are examples of green infrastructure techniques. Although many green infrastructure strategies are not approved by the City at this time, developers and contractors understand the need for better stormwater management and have made changes to their practices independently where permitted. As we become more knowledgeable about these techniques and the benefits they bring, the City can incorporate these mitigation practices as acceptable means of drainage design. Studies should be conducted using green infrastructure techniques to gain more confidence in implementing these practices, which can achieve proper drainage performance, flood safety and cost effectiveness.

Cisterns and rain barrels are a cost-effective way to collect and store water for garden and lawn irrigation and would keep the water out of storm drains.
Photos: www.epa.gov

Bioswales are vegetated, mulched or xeriscaped channels that provide treatment and retention as they move stormwater from one place to another. Swales slow, and filter stormwater flows. As linear features, vegetated swales are particularly suitable for draining water from streets and parking lots. Photo: Dave Leonard Tree Specialists, www.dlarborist.com

Permeable concrete and pavers allow rain to seep into the ground. Permeable paving can capture and soak in up to 80 to 100 percent of the rain that lands on it and can reduce construction costs for residential and commercial development by reducing the need for drainage features. Photos: www.epa.gov.

Sometimes, BMPs are not implemented properly or sufficient maintenance is not provided following construction. The City has begun to address this by dedicating additional staff and resources to inspection and enforcement of existing regulations. Policies calling for enforcement of BMPs may further improve these practices.[49] The use of structures to protect from flooding is sometimes necessary and even desirable, but structural floodplain management should not be the primary mitigation plan. Because areas exist that are already fully developed and near a flood hazard, it is necessary to thoughtfully explore some appropriate structural methods as part of an overall plan in order to protect existing property.

Upstream debris barriers stop or reduce the movement of debris down a channel system. Debris barriers may be permanent structures in the watershed or constructed as temporarily control measures. Either way, these structures allow flood waters and fine grained sediment to pass through but stop larger sediment, rocks and vegetative material from flowing downstream. Debris barriers are one example of an engineered watershed improvement designed to manage the effects of stormwater.

Like many urban communities, Las Cruces relies on drainage channels, storm sewers, and other expensive infrastructure to deal with localized flooding from sudden storms. Both public and private landowner tax dollars pay to clean up nonpoint-source pollution caused when water transports contaminants from parking lots and other impermeable surfaces. But natural hydrologic systems recharge and cleanse the watershed from NPS pollutants. Undeveloped areas (i.e. natural land) provide a natural nonstructural floodplain management BMP because the land has not yet been altered with structures subject to the effects of flooding. In addition, NPS pollutants in discharge from urban runoff can affect EBID agricultural drains and may put the District's agricultural exemption from NPDES permitting at risk.

At the Rio Grande, the levees are intended to keep flows from leaving the river into the surrounding land during a flood event, that is, away from the river. This hinders runoff from arroyos and watersheds that flows toward the river in times of flooding. Elephant Butte Irrigation District's (EBID) drain and canal system flows mostly north to south, creating multiple impediments to arroyos and channels reaching the river. These drains and canals were not designed for storm flows, and were not designed for the increases in storm flow runoff associated with recent development.

Watershed conservation has proven to be a cost-effective alternative to expensive structural BMPs. Also, water sources can become polluted when sediment, pesticides, oil, animal waste and other contaminants wash into them from impervious surfaces. Conserving land and re-establishing vegetation along the sides of arroyos and other stream beds can help prevent this pollution. Vegetation also assists in bank stability and water quality mitigation within watersheds. Roots of riparian plants filter and remove suspended materials. Plants and algae use and remove such nutrients as nitrogen and phosphorus. Bacteria, fungi, and other microorganisms decompose organic material.[50] These are important functions of a healthy watershed.

The most significant hazard to public safety along incised channel reaches is often related to lateral erosion into infrastructure and adjacent property rather than flooding, because the capacity of the incised channel is typically quite large. All of the soils in Doña Ana County are considered highly

[49] For the EPA's National Menu of BMPs, go to http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm

[50] "*Eco Tipping Points: How a Vicious Cycle Can Become Virtuous.*" Amanda Suutari and Gerald Marten. Earth Island Journal 22, no. 2 (Summer 2007).

erodible.[51] Wind, rainfall, soil moisture, the type and size of soil particles, and the condition of the soil surface (e.g. vegetated, barren, or disturbed) all determine how much erosion occurs. The unstable and erosive nature of soils in the arroyos are what makes it so difficult to predict how an arroyo will change in any given flood event. As shown below, unchecked erosion could eventually reach a point at which retaining walls, accessory structures, or infrastructure would have no support and fall away.

Sediment that is eroded during the incision process is carried downstream where it can deposit in low energy zones, decreasing channel capacity and potentially increasing the flood hazard in the depositional zones. Stormwater generally develops a flowpath in the hillside areas and follows existing arroyos that are in its natural path. Just as on the East Mesa, development on our western hillsides creates impervious surfaces and modifies storm flows, which can lead to increased erosion. Excessive incision can also remove natural vegetation and destroy habitat adjacent to the channel.

Besides their unsightly appearance, canalized arroyos increase runoff volume and water velocity, thus contributing to flooding and erosion downstream. This is a section of the South Fork of the Las Cruces Arroyo, east of Roadrunner Parkway.

Natural areas reduce runoff volume while providing wildlife habitat. Most of the arroyos in our region have great potential for restoration and preservation. This is a different section of the South Fork of the Las Cruces Arroyo, further east.
(Photos by Peter Bennett.)

Another problem associated with erosion is damage to culverts under road crossings, usually caused by flood waters eroding culvert entrances or outlets and road embankments, and usually resulting in a full or partial washout, or misalignment of the culvert. Damage or failure of a culvert could be due to insufficient culvert capacity and/or inefficient end sections (mouth of the culvert), so appropriate hydrologic analyses of flood peaks and volumes, and applying appropriate culvert design criteria are both important. It is important to make a careful determination of the cause of the damage, as different

[51] Soil Survey of Dona Ana County New Mexico.

causes require different mitigation. Also, mitigation applied inappropriately could actually increase risk to the facility or other structures in the floodplain.[52]

In its simplest sense, an arroyo is only a drainage path. But with closer inspection it can be seen that the curves, width, and grade are all dynamic properties and continually seek a balance in response to its most recent flood event. For these reasons urbanization along banks inherently carries a higher risk for instability than does development further away. Some of the risks include 1) bank mass failure from bank instability through undercutting erosion or overloading of stormwater through development, 2) weaknesses from previous mass failure events, and 3) water flow regime risks by flooding of zones that have moved downward to place them below a 100-year flood elevation.

Further analysis of a given arroyo would identify many of the risks of urban development outside its flood zone boundary. This would help determine its inherent stability and likelihood of erosion and erosion speeds, and would identify historic failures within the embankment. This information could be used to help determine any necessary buffer distance for arroyos that have not yet been developed.

The solution to this severe flooding problem near Rinconada was to broaden the channel and line it with concrete. The banks were seeded with native grasses and an erosion fence was added.

[52] Randolph Langenbach, Conservationtech.com: http://www.conservationtech.com

Flooding near the Sonoma Ranch Golf Course inspired a simple and inexpensive naturalistic erosion measure (below) which preserves natural vegetation and blends in with the surrounding terrain. Both photos: CLC Public Works Dept.

This photo illustrates what can happen when development restricts a natural channel. Continued erosion could eventually reach the point at which the retaining wall would have no support and would fall away. The photo below illustrates a quick and inexpensive (although unsightly) fix for the erosion problem. All photos: CLC Public Works Dept.

Utilities and Infrastructure

City utilities oftentimes place sewer interceptors in or near arroyos. These interceptors receive flow from a number of other sewer lines for transport to one of the three wastewater treatment plants operated by the City. Challenges with the location of these interceptors in or near arroyos can occur despite the installation of erosion control structures, such as rip-raps or check dams. For instance, since the soil is disturbed to bury the lines, the soil becomes more susceptible to erosion during a flood event and infrastructure may become exposed. Exposure may also occur when stormwater creates higher and faster runoff. In addition, water and gas mains and services are to have 5-foot minimum cover and sewer mains a 6-foot cover, as measured from the bottom, or floor, of the arroyo. But as arroyo floors erode with rain events, there is a risk of exposure, regardless of how deep the pipes were initially buried.

A cost-benefit analysis may warrant the efficiencies gained by locating interceptors or other utilities in or near arroyos. If warranted, updated design and installation procedures could help to ensure the least amount of disturbance to the arroyo environment. For example, when road crossings are constructed, arroyos become semi-closed channels that have limited or restricted access from a bridge or street. Most (if not all) of these bridges do not have large enough culvert openings to drive through, and bridge design typically doesn't include an access ramp for maintenance vehicles or a vactor truck. Without proper design to allow access, arroyo disturbance potentially increases when City staff needs to reach manholes or exposed pipes that cross or lie on the arroyo floor. According to the City's Utilities Standards, manholes must be accessible by 2-wheel-drive vehicles 24 hours a day and must be approachable by a dedicated 15-ft. (minimum) right-of-way or City utility easement.[53] However, this is very often not the case due to space constraints.

On the West Mesa, infrastructure such as utility lines and roads are more expensive to install and maintain due to a more hilly terrain. Access becomes more difficult to provide because hillside roads are generally narrower, do not always provide secondary connection due to physical constraints, and can be easily blocked or narrowed due to on-street parking.

[53] City Utility Standards Sections 504, Sewer Lines Outside of Street/Road Right-of-Way, and 510, Manhole Design Criteria, www.las-cruces.org/Departments/Utilities

Exposure around the manhole indicates incision in this reach of up to 2 to 3 feet in this area. Note that some of the exposure could also be due to lateral movement of the low flow channel. This is the Alameda Arroyo looking downstream (west) from Roadrunner Parkway. Both photos: USACE Sediment Transport Analysis Report

Exposed pipeline in an incised reach of the South Fork Arroyo downstream (west) from Roadrunner Parkway.

Flood Control Dam Functionality

Several of the flood control/detention dams listed on page 29 are within the East Mesa watershed. Some dams were built at the request of residents and were designed to protect those residents, but most were built with a lower hazard in mind and present a potential risk to those who have developed below them since their installation. Maintenance of these structures has been neglected over the past 30-40 years during which time the pool areas have experienced extensive sediment deposition and build-up. This has impeded the primary outfall of most of the dams and diminished their storage capacities. These dams were originally intended to protect agricultural land, not urban or rural development. The City's Storm Drain Master Plan of 2006 found that:

> "Under current conditions, the effectiveness of the Civilian Conservation Corps (CCC) dams as flood control structures is questionable; their main role at this time appears to [be] control and retention of sediment." [54]

According to the Natural Resources Conservation Service (NRCS), many of the dams are approaching the end of their planned service life and will require rehabilitation to continue to function safely. To ignore these dams will eventually place life and property at risk.[55]

The key areas where additional technical information is needed to support dam rehabilitation activities are summarized as:

- Technology for predicting performance of dams during extreme hydrologic events.
- Improved means of characterizing reservoir sediment quantity, quality, and distribution.
- Improved tools and guidance documentation for efficient application of current technology at the field level.
- Improved technology and tools for predicting the environmental impacts of dam failure.
- Improved procedures for predicting the response of channel and reservoir systems to change.
- Improved procedures for evaluating the short and long-term impacts of dam removal.

The Agricultural Research Service (ARS) and the NRCS have cooperated in the development and application of design criteria for flood control structures and channel stabilization measures. Over the past 60 years, achievements such as the development of tools to predict upland erosion, sediment delivery, and stream channel stability have contributed to improved reservoir design. ARS has also worked closely with NRCS in the development of design criteria for flood control project components such as spillways and stilling basins that allow the dams to operate effectively. Joint efforts in the area of software development for technology application are continuing to result in improved tools for design and analysis of dams and systems.

There are different options for dams to provide flood control functionality for Las Cruces. These could range from larger dams and reservoirs just outside developed areas, to a series of smaller dams strategically located through the extent of the arroyo system. These dams also represent the potential for wetlands and habitat where wetlands never existed before, but such repurposing could have impacts on the flood control function of the dams. Assessments on effective and desirable flood control structures would need to be addressed when considering upgrades or rehabilitation of the dams, and would involve the State Engineer's Office of Dam Safety, the NRCS, the Dona Ana County Flood Commission, the USBOR, the, private property owners and many other entities. In addition, the recent designation of the Organ Mountain Desert Peaks National Monument may impact owners' ability to maintain their dams, depending on the management plan created by the U.S. Bureau of Land Management.

Since the City has limited control over the fate of these dams (with the exception of the Villa Mora, Sandhill Arroyo and Las Cruces Dams), policies addressing upgrades and rehabilitation are not included in the AMP. However, the City fully supports a regional stormwater management strategy that fulfills

[54] City of Las Cruces Storm Drain Master Plan, 2006, Bohannan Huston Inc.
[55] Rehabilitation of Aging Watershed Flood Control Dams. U.S. Department of Agriculture Technology Fact Sheet, May 2001. www.nrcs.usda.gov

the programs of all entities and would participate as a regional partner in efforts to mitigate problems associated with improving dam functionality.

Factors that need to be considered include the costs for rehabilitation (including technology that would aid in decision-making), the values of downstream development which would be at risk due to dam ineffectiveness, and whether or not these flood control dams would be the best way to handle stormwater runoff. Other methods, including larger dams, designed channels to redirect flows where development has taken place downstream or ponds may be more effective. But the Las Cruces, Alameda, North Fork, and South Fork Dams are important to the overall drainage of the East Mesa watershed because they play a major role in the watershed's hydrology.

Weather and Climate Variability

One does not have to accept theories about climate change to understand that the unpredictability of El Niño, La Niña and the North American Monsoon makes it difficult to plan for storm events and flooding, and makes it all the more important. Monsoonal rainfall events in southern New Mexico tend to be short and spotty, with intense, local storms drenching some neighborhoods but not others. Rising temperatures and increased storm activity have occurred simultaneously, although the timing, intensities and frequencies of storms change from region to region and from year to year and may not be related to climate change at all.[56] It is worth noting, however, that the increased droughts, fires, flooding and severity of storms recorded in the last ten years have all occurred with a warming of only 1.3°F [57] and scientists project that Earth's average temperatures will rise between 2 and 12 degrees Fahrenheit by 2100.[58] In the Southwest, temperatures since 2000 have risen about 1.5°F from recorded averages.

Many regions are experiencing more frequent and severe heat waves while experiencing more intense rainfall, as well. Scientists theorize that changing the average global temperature by even a degree or two can lead to serious consequences and predict that for about every 2°F of warming, we can expect to see:

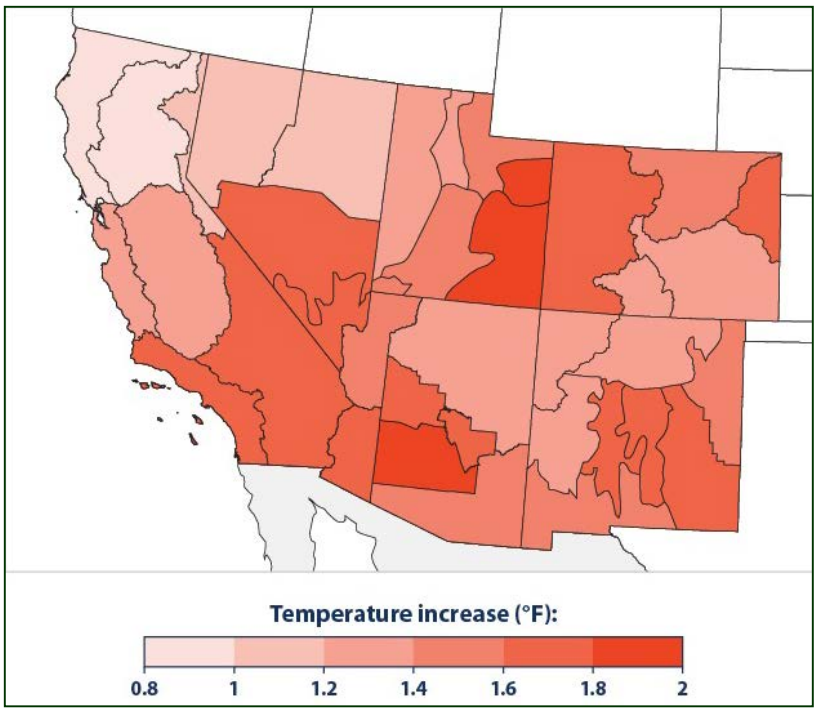
- 3—10% increases in the amount of rain falling during the heaviest precipitation events, which can increase flooding risks.
- 5—10% decreases in stream flow in some river basins, including the Rio Grande.
- 200%—400% increases in the area burned by wildfire in parts of the western United States which increases the likelihood of soil erosion and flooding in burned areas. [59]

[56] "Understanding the Southwestern Monsoon," Jack Guido. Southwest Climate Network, 2010. www.southwestclimatechange.org

[57] "Understanding Climate Change: A Primer," Woods Hole Research Center, 2014. www.whrc.org

[58] *America's Climate Choices: Final Report*. National Research Council, 2011. The National Academies Press, Washington, DC, USA. http://nas-sites.org/americasclimatechoices/

[59] *Climate Stabilization Targets: Emissions, Concentrations, and Impacts over Decades to Millennia*. National Research Council, 2011. The National Academies Press, Washington, DC, USA. http://nas-sites.org/americasclimatechoices/

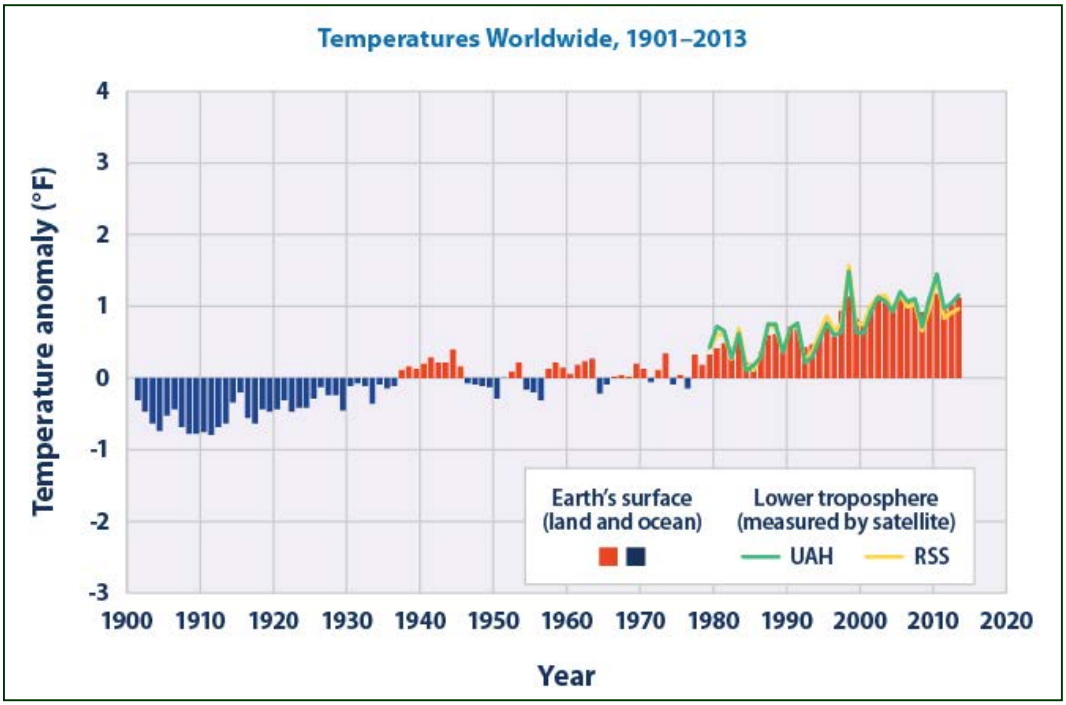


This map shows the average increase in air temperature in the Southwest compared to long-term averages (1901-2013). Southern New Mexico has experienced an average increase of 1.5° F in the last decade. National Climatic Data Center, National Oceanic and Atmospheric Administration (NOAA), 2014. www.ncdc.noaa.gov/oa/ncdc.html

The high costs associated with extreme and variable weather is something to keep in mind during discussions about development and arroyo management. Most climate models indicate that the Southwest will become drier in the twenty-first century, and that there will be increased frequencies of extreme weather events, including drought, flooding, and heat waves.[60] Increasing temperatures are expected to alter precipitation patterns (i.e. volume, frequency, and intensity) and correspondingly alter regional stream flow patterns.[61]

[60] IPCC 2007

[61] Climate Choices for a Sustainable Southwest," from The Assessment of Climate Change in the Southwest United States. Available at http://swcarr.arizona.edu/content/about-report. P 286



This figure shows how annual average temperatures worldwide have changed since 1901, when reliable temperature data began being collected. In the early part of the 20th century, temperatures were slightly below normal. The first significant heat wave occurred in the mid-1930s, but steady and sharp increases in temperature began to occur in the late 1970's. National Climate Data Center, National Oceanic and Atmospheric Administration (NOAA), 2014. www.ncdc.noaa.gov/oa/ncdc.html and www.epa.gov/climatechange/indicators

Typically, arroyo capacity is analyzed with respect to the 100-year storm event, to assure no development occurs within the inundated areas. With predicted increases in intensity and frequency of storms, arroyos will have to carry a greater amount of water than they currently do and will flow beyond the 100-year flood boundary.

Short- and long-term perspectives on disaster risk management and adaptation to weather extremes can be difficult to reconcile. But community vision changes over time and development decisions are framed by tradeoffs between competing prioritized values and objectives. In other words, what we want today may not be what we want tomorrow. A proactive approach would not necessarily commit our community to a different vision, but would simply prepare us for whatever it may be. Planners, developers and elected officials will face choices to react to extreme storms and flood events or to take steps that could help head off some of the more damaging and expensive results of them. In the long run, better planning and erring on the side of caution save money and could simultaneously make our region better able to cope with the coming changes.[62]

A regional stormwater management plan, based on thorough hydrologic modeling, may help identify the most fragile land forms where development should not occur. If we consider potential extreme weather events and climate change in determining locations of critical facilities and systems and more fully incorporate natural systems to help control erosion and manage stormwater, we may be reducing

[62] Melanie Lenart, Southwest Climate Change Network, March 2013. http://www.southwestclimatechange.org/node/16780

disaster risk because we have a better understanding and acceptance of the natural hazards we may face in the future.[63]

Vegetation and habitat

Mitigation measures to restore vegetation disturbed during development can be challenging because vegetation generally takes a long time to establish in the desert environment. Also, since soil is disturbed during construction, it is more likely to erode, making vegetation more vulnerable to destruction.

Vegetation loss and desertification are issues with development as well. More impervious surfaces and narrow channels diverting stormwater to arroyos cause increased velocities and flows. Devices such as rip-rap, check dams and energy dissipaters are not always incorporated at drainage outlets that enter arroyos, causing destruction of downstream vegetation. Those that are incorporated sometimes fail due to poor design or insufficient maintenance.

Construction permitees in New Mexico are required to follow Section 9.4. of the NPDES General Permit for Discharges from Construction Activities, which states that operators in New Mexico have three years to establish a uniform perennial vegetative cover with a density of 70 percent of the native background vegetative cover for all unpaved areas and areas not covered by permanent structures. Other areas of the U.S. are required to revegetate areas in one year, but the EPA recognizes the difficulty in arid desert regions and therefore has allowed a longer time period for this requirement in New Mexico.

According to the Army Corps of Engineers' *East Mesa Watershed Study* (2007), the relative scarcity of perennial grasses that would be expected to occur in this area is a cause for some concern and perhaps presents an opportunity for restoration. Typically native species like sideoats grama, black grama, fluff grass, vine mesquite, tobosa, burro grass, alkali mallow and cane bluestem are very rare or absent altogether across the East Mesa, but could be replanted as part of mitigation efforts following construction.

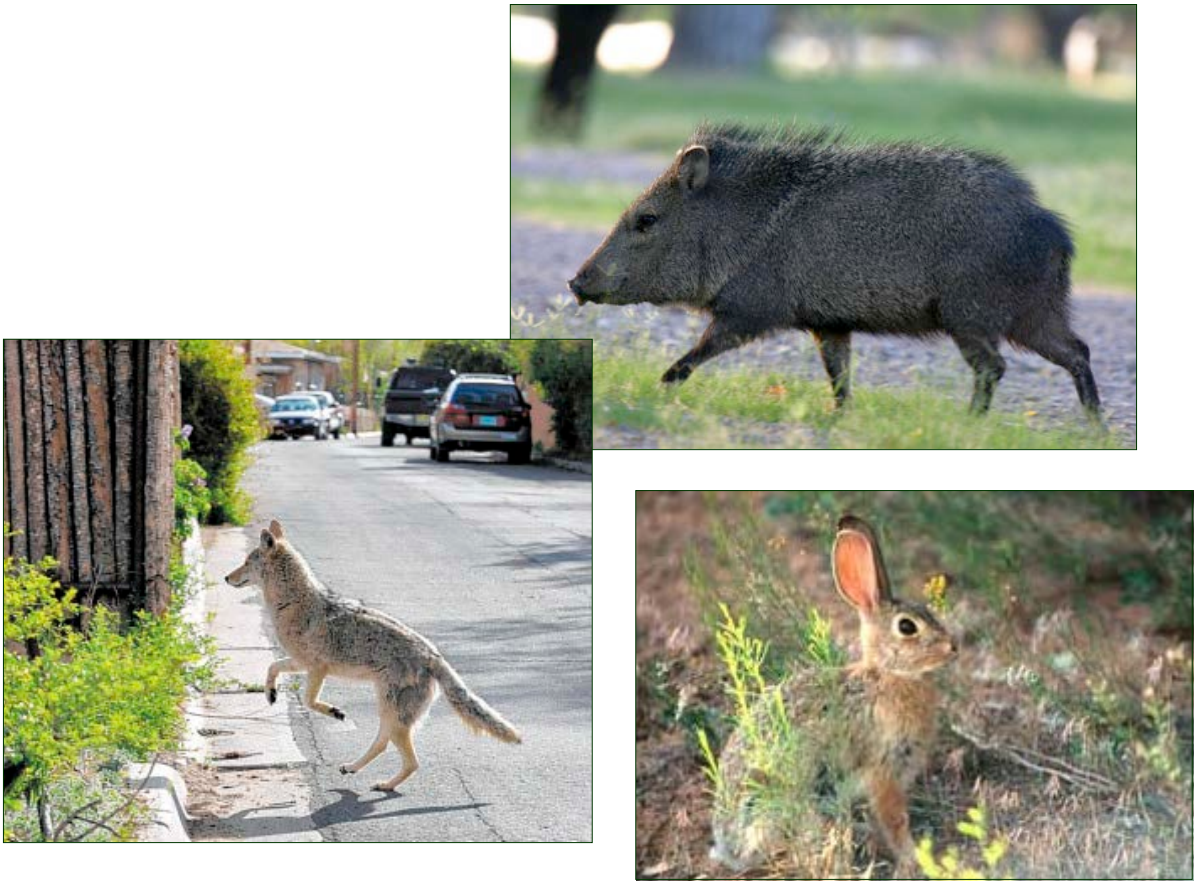
Wildlife

As part of a healthy desert ecosystem, arroyos provide vital wildlife habitat and are natural east-west wildlife corridors. It is important to have intact, unfragmented corridors so that wildlife can access different parts of their home territory without crossing highways or arterial roadways. The East Mesa Watershed has undergone significant changes over time, especially within the past two decades.[64] Before development, the watershed was largely comprised of Chihuahuan Desert vegetation, with Chihuahuan Desert arroyo riparian communities, interspersed in the valley areas and along the arroyos. However, these community types are experiencing increased pressure from development, grazing, and other human uses. With development, wildlife habitats are encroached upon which can force interaction with humans or the elimination of their ranges and areas altogether.

During the Army Corps of Engineers *East Mesa Watershed Study* (2007), many species of wildlife expected to be present in the area were either absent or not observed. It has been speculated that

[63] United Nations Office for Disaster Risk Reduction, www.unisdr.org/we/coordinate/hfa
[64] East Mesa Watershed Study, U.S. Army Corps of Engineers, 2007.

development and competition by other species or predation have caused this decline.[65] Development within the watershed has transformed the wide, uninhibited alluvial fan to a patchwork of subdivisions that have restricted arroyo flows and segmented wildlife corridors and habitat. New roadways and neighborhoods have interrupted connectivity and have made it nearly impossible for wildlife to travel outside a very limited range. Although they have been reduced in size and diversity, some unfragmented wildlife corridors could perhaps be identified and preserved. A requirement for arroyo buffers could also benefit wildlife in appropriate areas.



Wildlife have adapted to changes caused by human presence and are drawn to garbage, gardens, pet food, and backyard bird feeders. Left, Coyote: Albuquerque Journal. Middle, Collared Peccary aka Javalina: Encyclopedia of Life, http://eol.org. Right, Desert Cottontail: New Mexico Tech, http://www.nmt.edu.

[65] Ibid

Parks and Open Space

Arroyos are an important recreational asset. Runners, cyclists, equestrians and walkers use the arroyos the open spaces adjacent to them on a regular basis. Encroaching development has threatened open space recreational opportunities by limiting access to these areas through subdivision design. As an example, subdivisions may reduce or limit pedestrian and bicycle access, may make no provisions for trails and may reduce opportunities for amenities along arroyos due to development that is too close to the 100-year flood zone boundary. This limits the value of arroyo systems as a multi-faceted community asset. In addition to providing more trail possibilities, planning development further back from the 100-year flood zone would also provide more privacy for property owners and would provide greater flooding protection in higher risk areas.

Unfortunately, motorcycles and all-terrain vehicles (ATV) have disturbed vegetation and wildlife and over time, leave a scarred landscape that isn't easily returned to a natural state. Signage and perhaps fencing in specific areas may help with this as will education and raising awareness of the value of the natural environment. Providing dedicated ATV areas may also reduce the overall damage to natural areas.

Equestrians often travel along arroyo bottoms but crossing under thoroughfares is difficult because bridges are generally too low to ride under. Increased demand for natural areas, trails and trail connections, and equestrian amenities means there is a need for design standards for trail construction and trail and road crossings that consider the needs of all users. These do not currently exist.

Suitable trails for equestrians have become increasingly hard to find, particularly close to urban areas. Many trails prohibit equestrian use, fearing conflicts with other users and damage to the trail surface. However, with proper design, a multi-use trail can accommodate equestrians while minimizing user conflicts. Hard surfaces (asphalt and concrete) and coarse gravel can injure horse hooves, so loose or compacted dirt trails may be called for in selected locations.

There may be opportunities for east-west linear parks along certain arroyos, but this has not yet been studied in any great detail. Further analysis of arroyos based on geology and soil stability, vegetation, slopes, drainage patterns, etc. will identify suitable areas for such parks. More important, there is a need for an identified funding source so that open space and arroyo buffers may be acquired by the City and to ensure adequate maintenance and repairs are performed.

Buffers along arroyo systems can provide non-motorized transportation for commuting cyclists and pedestrians. Left: This mostly flat paved trail in Tucson follows the banks of the normally dry Santa Cruz River for 9.5 miles.
Photo: www.flickr.com/photos/lasertrimguy

According to the publication *Better! Cities & Towns*, total U.S. driving has dipped then leveled off in recent years, and per capita vehicle miles traveled (VMT) has steadily dropped since 2005. Per capita driving is down 8.75 percent, and is now at 1996 levels.[66] In other words, non-motorized transportation networks are becoming increasingly important. There are very few connections in Las Cruces between schools, neighborhoods, commuter bike routes and major commercial areas. Trails adjacent to arroyos are part of the Mesilla Valley Metropolitan Planning Organization's proposed trail plan and could easily be factored into new development proposals in an effort to provide additional connectivity for non-motorized transportation.

Passive recreation opportunities that incorporate arroyo systems can bring a boost to an area's economy through tourism, sporting events, and quality of life factors. Photos, clockwise from upper left: National Recreational Trails; BLM; Albuquerque Journal; Arizona Foothills Magazine.

The Economy and Quality of Life

Today the U.S. economy is dominated by high technology and service businesses selling knowledge and intellectual expertise. This economic sector is not tied to specific business locations or by the need for certain kinds of transportation facilities or raw materials. With more freedom to choose a site, businesses often select one with a high quality of life – including parks, aesthetics open space, and easy access to the outdoors – in order to compete for highly trained, in-demand workers.[67]

Companies frequently relocate where their top talent wants to live, and that is most often in places of natural beauty. When land is protected, the adjacent properties often increases in value, with homes selling for 10–20 percent more than comparable homes without access to such areas. A survey by the

[66] *Better! Cities & Towns,* Ithaca, NY 14851, June 2013. www.bettercities.net

[67] "Conservation: An Investment That Pays." Trust for Public Land, 2007, http://www.tpl.org[68] The Economic and Tax-Base Benefits of Land Conservation, Land Trust Alliance Factsheet. www.landtrustalliance.org. 2003

National Association of Realtors concludes that new homebuyers value trails and natural areas above any other amenity.[68]

As quality of life becomes an increasingly important factor for business location, there will be a greater demand for natural areas and passive recreation activities. Frederick Law Olmsted, designer of New York's Central Park, was one of the first people to suggest that parks could be paid for with increasing tax revenues that resulted from rising land values adjacent to the park. In fact, studies conducted by the Trust for Public Land have shown that investments in land conservation and open space return from $4 to $10 for every dollar invested.[69]

Conserved land and open space can provide opportunities for eco-tourism as well. The Bosque del Apache National Wildlife Refuge (NWR), which is located about 130 miles north of Las Cruces, is a protected area with unique wildlife viewing opportunities. Recreational visits generate over $4.5 million in tax revenue for the region. For every $1 of the NWR budget, there is a local economic effect of nearly $8.

One method for estimating the economic value of open space and recreation areas that do not have a market value is through hedonic[70] pricing methods. This statistical approach is used to link a good traded in the marketplace (i.e. a house) with an environmental good (i.e. a nice view) that is not traded in the market. According to a survey done by the Robert Wood Johnson Foundation, various research studies conclude that the average household living half a mile from open space would be willing to pay $4,104 more for a home to live a quarter mile closer to the open space.[71] In addition, traditional neighborhood development concentrates neighborhood density, allowing room for large open space areas. Neighborhoods that feature open spaces, parks and greenbelts have been found to have higher home sale prices, enhanced marketability and often faster sales or leases than conventional development.[72]

Key research results found by the Robert Wood Johnson survey include:

- Open spaces such as parks and recreation areas can have a positive effect on nearby residential property values, and can lead to proportionately higher property tax revenues for local governments.
- In general, urban parks, natural areas and preserved open spaces showed positive effects on property values.
- Environmental protection, greenhouse gas reductions, and mental health benefits, as well as recreational benefits, should be considered as indirect effects.

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[68] The Economic and Tax-Base Benefits of Land Conservation, Land Trust Alliance Factsheet. www.landtrustalliance.org. 2003

[69] Ibid

[70] Hedonic pricing is a model identifying price factors according to the premise that price is determined both by internal characteristics of the good being sold and external factors affecting it. The most common example of the hedonic pricing method is in the housing market: the price of a property is determined by the characteristics of the house (size, appearance, features, condition) as well as the characteristics of the surrounding neighborhood (accessibility to schools and shopping, level of water and air pollution, value of other homes, etc.).

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

[72] Ibid

- Natural area parks, on average, have the largest statistically significant effect on a home's sale price, holding all other factors constant. Value increase to homes located within 1,500 feet of the following types of parks:
    - Natural areas: $10,648
    - Golf courses: $8,849
    - Specialty parks: $5,657
    - Urban parks: $1,214[73]

It is often more cost-effective for a community to maintain open space, which can control flooding, filter water runoff, or help to mitigate air pollution, than to invest tax dollars in expensive infrastructure projects to achieve the same function.[74] For developers, these economic benefits can translate into reduced financial liability, faster sales and ultimately higher profits. The design elements of compact developments may also present cost savings. Watershed areas that are used as a form of natural drainage protection and open space also reduce construction and maintenance costs from stormwater drainage systems.

Conservation easements have been a powerful tool to protect land from development by providing federal tax breaks for donating land development rights. With a conservation easement, a property owner gives some or all of the development rights on the property to a government agency or not-for-profit (there are more than 1,700 local land trusts), and receives a federal income tax deduction for the gift amounting to the difference in the value of the land before and after the easement is in place. The land owner still owns the land and can continue to use it.

The Enhanced Easement Incentive is a temporary measure that was originally enacted by Congress in 2006, and repeatedly extended. The most recent extension, which was in effect until the end of 2013, allowed a non-farmer donor to use a conservation donation deduction for up to 50% of his gross income in any year, up from the normal 30% that is a permanent part of the law. The temporary break also allowed a donor to carry forward any unused write-off for a full 15 years, instead of the normal five. Currently, there is a new measure before Congress which would make the incentive permanent and would allow modest-income landowners to receive significant tax deductions for donating conservation easements that permanently protect important natural or historic resources on their lands.

[73] , Active Living Research, Robert Wood Johnson Foundation, May 2010. http://activelivingresearch.org.
[74] "Conservation: An Investment That Pays," Kline, J., et al, 2009. Trust for Public Land, www.tpl.org

CHAPTER 5. GOALS AND POLICIES

We are fortunate to be able to enjoy the arroyos for passive recreation activities, wildlife viewing and other fresh air experiences. But it's important to remember that first and foremost, arroyos exist as natural stormwater conveyance systems and are an integral part of the desert ecosystem. In developing policy guidance for arroyo management, our goals must further systematic flood control and drainage functions, allow continuance of historic flows in arroyos, and protect arroyos in their natural state. If those things are done well, we can continue to enjoy open space experiences for years to come.

This chapter is divided into four sections. *Land Use* addresses overarching issues related to development and growth management. *Environment* focuses ways in which the land, vegetation and wildlife can be protected. *Community Facilities* suggests policies to increase the use of arroyo systems as community assets. *Utilities and Stormwater* looks at design standards for more effective and efficient stormwater management, including erosion control, sedimentation, and utilities installation and maintenance.

Goals and Policies describe *what* should be accomplished; Actions explain *how* they will be carried out. The guiding actions to implement the goals and policies are listed in tables in Chapter 6, Administration and Implementation. Many of the policies in this plan are limited to arroyos that are not already privately owned or to arroyo areas that have not yet been developed. This will have to be determined on a case-by-case basis as individual arroyo characterization modeling is carried out. Those that may affect developed areas are limited to maintenance or mitigation issues, since flood control systems are already in place. Some of the policies below will require changes to existing codes, including LCMC Chapter 32 Design Standards and Chapter 37 Subdivisions. However, AMP policies provide guidance for decision making but are not regulatory. As is the case currently, public and private development projects follow codes that are in place at the time of development.

SECTION 1 -- LAND USE

Wise land use practices must balance the rights of landowners with the protection of our region's unique landscapes, arid vegetation and natural wildlife habitat. It is also critical that we increase our ability to manage arroyos holistically by understanding the potential impacts of our actions on a regional and watershed level. Development in the East Mesa area (and eventually on the West Mesa) should logically occur from downstream to upstream so that downstream infrastructure can be in place before upstream development occurs. It is also important that upstream flood control measures be engineered sufficiently so that downstream properties are not adversely affected.

The major arroyos that are most important to the City in the context of stormwater management and open space protection are the Alameda, Sandhill and Las Cruces Arroyos. As development moves further away from the city center, managing other arroyos properly will also become a priority. The Fillmore, Doña Ana, Moreno and Tortugas Arroyos extend into the ETZ and will be impacted as our community grows.

GOAL 1. Take a proactive approach to watershed management that takes into account existing drainage conditions as well as conditions affected by future development.

Policies:

1.1. Complete a detailed characterization of the main stems of each major arroyo so that it may be managed for optimum protection, stabilization and resiliency.

1.2. Work with governmental agencies (BLM, SLO, etc.) to retain or dedicate their arroyos and identified buffer areas to the City or County before public lands are sold for development.

1.3. Identify critical and sensitive environmental areas and contiguous open spaces and protect them from development using conservation easements, incentives, the Open Space (OS) zoning designation, etc.

1.4. Develop public/private partnerships to develop funding strategies for acquisition and maintenance of arroyo systems.

1.5. Clearly outline drainage or flood control modifications to arroyos in PUD concept plans and master plans, and include necessary details in subsequent development processes for review and approval purposes.

1.6. In areas that are in close proximity to arroyos, design and lay out lots and street locations in a way such that the natural characteristics of arroyos, such as vegetation and contours, are utilized. Site specific plans that address these issues rather than a standard design often results in a safer, more cost effective result.

1.7. In new development proposals include intended pedestrian, bicycle and equestrian connections between arroyos, thoroughfares and existing developments.

1.8. Allow green infrastructure techniques in development proposals as a way to manage storm water before it reaches the arroyos.

1.9. Increase the availability of reclaimed (purple pipe) water that could be used for establishing and supplementing native vegetation adjacent to arroyos.

1.10. Identify areas adjacent to arroyos or sections of arroyos that may be suitable for linear parks, trails or scenic corridors and provide incentives to create them.

GOAL 2. Improve the safety of the flood control dams and restore native vegetation in the storage pool areas.

Policies:

2.1. Evaluate conditions of Sandhill, Villa Mora and Las Cruces flood control dams and prioritize them for necessary mitigation, such as seepage and slope stability, pool area and spillway capacity of each dam, etc., and identify responsible City departments for these actions.

2.2. Complete appropriate re-vegetation with Chihuahuan Desert native grasses following any dam rehabilitation or maintenance activities that disturb existing vegetation.

2.3. In development proposals downstream of flood control dams, include an analysis of dam effectiveness and potential flooding impacts to that development.

2.4. Support a regional stormwater management strategy that fulfills the programs of all entities and participate as a regional partner in efforts to mitigate problems associated with improving dam functionality.

2.5. Ensure that development, zoning, and land use changes do not impede flood control dam maintenance or operations.

GOAL 3. Improve road crossing infrastructure to maximize drainage function

Policies:

3.1. Design and/or retrofit existing arroyo crossings to limit or prevent a hydraulic constriction/bottleneck under present conditions and for potential flows under future hydrologic conditions. Failure to do so could lead to incision problems and hazards to adjacent infrastructure and property improvements.

3.2. Make maximum use of existing infrastructure and previously developed road crossings to minimize encroachment into natural areas.

SECTION 2 -- ENVIRONMENT

Many opportunities exist for environmental restoration of riparian ecosystems on the East and West Mesas. While it may be unrealistic to set goals to restore developed areas to historic riparian and grassland ecosystems, it is possible to make significant strides in that direction. Desert riparian communities that will survive with surface water flows along arroyos can be restored within the watershed by various erosion control and arroyo stabilization techniques. Also, there are opportunities for environmental restoration at the dam sites in the watershed.[75] Through sound development standards, new development can adapt to existing natural environments, topography, soils, vegetation, geology, and hydrology so that fragile land forms, natural wildlife habitat and wildlife connectivity are protected.

GOAL 4: Protect and maintain natural vegetation within arroyo systems and mitigate damage that may result from development.

Policies:

4.1. Without compromising engineering design standards, promote flexibility in planning and landscaping development and utility installations that propose to retain the natural characteristics of the terrain or preserve undisturbed tributaries that feed major arroyo corridors.

4.2. When constructing and installing utility components, survey existing vegetation in arroyos and design utility installations to disturb as little vegetation as possible.

4.3. Replace vegetation lost during construction by reseeding with Chihuahuan Desert native vegetation following the requirements in NPDES 9.4.[76]

[75] ACOE East Mesa Watershed Study 2007

[76] Construction permitees in New Mexico are required to follow section 9.4. of the NPDES General Permit for Discharges from Construction Activities, which states that operators have additional time – up to three years – to establish a uniform perennial vegetative cover with a density of 70 percent of the native background vegetative cover for all unpaved areas and areas not covered by permanent structures. See EPA Construction General Permit, http://cfpub.epa.gov/npdes/stormwater/cgp.cfm

GOAL 5: Manage arroyos to retain wildlife corridors.

Policies:

5.1. Increase valuable desert wildlife habitat by evaluating areas within the watersheds where native plant restoration is feasible.

5.2. Identify and map wildlife corridors so they may be protected from construction activities.

5.3. No fencing or walls may obstruct free flow of waters or debris.

SECTION 3 -- COMMUNITY FACILITIES

Strengthening arroyo systems as a community asset can improve quality of life and bolster our economy. Las Cruces' natural areas attract tourists and new residents to the community. In addition, arroyos already provide occasions for outdoor recreation and non-motorized transportation for current residents. But it is important that in doing so, the privacy and rights of residents living adjacent to the arroyos are respected. Proper design of parks, trails, trail amenities, connectivity, equestrian facilities, street crossings, parking, signage, etc. will result in opportunities that meet the needs of all users. The Mesilla Valley Metropolitan Planning Organization (MPO) includes a Trail Plan map in their long-range transportation plan, Transport 2040. Policies in the Arroyo Management should complement and support the MPO's goals.

GOAL 6: Minimize impacts created by development and human activities to realize the full potential of arroyo systems as a community and economic asset.

Policies:

6.1. Create regional development and conservation guidelines for arroyos that cross jurisdictional boundaries.

6.2. Identify and map those arroyos and open spaces that might serve as natural connections to other public properties.

6.3. Promote neighborhood and subdivision designs that incorporate arroyos as neighborhood amenities. These may include such things as street alignments that are placed between developed areas and arroyos; open space corridors, linear parks, trails, etc.

6.4. Put forth a Quality of Life initiative to help fund community amenities such as open space acquisition.

6.5. Use adopted park impact fees or development waivers as incentives to developers to designate open space, trails and connectivity, or a linear park on a case-by-case basis.

6.6. Work with other City departments and other agencies to develop strategies to prevent illegal dumping in the arroyos, such as sign postings, Neighborhood Watch, Adopt-A-Spot, increased patrols by Codes Enforcement officers, etc.

6.7. Incorporate linear parks adjacent to arroyos into the City's Parks and Open Space Master Plan in areas where an arroyo is suitable for such a park.

6.8. Create a promotional outreach campaign about recreation opportunities, nature and open space experiences, etc. in the Las Cruces area.

GOAL 7: Achieve the goals of the MPO Trail Plan to create a continuous system of regional trails that integrates and connects arroyo systems.

Policies:

7.1. Working from the proposed trails mapped in the MPO Trail Plan, identify areas where arroyo trails may be located.

7.2. Provide adequate distance from residential development to protect privacy of property owners and from roadways to provide safe pedestrian and bicycle passage.

7.3. Construct trails outside the designated 100-year flood zone boundary on an arroyo.

7.4. Update MPO Trail Plan to improve connectivity of trails between arroyos, parks and other public open spaces, such as SLO and BLM land.

7.5. Identify potential trail locations that would be appropriate for accessibility and compliance with ADA standards.

GOAL 8: Work with the Mesilla Valley MPO to create design guidelines that ensure trails suit the characteristics of the arroyo, provide maximum usefulness and address pedestrian, cyclist and equestrian safety.

Policies:

8.1. Develop standards in the LCMC Chapter 32 Design Standards for arroyo trails according to the characteristics of the arroyo and its available buffer area.

8.2. Design arroyo crossings to include appropriate measures such as signage, push button signals or other features that will maximize safety, access and mobility.

8.3. Where applicable during the development design process, meet with adjacent neighborhoods to discuss appropriate trail amenities for pedestrians, bicycles and equestrians.

8.4. Where possible, locate parking, trail heads and amenities in such a way as to support a dual use such as postal cluster boxes, playgrounds, parks, etc.

8.5. In partnership with the MPO, develop standards for park, trail and facilities signage, route and wayfinding signage and an informational brochure identifying existing and planned trail facilities.

SECTION 4 – UTILITIES AND STORMWATER MANAGEMENT

Safe and effective engineering standards for flood control, utilities installation, storm water conveyance and water storage are important. But these designs should maintain the natural character of the arroyo and minimize impacts of development so the arroyos function optimally and natural terrain is not destroyed. This is also important to ensure historical drainage patterns are not altered.

The City promotes flexible design standards when channelizing and storing stormwater for development adjacent to designated arroyos that will enhance the natural arroyo system. It should be noted that the LCMC Chapter 34 (Drainage and Flood Control) may require more than minimum storm water standards if arroyos on a site to be developed or immediately downstream of the site show evidence of increased

flooding, accelerated erosion, channel erosion of sedimentation, as a direct result of conditions on the site. These additional requirements may include buffer zones, re-vegetation of highly eroded areas, and arroyo restoration or other erosion control measures within highly eroded channels.

GOAL 9: Create safe and effective engineering standards for flood control and conveyance while maintaining the natural character of the arroyo and achieving visual harmony.

Policies:

9.1. Keep arroyos in a natural or naturalistic condition to counteract erosion. Naturalistic treatments could include such things as native vegetation and channel stabilization using rock riprap, weirs, weirs, gabions, contouring, etc.

9.2. Do not alter a natural arroyo unless such a modification is shown to be without reasonable hazard and liability, and there are no adverse impacts to public and private infrastructure, habitats and open space. Altering a drainage path may create new and unpredictable flood responses.

9.3. Replace vegetation in areas that are disturbed during construction, in accordance to NPDES 9.4. This includes a well-established mixture of native grasses, forbs, and other ground cover to help reduce sediment movement.

9.4. In laying out adjacent street systems, keep drainage outfall structures to the minimum needed to maintain a naturalistic arroyo treatment.

9.5. Pursue innovative methods of funding storm water management practices. Special funding could include user fees, special taxation, tax incentives, grants, conservation easements, and Public or Private Improvement Districts.

GOAL 10: Minimize soil and slope instability, erosion, sedimentation and water run-off to protect water quality and the natural characteristics of the land.

Policies:

10.1. Use public education to raise awareness level of the general public and the construction/development community in regard to urban runoff, non-point source pollution and other watershed-related issues.

10.2. Strengthen the permitting and inspection process to improve compliance with the EPA NPDES MS4 permit and Construction General Permit

10.3. Do not discharge stormwater runoff directly into arroyos. Direct discharge into a settling pond, impoundment or other solution designed to stop or slow water before it reaches the arroyo. This will assist in bank stabilization by minimizing erosion and promoting growth of native vegetation.

10.4. Extend drainage structures completely into the arroyo bottom, extending to the arroyo flow line, and matching the natural terrain.

10.5. Confirm that a Notice of Intent (NOI) to the Environmental Protection Agency (EPA) has been submitted before issuing grading permits.

10.6. Place fills in such a way that they do not cause encroachment upon arroyos or other natural drainage ways.

10.7. Use Best Management Practices (BMPs) related to NPDES compliance to reduce pollutants from storm water.

10.8. Apply credits to the FEMA/Community Rating System (CRS) program for those projects adopting the management practices in the CRS program plan. This will provide additional flood protection and cost savings.

GOAL 11: Improve the safety and efficiency of utilities installation to better protect the natural environment.

Policies:

11.1. Bury utilities to a depth as determined through a soil stability analysis and to meet requirements outlined in the City Utilities Standards. In some cases this may be deeper than the minimum standard.

11.2. Design utility crossings to minimize damage to flora and fauna and to minimize changes in surrounding natural grades.

11.3. Replace desert vegetation lost during utilities installation as per NPDES 9.4.

11.4. Provide erosion control measures for infrastructure built in arroyos.

11.5. Provide appropriate access provisions to infrastructure and other facilities in arroyos and along their buffers to provide for necessary operation and maintenance.

CHAPTER 6. ADMINISTRATION AND IMPLEMENTATION

The City's comprehensive planning framework begins with broad goals defined in *Comprehensive Plan 2040*, and is referred to as "Level 1" within the framework. More detailed plans, Level 2, include community planning blueprints and neighborhood, corridor and technical plans. The Arroyo Management Plan (AMP) is considered a Level 2 technical plan. In order to accomplish goals and policies in these Level 2 plans, Actions are identified, some of which lead to regulations in our codes, such as the Zoning Code, Development Standards, Subdivision Code and other related chapters in the City's Municipal Code. Goals, Policies and Actions are defined as:

> **Goals** represent an ideal future condition or long-term end state that the City strives to achieve, but which are not necessarily measurable.
> **Policies** are statements that guide action and imply clear commitment toward achieving or advancing a goal.
> **Actions** identify procedures, programs, or techniques City departments and/or other entities accomplish on a day-to-day basis that will make the policies and goals a reality.

The last step is in this process is implementation, during which most of the actions are carried out. Actions in the AMP involve changes to codes, strengthening enforcement of these codes, educating the public, and regulating the City's own practices in such a way that we meet or exceed the minimum requirements. In some cases, regulations and practices that are not already reflected as policies in the AMP will have to be added later as a plan amendment. In this way, policy and practice are consistent and support the same purpose. Listed below are actions that address goals in the Land Use, Environment, Community Facilities, and Utilities & Stormwater Management sections of Chapter 5. In most cases, cooperation among City departments, other governmental agencies and/or the private sector will be critical.

The actions noted below are intended to guide arroyo management and may need to be modified somewhat to reflect the realities of implementation. For example, some measures as written may simply be too expensive to implement or may conflict with existing regulations. In these cases, steps should be taken to remove barriers to implementation, i.e. secure funding, amend existing codes, etc.

As noted earlier, the City supports a regional stormwater management strategy and would participate as a regional partner in efforts to manage arroyo systems. It is important that we look broadly at arroyo systems at the watershed level, and then continue to characterize individual arroyos for specific management needs. This will require the participation and collaboration of many different public and private entities with land and natural resource management responsibilities. Development would then occur systematically and would be based on thorough physical and regulatory analyses of the arroyos and surrounding terrain.

LAND USE

GOAL 1. Take a proactive approach to watershed management that takes into account existing drainage conditions as well as conditions affected by future development.

Actions for Policies 1.1 – 1.10

It is important 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. Protecting arroyo systems and improving overall stormwater management begins by amending existing ordinances that would set parameters for these activities. Once amended, a checklist of reports, data or other appropriate information that should be submitted with development proposals ensures that these issues are addressed to the satisfaction of the City.

ACTION	COLLABORATING PARTIES
To characterize individual arroyos, combine existing and new modeling work to include data about hydrology, land use, vegetation, wildlife, soil type, topography, drainage patterns, etc. This complete watershed model would be used to determine buffers, areas appropriate for linear parks, scenic corridors, and areas that are more susceptible to erosion that may require treatments beyond the minimum regulations. Measured laterally from the 100-year flood zone boundary, buffers would be determined based on the characteristics of the arroyo or its banks. For example, a buffer may include bands of indicator species of vegetation and small channels that are apparent outside the 100-year floodplain if the modeling data support those inclusions.	City of Las Cruces all appropriate departments
Carry out appropriate joint agreements to dedicate arroyo systems (arroyo + buffer) to the City of Las Cruces.	City of Las Cruces, NM State Land Office, Bureau of Land Management
Identify long-term funding sources and other strategies for land acquisition, maintenance and other activities. These may include such things as: • Land and Water Conservation Fund **(**LWCF**)** funding to acquire new lands and secure conservation easements on private lands. • General obligation bonds could be used for "Quality of Life" amenities including open space acquisition. Generally backed by the City and paid back through property taxes. • Special Assessment District (SAD) distributes the cost of a project to property owners who realize a direct benefit once the improvements are constructed. This could be used for storm drains, sanitary sewers, water service, roadways, sidewalks and other related public infrastructure. •	CLC all appropriate departments

[The following revision, including the deletion and added Action, have been recommended by the City's Legal Department.] • Public Improvement Districts are similar to a SAD in that they provide a means to generate funds for construction and maintenance of public infrastructure. Cost of project is distributed to only those properties that gain a direct benefit. Different from SAD in that funds are placed in a fund that is managed by a board of directors. • Other federal funding sources for environmental protection.	
• Prepare a cost benefit analysis of implementing Sections 3-41-1 through 3-41-5, NMSA 1965, entitled "Flood Control," which allows New Mexico cities to tax properties within their municipal boundaries up to $5 per $1000 (5 mill) of net taxable value to pay for authorized flood control structures within and without the municipal boundaries. Include a historical analysis of funding for City Fund #4400 for flood control purposes. This would show the amount acquired annually at the current 2 mill rate ($2 per $1000).	CLC all appropriate departments
Map arroyos and proactively zone major arroyo systems as OS-NC to preserve them as open space.	CLC Community Development
Consider a City development pilot project that adheres to the goals and policies of the AMP to demonstrate the plan's implementation.	CLC all appropriate departments
Amend appropriate chapters of the LCMC to revise requirements for PUD and subdivision proposals to fulfill policies herein.	CLC all appropriate departments
Expand education program about project designs that minimize impact to water quality.	CLC all appropriate departments
Identify areas requiring erosion protection in development proposals and require designs for protective measures, as provided in UTILITIES & STORMWATER MANAGEMENT GOALS in Chapter 5	CLC all appropriate departments
Strengthen enforcement of NPDES Stormwater BMPs for Construction and Post-Construction.	CLC all appropriate departments
Create incentives for developments that zone arroyo buffers or larger contiguous areas of opens space as OS-NC.	CLC Community Development
Increase access to reclaimed water.	CLC Utilities

GOAL 2. Improve the safety of the flood control dams and restore native vegetation in the storage pool areas.

Actions for Policies 2.1 – 2.5:

The initial purpose of East Mesa flood control dams, particularly the Alameda, North Fork, and South Fork Dams, was to provide localized flood and sediment control. These dams are at varying stages of effectiveness and currently serve, mainly, as sediment catch basins. According to the 2006 Storm Drain Master Plan, these three dams are serving to reduce peak discharge rates under both the 100- and 500-year storms. The dams do not have a major impact on the total volume of water that is delivered to each analysis point as they are designed as detention and not retention facilities; even so, the dams are still

valuable for peak reduction and lagging.[77] Additionally, the conditions of the dams have probably changed somewhat since 2006. For example, the Bureau of Land Management has performed rehabilitation work on the Alameda Dam. Updating the dam condition and effectiveness reports may be called for.

There is an opportunity for improving dam safety and bringing them up to current safety standards. Additionally, there is an opportunity for environmental restoration features in the storage pool areas. Las Cruces can participate in a regional effort to address problems related to the flood control dams. But direct responsibilities and actions are limited to the Villa Mora, Las Cruces and Sandhill dams.

ACTION	COLLABORATING PARTIES
[The following deletion has been recommended by the City's Legal Department.] For dams outside the jurisdiction of the City of Las Cruces, the City encourages participating entities to re-evaluate dam effectiveness and make appropriate decisions about mitigation measures, such as breaching, installing hydraulic structures, rehabilitating, etc. This may include vegetative restoration if disturbed during dam maintenance or rehabilitation. For the City's dams and for dams outside the jurisdiction of the City of Las Cruces, the following measures are suggested: • Install hydraulic structures upstream and increase capacities of those dams identified by the Army Corps of Engineers for such measures. • Utilize the full catalog of storm water management, erosion control, and revegetation options for dam rehabilitation before making the decision to breach those dams which have been identified for such actions. • Implement appropriate restoration measures in the upper reaches of the watersheds to slow flow and decrease sediment loads that reach the dams.	All entities participating in regional stormwater management.

GOAL 3. Improve road crossing infrastructure to maximize drainage function

Actions for Policies 3.1 – 3.2:

[77] City of Las Cruces Storm Drain Master Plan, Section 4, Analysis of the Dams in the East Mesa Watershed, Bohannan Huston, Inc., 2006

ACTION	COLLABORATING PARTIES
Amend Design Standards to require strategies to prevent erosion, sedimentation and constriction problems under roadway crossings, such as installing sediment catch basins upstream of the culvert, debris barriers, energy dissipaters, etc.	City of Las Cruces all appropriate departments
Identify and secure increased funding for regular maintenance of such infrastructure.	

ENVIRONMENT

GOAL 4: Protect and maintain natural habitat & wildlife connectivity within arroyo systems to the greatest extent possible and mitigate damage that may result from development.

Goal 5: Manage arroyos to retain wildlife corridors.

Actions for Policies 4.1 – 5.3:

ACTION	COLLABORATING PARTIES
Amend Landscape Design Standards to include revegetation requirements as per NPDES General Construction Permit Section 9.4., including a list of acceptable/desirable species for revegetation in and/or adjacent to arroyos and dam ponding areas.	CLC all appropriate departments
Work with the local Soil and Water Conservation District to offer programs to encourage planting native vegetation and trees. Outreach to developers and homeowners would demonstrate the importance of establishing vegetation and other measures to control soil erosion.	CLC all appropriate departments
Work with NMSU, U.S. Fish & Wildlife and/or other appropriate organizations to begin a wildlife corridor database project.	CLC, NMSU, USFW, etc.

COMMUNITY FACILITIES

GOAL 6: Minimize impacts created by development and human activities to realize the full potential of arroyo systems as a community and economic asset.

Actions for Policies 6.1 – 6.8:

Since these areas are managed by private and public sector parties, actions that will maximize the public value of arroyo systems and open space must satisfy the policies and needs of all parties. Providing incentives, securing additional funding sources and creating partnership agreements are just some of the ways this can be achieved.

ACTION	COLLABORATING PARTIES
Work with appropriate agencies to establish regional conservation guidelines within city limits and the ETZ area.	CLC all appropriate departments, Doña Ana County (including Flood Commission), SLO, BLM, NMSU, etc.
Identify and map existing and potential open space linkages and zone as OS-NC.	CLC all appropriate departments
Amend appropriate codes to allow transfer of development rights.	CLC all appropriate departments
Intensify Neighborhood Watch, Adopt-A-Spot, and other anti-dumping programs in areas where illegal activity is frequent.	CLC Police (Codes Enforcement)
Advertise local transfer stations and county collection centers to promote proper disposal of waste and reduce trash dumping in arroyos and other open spaces.	CLC all appropriate departments, Doña Ana County
Using the arroyo characterization model, develop criteria to define a linear park and identify arroyo systems suitable for such parks.	CLC all appropriate departments

GOAL 7: Working from the MPO Trail Plan, create a plan for a continuous system of regional trails that integrates and connects arroyo systems.

GOAL 8: Create design guidelines for trails and trail crossings to ensure that the trails suit the characteristics of the arroyo, provide maximum usefulness and address pedestrian, cyclist and equestrian safety.

Actions for Policies 7.1 – 8.5:

Connecting isolated pockets of open space to each other and to existing parks, trails and schools will expand the potential of arroyos systems as a public asset. While some arroyo systems may be perfectly suited for a multi-use trail, others may not due to lack of soil stability or sufficient buffer distances. Trails and trail crossings must be designed according to the type of trail desired and the characteristics of individual arroyos.

ACTION	COLLABORATING PARTIES
Amend Design Standards to reflect policies 7.1 through 8.7. regarding landscaping, trails, trail crossings and trail heads that will meet the needs of bicyclists and equestrians as well as pedestrians.	CLC Community Development, Public Works (Facilities), and Parks
Identify appropriate locations for multi-use trails (accessible) and include them in next updates of the Parks & Recreation Master Plan and MPO Transport 2040.	MVMPO, CLC Community Development, Parks,

	Public Works (Facilities), GIS

UTILITIES AND STORMWATER MANAGEMENT

GOAL 9: Create safe and effective engineering standards for flood control and conveyance while maintaining the natural character of the arroyo and achieving visual harmony.

Actions for Policies 9.1 – 9.5:

These actions are intended to minimize the visual impacts of stormwater management structures adjacent to and in the arroyos and protect the natural landscape as much as possible. While it may first appear difficult or expensive to carry out these methods, most of them are techniques that are already used extensively and will only require small changes.

ACTION	COLLABORATING PARTIES
Consistently follow and enforce Storm Water Management Ordinance requirements.	CLC all appropriate departments
Amend Chapter 32 Design Standards and other relevant codes to reflect policies above.	CLC all appropriate departments
Improve review and inspection of all construction projects, including CLC-initiated projects, for compliance with the MS4 Permit, specifically PART 5 Storm Water Management Program (SWMP).	CLC all appropriate departments

GOAL 10: Minimize soil and slope instability, erosion, sedimentation and water run-off to protect water quality and the natural characteristics of the land.

Actions for Policies 10.1 – 10.8:

ACTION	COLLABORATING PARTIES

Amend development standards in Chapter 32 to create maximums for the amounts and types of cut and fill activity allowed adjacent to and surrounding identified arroyos systems and drainage facilities.	City of Las Cruces all appropriate departments
Amend Design Standards to adhere more closely to National Menu of Best Management Practices (BMPs) to further reduce pollution from stormwater. http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm	City of Las Cruces all appropriate departments

GOAL 11: Improve the safety and efficiency of utilities installation to better protect the natural environment.

Actions for Policies 11.1 – 11.5:

ACTION	COLLABORATING PARTIES
Create improved methods for constructing utilities, taking into account proper scour analysis, loss of service risk, and minimizing aesthetic impacts to the arroyos.	City of Las Cruces all appropriate departments
Require revegetation of areas where native vegetation is disturbed, as per NPDES General Construction Permit Section 9.4.	City of Las Cruces all appropriate departments
Develop handbook of appropriate modifications to arroyos for situations in which minimally containing the arroyo would be the most appropriate option. For example, illustrations of acceptable structures, materials, etc.	City of Las Cruces all appropriate departments
Engage the Soil and Water Conservation District to offer programs to encourage planting native vegetation and trees. Outreach to developers and homeowners would demonstrate the potential for soil erosion in the region and the importance of establishing vegetation and other measures to control soil erosion.	CLC Community Development, Public Works (Facilities), Utilities and Parks
Develop an erosion and sedimentation design guide for use by the City, developers and property owners.	CLC Public Works
Require minimum LID techniques in all development proposals and provide incentives for those proposals that exceed minimums.	CLC Public Works, Parks, Community Development

CHAPTER 7. CONCLUSIONS

Since 1956, City of Las Cruces planning documents have called for an approach to development and stormwater management that preserves arroyos in their natural state. In recent years, Comprehensive Plan 2040, the Storm Water Management Plan, Transport 2040, the Parks and Recreation Master Plan, and other related plans adopted by the City have included policies to guide both public and private efforts. The Comprehensive Plan 2040 Future Concept Map 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.

As development has increased, arroyos have been rerouted, channelized, or dammed to prevent or mitigate flood damage. In some cases, these actions were the only alternatives to protect downstream property. But in general, this has interrupted natural drainage function, wildlife connectivity and the propagation of vegetation, and have, in several instances, modified historic drainage in negative ways.

Specifically in arroyo environments, development designs can be implemented to maintain the natural character of the arroyo. It is also important to maintain 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. In addition, arroyos can provide a variety of recreational opportunities.

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, as called for in the 1992 Storm Water Management Policy Plan. 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.

The AMP suggests utilizing "buffers" in certain instances where additional flood protection may be called for. The plan defines a buffer as an area adjacent to an arroyo where development may not occur or may be reduced in intensity. It would be measured laterally from the boundary of the 100-year flood zone. Over the arroyo's length, the buffer may vary, depending on 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. Additional data could be integrated into the modeling, such as the presence of wildlife, pockets of vegetation outside the 100-year flood zone and other geographical or built features that may inform appropriate buffer locations and distances.

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

Although one may not think immediately of economic development when considering arroyo management, key research results found by a Robert Wood Johnson Foundation survey conclude that open space has a positive effect on residential property values and that environmental protection and the mental health benefits afforded by open space protection should be considered indirect positive effects. In addition, it is often more cost-effective for a community to maintain open space, which can control flooding, filter water runoff, or help to mitigate air pollution, than to invest tax dollars in expensive infrastructure projects to achieve the same function. For developers, these economic benefits can translate into reduced financial liability, faster sales and ultimately higher profits.

Planning for the possibility of more intense rain storms in the future, protecting vegetation and wildlife habitat, maintaining the flood control dams, and carrying out improved installation and maintenance of utility infrastructure are just some of the considerations that must be kept in mind when planning for future growth in our community. Requiring buffers in specific areas for added erosion protection, proactively zoning land as Open Space-Recreation (OS-R) and Open Space-Natural/Conservation (OS-NC), tightening compliance with stormwater management regulations, opting to go beyond the minimum requirements, and committing to Best Management Practices are a few changes that will further protect the health, safety and welfare of the general public. This integrated approach to development and open space preservation will prevent further damage to our open lands and improve the overall health of our environment.

RESOURCES

EPA Stormwater Home Page -- This website contains technical and regulatory information about the NPDES stormwater program. It is organized according to the three types of regulated stormwater discharges – municipal separate storm sewer systems (MS4s), construction activities, and industrial activities. It also provides links to general stormwater topics and tools available, including Best Management Practices (BMP).
http://water.epa.gov/polwaste/npdes/stormwater/index.cfm

Using Smart Growth Techniques as Stormwater Best Management Practices
http://www.epa.gov/smartgrowth/pdf/sg_stormwater_BMP.pdf

Protecting Water Resources with Higher-Density Development – This report is intended for water quality professionals, communities, local governments, and state and regional planners who are grappling with protecting or enhancing their water resources while accommodating growing populations.
http://www.epa.gov/smartgrowth/pdf/protect_water_higher_density.pdf

Center for Watershed Protection -- The Center for Watershed Protection, Inc. is a 501(c)(3) non-profit organization dedicated to fostering responsible land and water management through applied research, direct assistance to communities, award-winning training, and access to a network of experienced professionals.
http://www.cwp.org/

The **Stormwater Manager's Resource Center** is designed specifically for stormwater practitioners, local government officials and others that need technical assistance on stormwater management issues. Created and maintained by the Center for Watershed Protection, the SMRC has everything you need to know about stormwater in a single site:
http://www.stormwatercenter.net/

Low Impact Development -- LID is an approach to land development (or re-development) that works with nature to manage stormwater as close to its source as possible.
http://water.epa.gov/polwaste/green/

Low Impact Development (LID) Urban Design Tools Website -- This site provides watershed managers with a new set of tools and techniques that can be used to meet regulatory and receiving water protection program goals for urban retrofits, re-development projects, and new development sites.
http://www.lid-stormwater.net/index.html

Green Infrastructure – GI generally refer to systems and practices that use or mimic natural processes to infiltrate, evapotranspirate (the return of water to the atmosphere either through evaporation or by plants), or reuse stormwater or runoff on the site where it is generated.
http://water.epa.gov/infrastructure/greeninfrastructure/index.cfm

Municipal Separate Storm Sewer System (MS4) Main Page -- Stormwater runoff is commonly transported through a Municipal Separate Storm Sewer System (MS4), from which it is often discharged untreated into local water bodies such as the Rio Grande. To prevent harmful pollutants from being washed or dumped into an MS4, operators (in our case, the City of Las Cruces) must obtain a NPDES permit and develop a stormwater management program.
http://water.epa.gov/polwaste/npdes/stormwater/Municipal-Separate-Storm-Sewer-System-MS4-Main-Page.cfm