Lyon County Development Guidelines

For Area Drainage Master Plan Areas

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NOTE – this document supersedes prior ADMP development guidelines that may have been drafted as part of an individual ADMP study.

1 INTRODUCTION

Natural environmental hazards associated with drainage and storm water runoff exist in all watersheds. Development can adversely affect natural drainage pathways and create flood and erosion hazards if adequate planning and management rules are not applied. To protect private and public property, and the health and general welfare of the public, naturally occurring drainage hazards and potential hazards related to development need to be identified, and appropriate development standards applied to manage new development.

Area Drainage Master Plans (ADMP) within Lyon County identify certain drainage hazards in the watersheds found within each ADMP study area. The development guidelines outlined in this document are a non-structural component of a comprehensive flood hazard management plan that can be applied to all ADMP study areas within Lyon County. Other flood mitigation strategies may be implemented by developers or agencies, such as flood warning systems, at-risk property acquisition, or structural flood control measures. The development guidelines identify drainage issues, recommend development practices, identify required engineering analysis, and describe best management practices for floodplain management and drainage engineering.

Implementation of development guidelines for drainage hazards has been shown to reduce public expenditures for structural flood control measures, decrease the level of maintenance needed for flood control facilities, and lessen the need for acquisition of public right-of-way for flood control. In addition, application of development guidelines reduces the potential for flood damage to private and public property and reduces the need for public funding for flood mitigation.

The guidelines presented in this document are intended to be used by Lyon County as a tool in assessing the flooding risk impacts of future small- (individual lot) and large- (master planned community) scale development. The guidelines are intended to be used concurrently with data developed in conjunction with ADMP studies to determine existing conditions flood risk, and appropriate mitigation procedures. The guidelines are also intended to assist Lyon County in determining when additional engineering analyses are needed for future development approval.

NOTE – this document supersedes prior ADMP development guidelines that may have been drafted as part of an individual ADMP study.

1.1 BACKGROUND AND RATIONALE

Historically, governmental agencies have developed floodplain management measures such as floodplain ordinances, drainage ordinances, and development standards intended to mitigate the flood impacts of urbanization. If these measures are not adequate or are not adequately enforced, the consequences may include flooding of homes and businesses, displacement of existing natural flood flows, increased flood depths, and flooding of lands previously not in a floodplain. The adverse impacts of urbanization on drainage often include elements described in the following sections.

1.1.1 More Frequent Flooding
As the land area within a watershed is converted from natural rangeland to buildings and pavement, less rainfall infiltrates into the ground and more rainfall becomes runoff. This results in more frequent runoff events and increased nuisance flooding.

1.1.2 Larger Flood Peaks
The change from naturally occurring pervious land surfaces to urbanized impervious surfaces also causes the size of floods to increase, as more runoff leaves the watershed. Urbanized watersheds generate not only large flood peaks, but also larger flood volumes and floods of longer duration, both of which increase flood damages. As flood peaks increase with urbanization, existing drainage structures become inadequate and have a greater risk of underperformance and/or failure.

1.1.3 Scour, Erosion, and Sedimentation
Because more land area is covered by homes, streets, and landscaping, as a watershed urbanizes, the natural sediment supply to streams is decreased, which causes floods to be more erosive. This erosion leads to loss of homes, property, and farmland due to riverine bank erosion, scour damage to bridges and culverts, and adverse impacts to flood control facilities and natural river habitat. Increased frequency and magnitude of channel scour results in channel instability, and eroded sediment will often end up on roadways and in and around buildings downstream. Clean-up efforts for sedimentation issues can be costly in areas that experience repetitive flooding.

1.1.4 Flow Diversion
Unmanaged development can block natural flowpaths, diverting runoff toward areas that were previously not flooded. This is frequently seen in areas with low density development and shallow, distributary flow patterns. Individual property owners will construct berms to divert flood flows away from their property, resulting in adverse impacts to adjacent and downstream properties. Similarly, construction of buildings in distributary flow areas can result in diversion and concentration of flow to adjacent properties. Such diversion activity can generally be simulated by modern engineering and modeling tools, demonstrating the liability of the upstream property with great accuracy and certainty. This often pits neighbor against neighbor and results in costly litigation.

1.1.5 Flow Concentration
Development in riverine or sheet flooding floodplains blocks natural overland flowpaths, concentrating runoff through narrower conveyance corridors. Flow concentration leads to higher flood peaks, higher flood velocities, and accelerated scour and erosion.

1.1.6 Expanded Floodplains
Increased flood peaks and flow diversion increase flood water elevations and expand floodplain widths, inundating properties previously safe from flooding and expanding the number of homes and business at risk for future flood damage.

1.1.7 Reduced Surface Storage
Reducing surface storage area by grading individual lots to reduce ponding areas or soggy soils, by erecting structures within former ponding and flood-prone areas, increases both the peak flow and the volume of runoff generated by a given storm, and may also result in a loss of vegetation that further increases runoff rates.

1.1.8 Decreased Ground Water Recharge

Increased impervious surface area in an urbanized watershed inhibits ground water recharge and reduces soil moisture, with adverse consequences to long-term water supply, subsidence, and loss of vegetation.

1.1.9 Loss of Riparian Habitat

Increased erosion due to increased flood peaks and reduced sediment supply leads to degraded habitat along river corridors, with adverse impacts to wildlife and public recreation.

Adherence to the development guidelines will lessen the adverse impacts of urbanization and decrease the cost of flooding for the public.

1.2 Objectives

Communities develop drainage ordinances, policies, and standards with the intent to mitigate/minimize flooding impacts due to urbanization of a watershed. The overall objective of these development guidelines is to minimize the occurrence of losses, hazards, and conditions adverse to public health, safety, and general welfare that can occur during flooding.

The general objectives of the development guidelines include the following:

- Enhance public safety by guiding development in the watershed to protect current and future residents from the effects of flooding.
- Reduce adverse drainage impacts due to development in the watershed by guiding activities of new construction.
- Guide future development in a manner consistent with the floodplain management objectives found within each ADMP study.

The following specific objectives were established to guide the development of criteria and the means of implementation:

- Develop guidelines that have been tested on the actual environmental and development conditions within Lyon County.
- Develop guidelines consistent and compatible with existing statutes, ordinances, and regulations.
- Limit the guidelines to solely those necessary to address watershed-specific problems not adequately covered by existing Floodplain and/or Drainage Regulations.

The proposed Development Guidelines for the ADMP areas are consistent with the general and specific objectives set forth above.

1.3 Authority

1.3.1 National Flood Insurance Program

Under the National Flood Insurance Program (NFIP), federal laws require the State of Nevada and Lyon County to manage and regulate all development in flood zones. The NFIP regulations are outlined in the Code of Federal Regulations (44 CFR Chapter 1 Part 59-80).

1.3.2 Nevada Revised Statutes

Local governmental entities are limited in their powers to those expressly granted by the State, as codified in the Nevada Revised Statutes[1] (NRS).

1.3.3 Local Drainage Regulations

Any development within Lyon County is subject to the drainage regulations within which the development is proposed.

1.3.4 Local Jurisdiction Hazard Mitigation Plan Documents:

Lyon County Multi-jurisdictional Hazard Mitigation Plan (latest effective revision)[2].

Section Eight Mitigation Strategy	Goal 3 (Actions 3A - 3C): Reduce the possibility of damages and losses due to dam/canal failure. Goal 7 (Actions 7A – 7K): Reduce the possibility of damages and losses due to flooding.
Section Eight Mitigation Strategy	Goal 4 (Actions 4A - 4C): Reduce the possibility of damages and losses due to flood and flash flood.

1.4 Additional Resources

The following are hyperlinks to additional resources on local development requirements and general floodplain management.

Lyon County Development Standards
https://www.lyon-county.org/993/Development-Standards

Navada Division of Water Resources
https://water.nv.gov/index.php/programs/floodplain-management
https://water.nv.gov/uploads/floodplain-mgmt-docs/NV_Quick_Guide.pdf

Navada Department of Transportation
https://www.dot.nv.gov/doing-business/about-ndot/ndot-divisions/engineering/design/drainage-manual

[1] https://www.leg.state.nv.us/NRS/
[2] https://www.lyon-county.org/1078/Hazard-Mitigation

1.5 COMPLETED AREA DRAINAGE MASTER PLANS

Table 1-1 lists the areas within Lyon County that have been assessed with ADMP studies as of the date of this document. This table should be updated with each completed ADMP in the future. Figure 1-1 through Figure 1-4 show each ADMP study area.

Table 1-1. ADMP Project List

Project Name	Area Description	Year Completed
Dayton Valley Area Drainage Master Plan	Dayton Valley north of the Carson River	2019
South Dayton Valley Area Drainage Master Plan	Dayton Valley south of the Carson River	2020
North Silver Springs Area Drainage Master Plan	North Silver Springs north and south of US Highway 50	2024
Stagecoach Area Drainage Master Plan	Stagecoach north and south of US Highway 50	2024

1.6 FUTURE DEVELOPMENT AREAS

The development guidelines presented herein are applicable within Lyon County for areas not yet evaluated with a regional ADMP study under the following conditions:

- A Flood Hazard Types assessment be conducted for the area of interest (see Section 2.1.1). 33
- A regional two-dimensional model be developed that includes any piedmont area upstream of the proposed development.
- An alluvial fan assessment be conducted to determine if the proposed development is subject to active alluvial fan flooding (see Section 2.4).

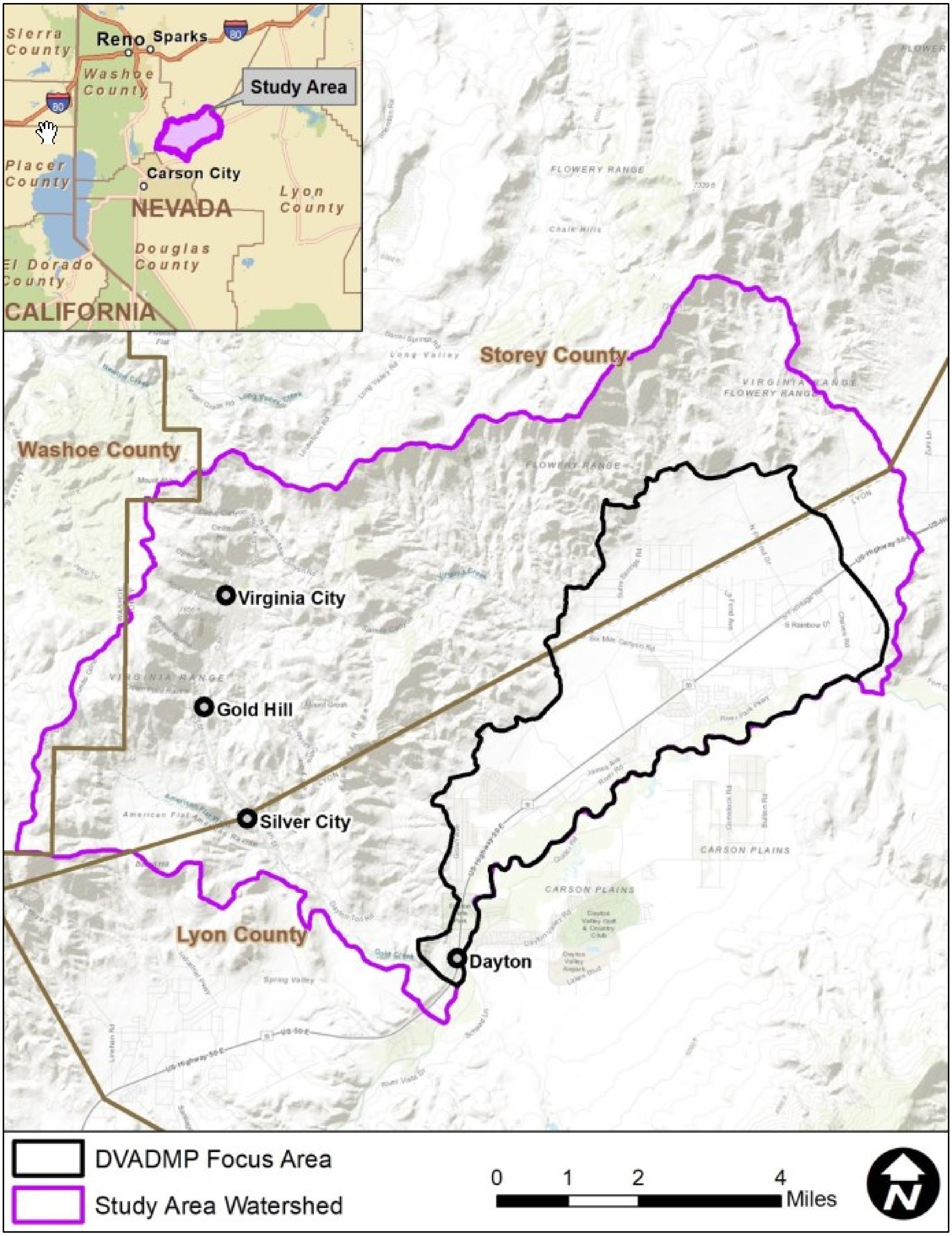

Figure 1-1. Dayton Valley ADMP project area

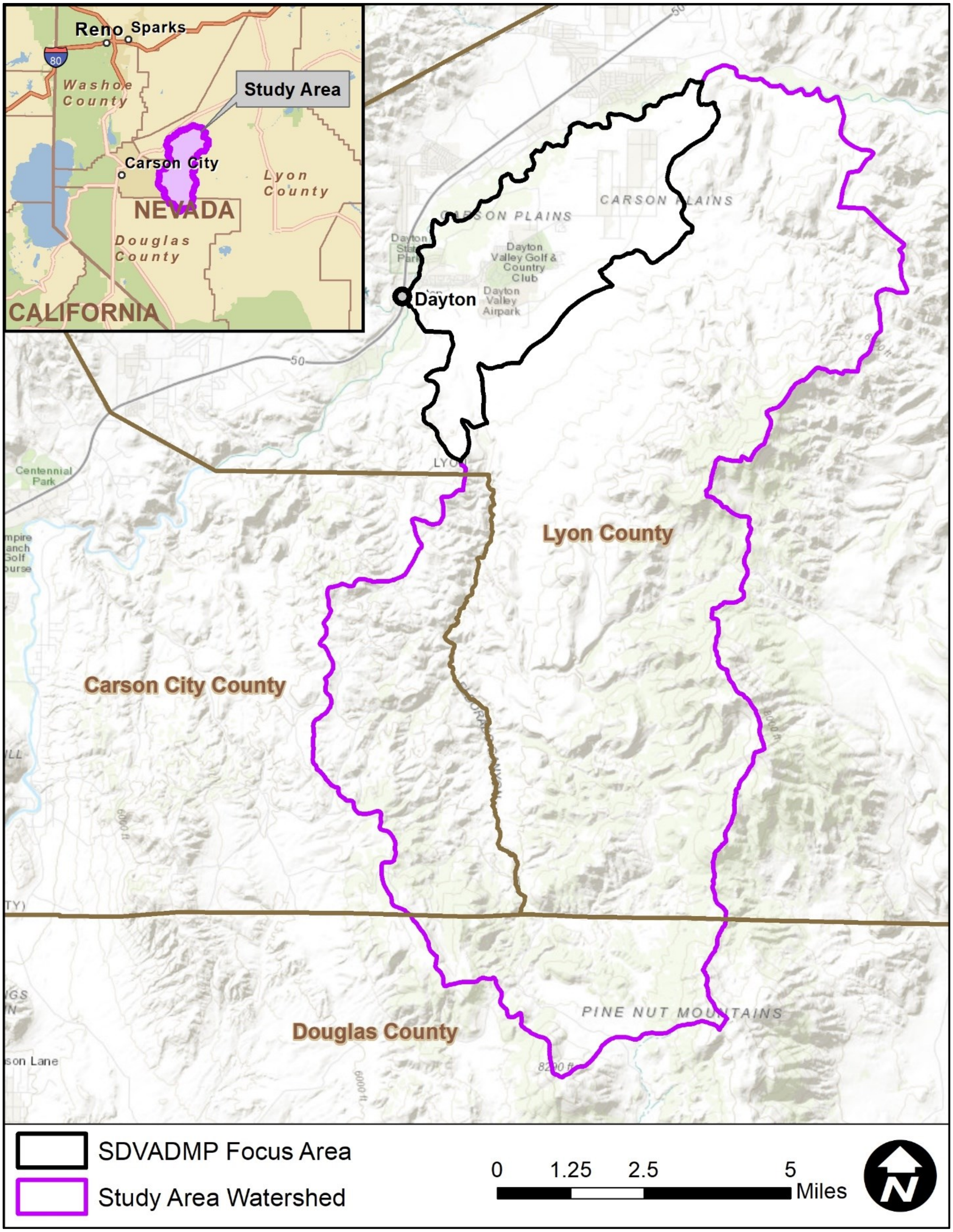

Figure 1-2. South Dayton Valley ADMP project area

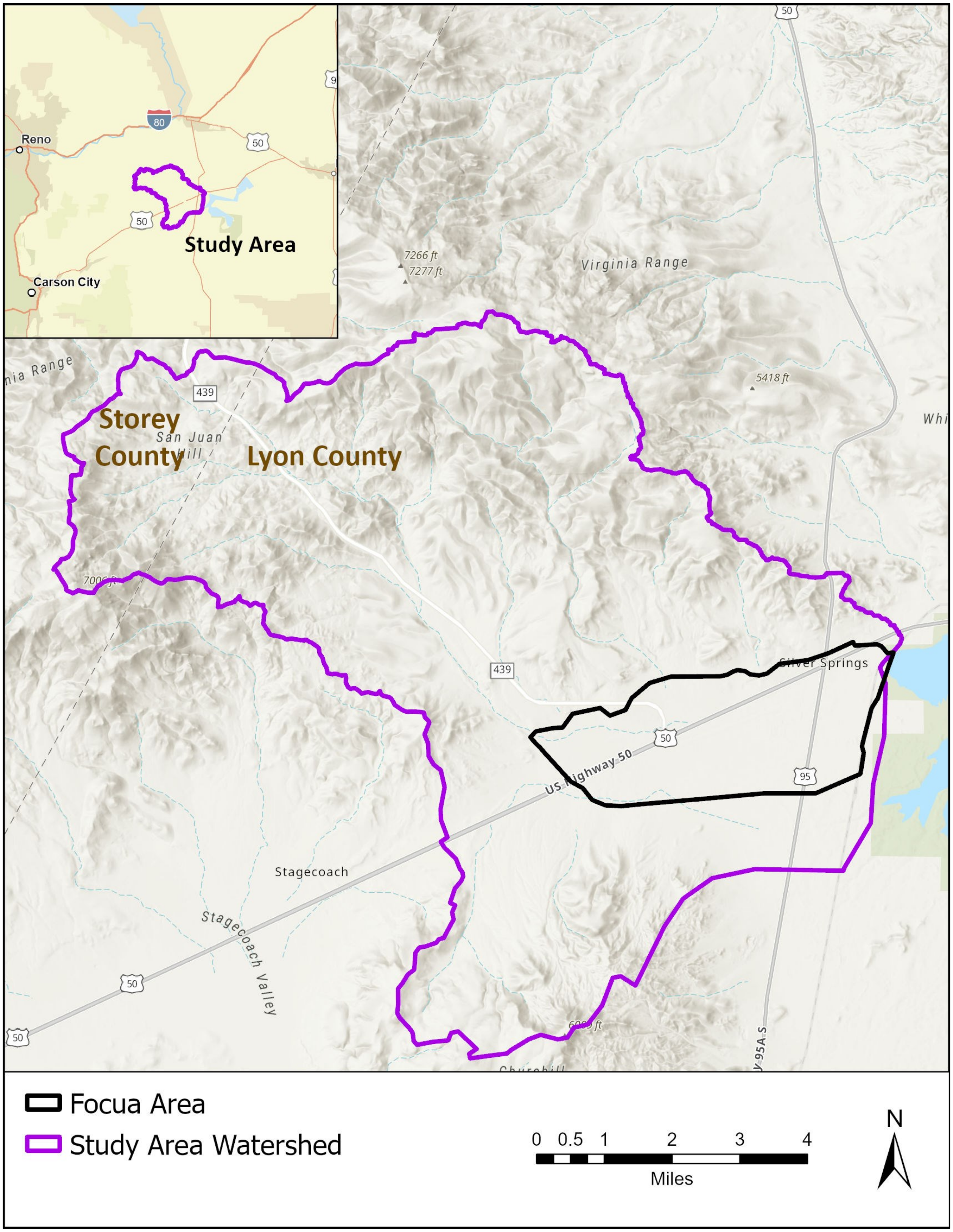

Figure 1-3. North Silver Springs ADMP project area

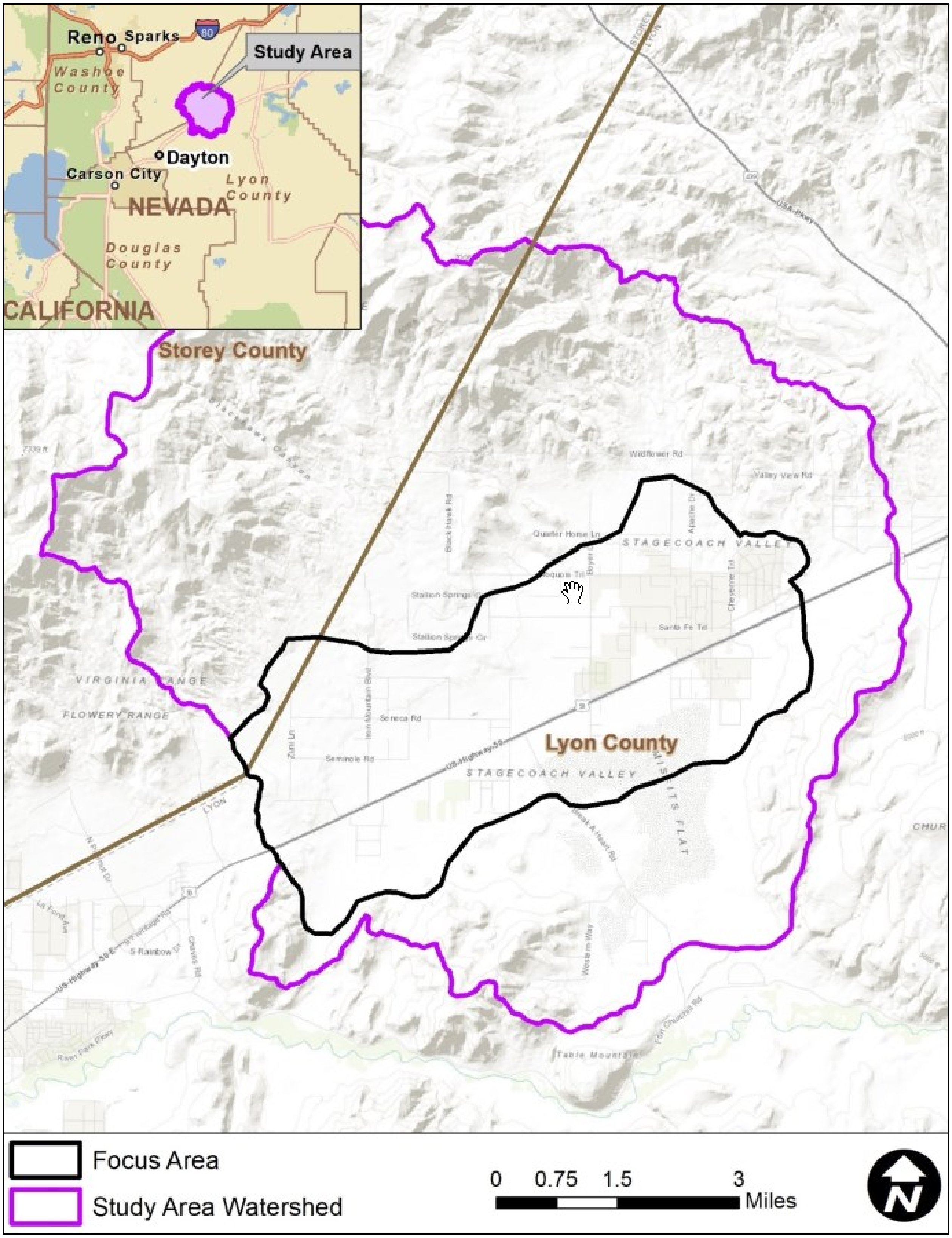

Figure 1-4. Stagecoach ADMP project area

2 DEVELOPMENT GUIDELINES

2.1 FLOODPLAINS AND SPECIAL CONSIDERATION AREAS

2.1.1 General Considerations

Development guidelines for the following types of natural hazards are presented in this chapter:

- Section 2.2: Riverine Flooding
- Section 2.3: Distributary Flooding
- Section 2.4: Alluvial Fan Flooding
- Section 2.5: Sheet Flooding
- Section 2.6: Development Modified

A definition, example photographs, and several key technical references are provided for each hazard type and are followed by the hazard-specific development guidelines.

To determine which flooding type is applicable to a specific location, a flooding hazard type delineation must be developed. Such mapping is available for the Dayton Valley, South Dayton Valley, and Stagecoach ADMP study areas (Figure 2-1). It is recommended that a flooding hazard map be generated for all future ADMP studies in Lyon County.

One of the flooding types shown in Figure 2-1 is Development Modified. These are areas where high-density development has significantly altered the natural drainage pattern. These areas fall under County drainage standards and ordinance requirements.

For any specific development parcel in an ADMP study area, general information regarding flood hazards impacting the site can be identified using the ADMP hydraulic flood modeling results. The hydraulic modeling provides comprehensive but generalized hazard information. It is highly recommended that individuals developing property in the study area also contact qualified registered professional engineers, geologists, and/or hydrologists for more site-specific information regarding the hazards at specific development parcels.

In case of conflict between the development guidelines and other policy or regulatory guidelines, the following two guiding principles for development should be considered universally:

- **No Adverse Impact**. All development shall have no adverse impact on the pre-development hazard level on any adjacent property.
- **Existing Regulations Enforced**. All development shall comply with all existing local, state, and federal floodplain regulations.

For the purposes of this document, development means any man-made change to property, including but not limited to buildings or other structures, mining, dredging, filling, grading, paving, excavation or drilling operations, or storage of materials or equipment.

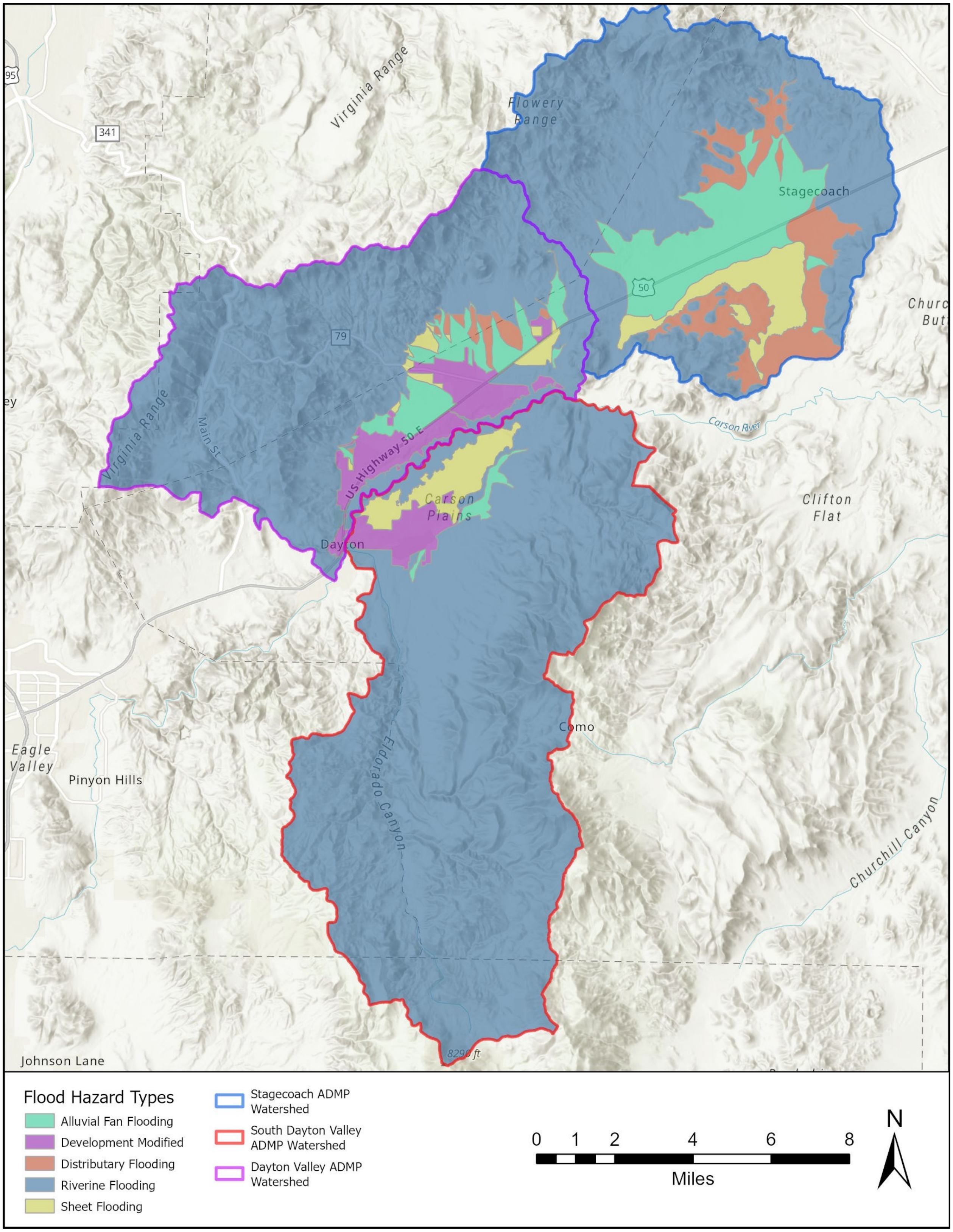

Figure 2-1. Mapped flooding hazard types from existing ADMP studies

2.2 RIVERINE FLOODING

Riverine flooding is generally the most common and is caused by channel bank overtopping when the flow capacity of a channel is exceeded locally. The rising water levels generally originate from heavy high-intensity rainfall creating soil saturation and large runoff - locally or in upstream watershed areas. Riverine areas are characterized by a tributary (or dendritic) drainage pattern in which there are many contributing streams (analogous to the twigs of a tree), which are then joined together into the tributaries of the main river (the branches and the trunk of the tree, respectively). They develop where the river channel follows the slope of the terrain (Figure 2-2 and Figure 2-3).

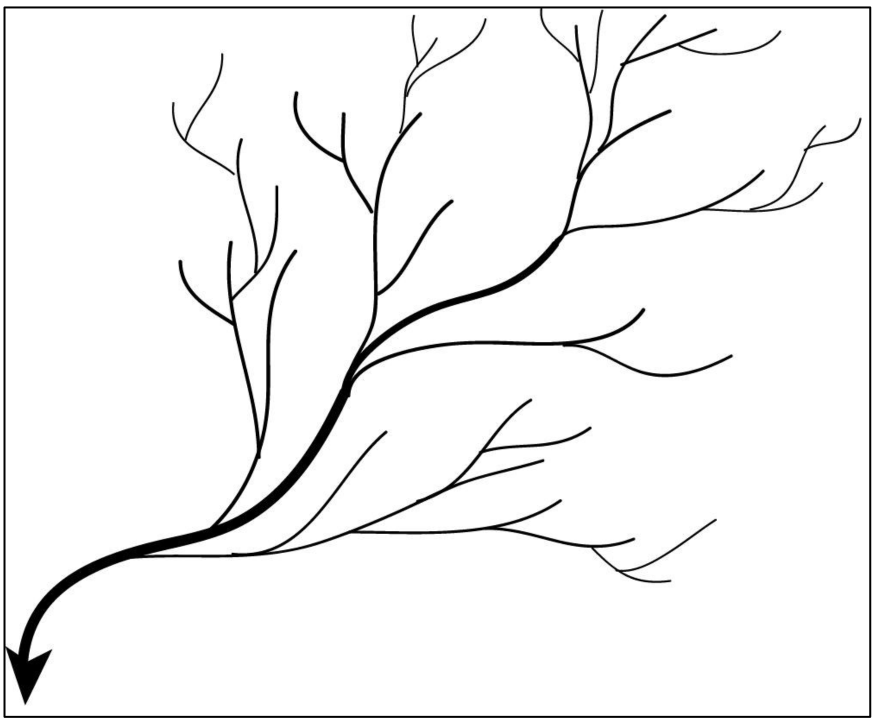

Figure 2-2. Example of tributary (dendritic) drainage pattern

2.2.1 Development Guidelines for Riverine Flooding Areas

Future development within the riverine areas should be processed using the current Lyon County Development Standards[3] and ordinances and/or FEMA guidelines for development in Federal Emergency Management Agency (FEMA) regulatory floodplain zones.

If the proposed development is within a completed ADMP study area, the ADMP study hydrologic and hydraulic data should be used as the basis for the existing conditions drainage assessment. If the topographic mapping data used in the ADMP is greater than 5-years old, it is recommended that updated mapping be conducted to adequately represent the existing conditions terrain.

[3] https://www.lyon-county.org/993/Development-Standards

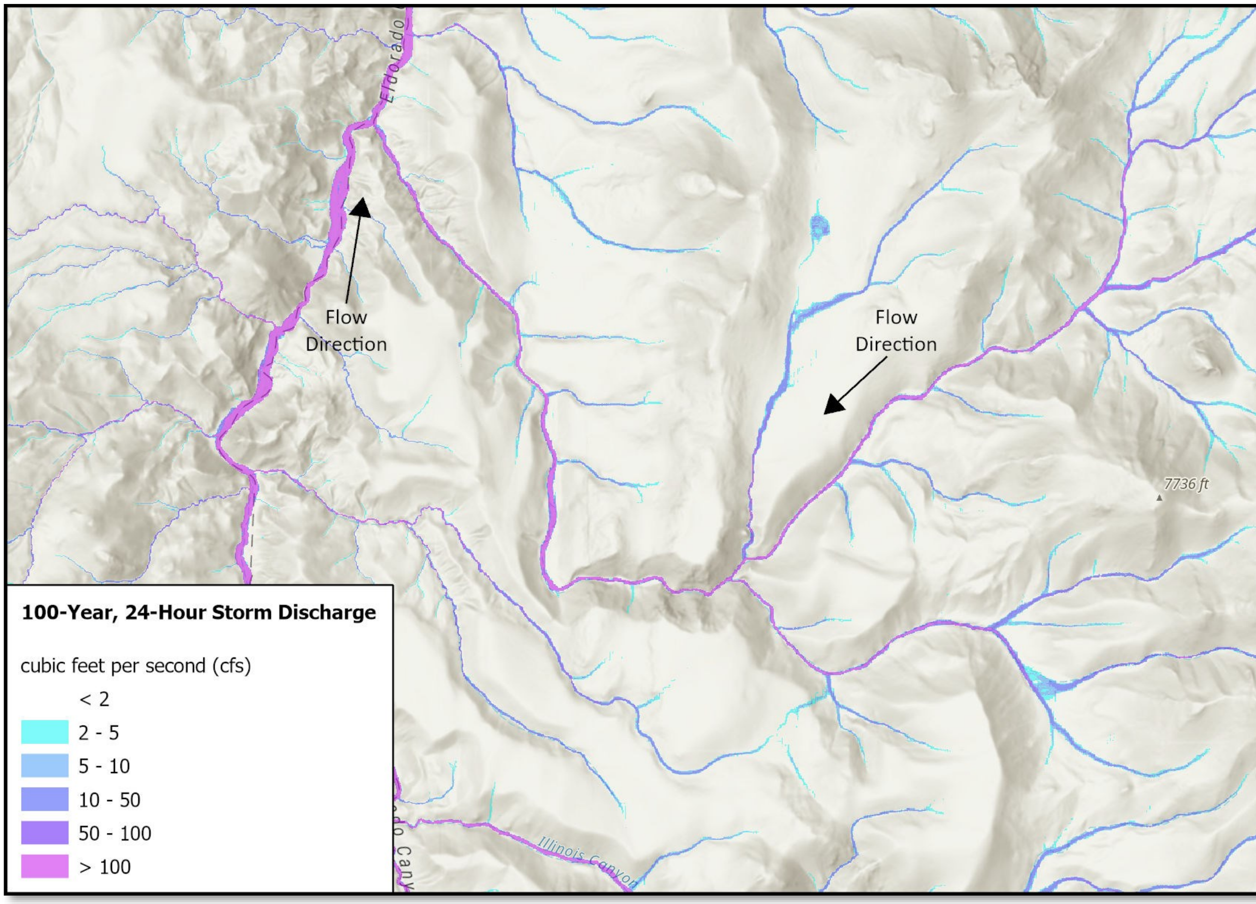

Figure 2-3. Example of riverine flooding (South Dayton Valley ADMP)

2.3 Distributary Areas

2.3.1 Hazard Description

Distributary areas are distinctive flood hazards that occur throughout Lyon County, and which create difficulties for engineering design and floodplain management due to the uncertainty created by diverging flowpaths (Figure 2-4). Unlike riverine channels that combine in the downstream direction, distributary channels diverge (or split) in the downstream direction distributing flow across a wider area as flow moves downstream. Distributary channels may be stable and not subject to significant changes in flow distribution over time, or they may be dynamic and gradually change over time or rapidly during a single flood event. Unregulated development in distributary areas can cause changes to flow distributions and result in adverse impacts to downstream properties.

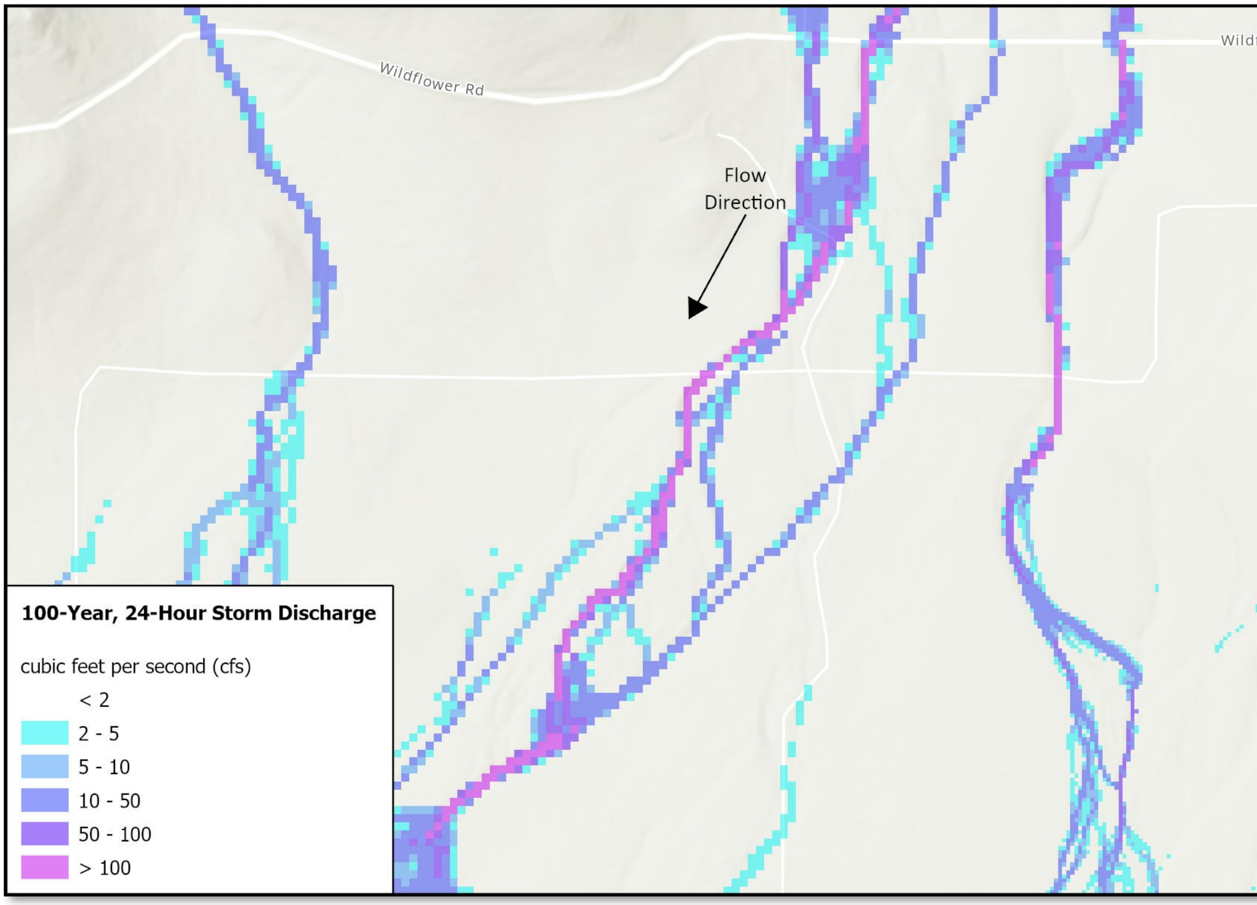

Figure 2-4. Example of distributary flooding (Stagecoach ADMP)

2.3.2 Development Guidelines for Distributary Flooding Areas

2.3.3 Definitions

Distributary flow is a loosely defined term. In general, the term "distributary flow" may refer to any form of runoff that occurs over a broad, expansive, sloped area in which flow diverges in the downstream direction.

In general, distributary flooding Lyon County has the following characteristics:

- The primary identifying characteristic of distributary flow is that flood water is conveyed in a series of channels, some defined, some undefined, across and surface.
- Distributary flooding may exhibit similar characteristics of sheet flooding (see Section 2.5) but generally occurs on steeper slopes with a more defined channel network.
- Distributary flooding has the capacity to transport significant volumes of sediment. Distributary channels tend to be smaller than tributary channels so the sediment size for transport is often limited to coarse sand or finer.
- Distributary flooding may not have gradually varied or steady flow and may have a strong two-dimensional character. One-dimensional hydraulic models may not be the most appropriate tool

to evaluate distributary areas as the complex channel network is not often captured adequately in the model geometry. Two-dimensional hydraulic modeling may be the most appropriate tool to evaluate distributary flow areas. The choice of hydraulic modeling software should be at the discretion of the modeler but should be discussed with Lyon County engineering staff before commencement of any technical study or analysis.

- Significant loss of flow volume may occur during distributary flooding due to infiltration and transmission losses. These losses are most appropriately accounted for in two-dimensional modeling software applications.

2.3.4 Development Guidelines for Distributary Flow (DF) Areas

Policy DF 1: Single Lot Site Conveyance. For single-lot development in the distributary flow areas, collecting flows from multiple channels will result in a concentration of flow that will likely be larger than the capacity of any one of the distributary channels. Diverting concentrated flow away from structures and onto adjacent properties must be avoided. Concentrated flows shall be returned downstream to the natural flow condition prior to exiting the property. This may be accomplished through onsite detention or other structural improvements.

Policy DF 2: Subdivision Flow Concentration. Drainage design in distributary flow areas should limit the concentration of flows and preserve natural flowpaths wherever possible. Where multiple channels are captured and channelized, appropriate scour and erosion protection shall be applied to the channelized areas. Concentrated flows shall be returned downstream to the natural flow condition prior to exiting the property.

Policy DF 3: Drainage Master Plan. A drainage master plan should be developed for any subdivision located in a distributary flow area. Among other requirements, the drainage master plan should demonstrate that the roadway network that serves the divided property has no adverse impact to drainage patterns and runoff concentration. In general, the street layout should be designed to cross perpendicular to the primary flow direction to prevent capture and diversion of distributary flow.

Policy DF 4: Finished Floor Elevation. For non-subdivision development, elevate the lowest finished floor elevation of habitable structures to a minimum of 1.5 feet above the 100-year, 24-hour flow depth as determined from the ADMP depth grids. Note that significant backwater conditions may occur in distributary flow areas upstream of roadways with drainage structures that are not sized for the 100-year storm. Flood depths resulting from these backwater conditions may exceed depths indicated by local geomorphology or field conditions. In such areas, the finish floor elevations should be elevated at least 1 foot above the elevation of the roadway which creates the backwater condition. For subdivisions planned in distributary flow areas, finished floor elevations should be established by detailed engineering analyses, and should include two-dimensional modeling.

Policy DF 5: Structure Alignment. Homes in distributary flow areas should be aligned parallel to the primary flow direction. Streets should be oriented perpendicular to the primary flow direction.

Policy DF 6: Development Density. Zoning densities higher than 1 residence per acre (RAC) may be appropriate within distributary flow areas if they are based on drainage studies that analyze potential concentration of flow, downstream impacts, and result in no adverse impacts to adjacent properties.

All development within a distributary flow area should be conducted using sound drainage engineering principles. If the proposed development is within a completed ADMP study area, the ADMP study hydrologic and hydraulic data should be used as the basis for the existing conditions drainage assessment. If the topographic mapping data used in the ADMP is greater than 5-years old, it is recommended flowpaths be verified for accuracy with current conditions, or new mapping be conducted to adequately represent the existing conditions terrain.

2.4 ALLUVIAL FAN AREAS

2.4.1 Hazard Description

Alluvial fan landforms pose unique flooding hazards that are not present on non-fan landforms (e.g., riverine landforms). The Federal Emergency Management Agency (FEMA) defines alluvial fan flooding as "Flooding occurring on the surface of an alluvial fan or similar landform which originates at the apex and is characterized by high-velocity flows; active processes of erosion, sediment transport, and deposition; and unpredictable flowpaths" (FEMA 2016)[4]. Alluvial fans generally originate at a topographic apex located between a mountain front and the adjacent piedmont landform. Properly identifying alluvial fan landforms is a critical first step in understanding flood risk to downstream development (Figure 2-5). Active alluvial fans are unique flood hazards in that they experience not only flash flooding and erosion common to all arid region streams, but they can also experience dramatic shifts in channel location that make floodplain management and flood hazard mitigation challenging. Active alluvial fans are a much more dynamic landform and are more hazardous than distributary flow areas.

[4] FEMA, 2016, Guidance for Flood Risk Analysis and Mapping – Alluvial Fans. Available on-line at: https://www.fema.gov/sites/default/files/2020-02/Alluvial_Fans_Guidance_Nov_2016.pdf

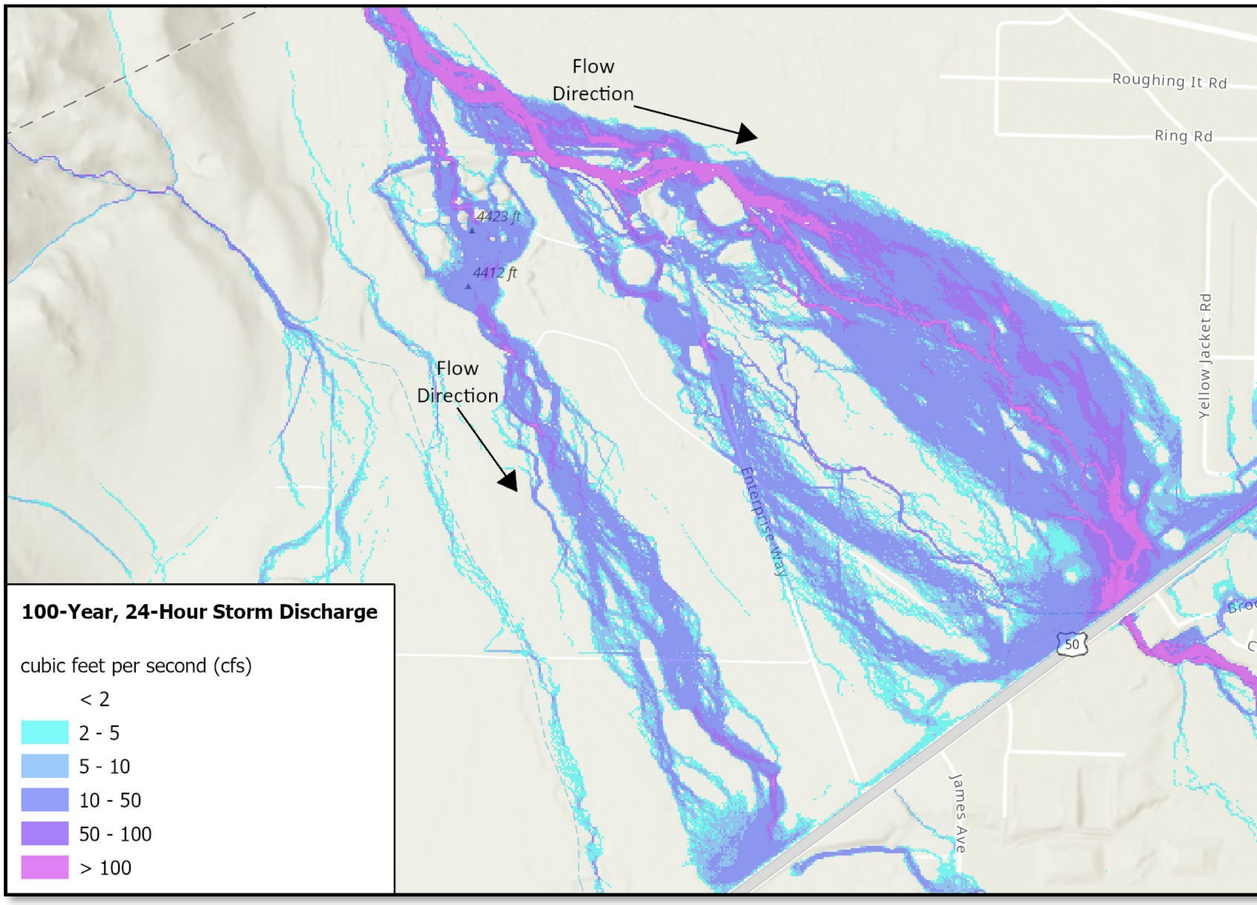

Figure 2-5. Example of alluvial fan flooding (Dayton Valley ADMP)

2.4.2 Definitions

- **Alluvial Fan** means a sedimentary deposit located at a topographic or hydrographic break, or sudden loss of lateral confinement, such as the base of a mountain, escarpment, or valley side. Alluvial fan landforms are composed of streamflow and/or debris flow sediments (alluvium), and that have the shape of a fan either fully or partially extended. Alluvial fans may be active or inactive. The development guidelines described below apply primarily to active alluvial fans. Inactive alluvial fan landforms are generally defined by riverine or distributary flooding types.

- **Alluvial Fan Flooding** occurs only on active alluvial fans and is characterized by flowpath uncertainty, meaning flowpaths are susceptible to changing in both direction and geometry over time or during a single flood event. The presence of alluvial fan flooding is indicated by three key criteria:
    - Flowpath uncertainty below the topographic or hydrographic apex.
    - Abrupt deposition and ensuing erosion of sediment as a stream or debris flow loses its competence to carry material eroded from a steeper, upstream source.
    - An environment where the combination of sediment availability, slope and topography creates a potential ultra-hazardous condition near the hydrographic apex, and uncertainty in flood risk on the downstream area of the fan.

- **Apex** means a point on an alluvial fan below which the flow of the major stream that formed the fan becomes unpredictable and alluvial fan flooding may occur.

2.4.3 Types of Alluvial Fans

A variety of terms are commonly used to describe alluvial fans. The terms are not synonyms, as each type of fan is subject to different types of flood hazards. More detailed information on these can be found in the references listed below.

- **Active Alluvial Fan.** Those locations where flooding, erosion, and/or deposition have occurred on the landform in relatively recent time (within the historical record) and probably will continue to occur on that part of the landform.

- **Alluvial Plain.** A level or gently sloping tract or a slightly undulating land surface produced by extensive deposition of alluvium, usually adjacent to a river that periodically overflows its banks. It may be situated on a floodplain, a delta, or an alluvial fan.

- **Bajada.** A broad, continuous alluvial slope or gently inclined detritus surface, extending along and from the base of a mountain range out into and around an inland basin, formed by the lateral coalescence of a series of separate but confluent alluvial fans, and having an undulating character due to the convexities of the component fans. A bajada is a surface of deposition, as contrasted with a pediment (a surface of erosion that resembles a bajada in surface form), and its top often merges with a pediment.

- **Inactive Fan.** A geologically older alluvial fan landform where active fan processes have not occurred typically within the past 10,000 years and probably will no longer occur on that part of the landform in the future. On inactive alluvial fans flood water typically is conveyed along incised channels and adjacent to stable land.

- **Pediment.** A broad, flat or gently sloping, rock-floored erosion surface or plain of low relief, typically developed by sub aerial agents (including running water) in an arid or semiarid region at the base of an abrupt and receding mountain front or plateau escarpment, and underlain by bedrock (occasionally by older alluvial deposits) that may be bare but more often partly mantled with a thin and discontinuous veneer of alluvium derived from the upland masses and in transit across the surface. The longitudinal profile of a pediment is normally slightly concave upward, and its outward form may resemble a bajada (which continues the forward inclination of a pediment).

- **Piedmont.** A general term for an area, plain, slope, glacier, or other feature formed at the base of a mountain or mountain range. May be referred to as a piedmont terrace, piedmont pediment, or bajada.

2.4.3.1 Technical References:

- FEMA, 2016, Guidance for Flood Risk Analysis and Mapping – Alluvial Fans. Available at: https://www.fema.gov/sites/default/files/2020-02/Alluvial_Fans_Guidance_Nov_2016.pdf
- National Research Council, 1996, Alluvial Fan Flooding, National Academy Press, Washington, D.C. Available for purchase at: http://www.nap.edu/

- Arizona Department of Water Resources (ADWR). State Standards for Floodplain Management. Standard for Development Within Sheet Flow Areas (SS4-95A). Available at: http://www.azwater.gov/AzDWR/SurfaceWater/FloodManagement/StateStandards.htm

2.4.4 Development guidelines for Active Alluvial Fans (AF)

Policy AF 1: Floodplain Delineation. Any new FEMA floodplain delineation within the ADMP alluvial fan areas must be completed to FEMA standards. For subdivisions, the alluvial fan floodplain delineation must extend from a point above the apex where no flowpath uncertainty exists downstream to the piedmont axial stream or playa. In most cases, the floodplain delineation must be submitted to and approved by FEMA prior to the issuance of building permits. For single lot residential development, the floodplain delineation may be limited to the building envelope and does not need to be submitted to FEMA. For all delineations, lateral tie-in upstream and downstream to effective (approved) floodplain delineations and to CLOMR/LOMR delineations that reflect structural flood control measures. Floodplain delineations on alluvial fans shall be completed using the procedures described in current FEMA Guidelines.

Policy AF 2: Whole Fan Solution Preferred. Identification of active alluvial fans, control of their apex, and conveyance of flow through the entire fan will usually be necessary for development within active alluvial fan areas. Whole fan solutions that control the apex of the active alluvial fans are strongly preferred. These types of solutions provide for flood conveyance through the entire fan (a regional solution), and outfall into a regional drainageway sized to convey the 100-year discharge.

Policy AF 3: Non-Structural Flood Control. Special consideration should be given to avoiding development within flood prone areas on active alluvial fans, accommodating the unstable and indeterminate flow associated with the alluvial fans, and maintaining existing sediment transport conditions. Consideration should be given to protect the major conveyance channels, and associated banks and vegetation.

Policy AF 4: Flowpath Uncertainty Modeling. An avulsion is the process by which flow is diverted out of an established channel into a new course on the adjacent floodplain[5]. Avulsions divert flow from one channel into another, leading to a total or partial abandonment of the previous channel[6], or may involve simple flowpath shifts in a braided or sheet flooding system. Avulsions are commonly associated with active alluvial fan flooding but are also known to occur on riverine systems and river deltas.

The occurrence of avulsions is what makes an alluvial fan "active." Avulsions give the alluvial fan the ability to distribute water and sediment over the surface of the landform, which results in the radial "fan" shape. Avulsions influence flood hazards on alluvial fan landforms by changing the location, concentration, and severity of flooding on the fan surface. That is, an area not previously inundated by flooding (or inundated only by shallow flow) may in a subsequent flood become the locus of flood inundation, sediment deposition, and/or erosion. If an alluvial fan has no risk of avulsion, flood hazard

[5] Slingerland, R and Smith, N.D., 2004, River Avulsions and Their Deposits, Annual Review of Earth and Planetary Science, Vol. 32:257-285.
[6] Field, John, 2001, "Channel avulsion on alluvial fans in southern Arizona," Geomorphology, Vol. 37, p. 93-104.

delineation and mitigation become much simpler engineering problems, consisting only of modeling two-dimensional flow and/or normal riverine hydraulic and sedimentation issues.

The occurrence of major avulsions in an alluvial fan drainage system introduces the following complications into an engineering analysis of the flood hazard:

- Uncertain and changing flowpath locations, during and between floods
- Continually changing channel and overbank flowpath topography
- Inundation and/or sedimentation hazards in previously un-flooded areas
- Uncertain and changing flow rate distribution for areas downstream of avulsions
- Uncertain and changing watershed boundaries for areas downstream of avulsions
- Aggrading, net depositional land surfaces and channels with diminishing capacity
- Unsteady, rapidly varied flow conditions
- High rates of infiltration and flow attenuation across the fan surface

In addition to considering flowpath uncertainty, future non-subdivision development that occurs on active alluvial fans shall elevate the lowest finished floor elevation of habitable structures to be a minimum of two feet above the 100-year, 24-hour flow depth as determined from the ADMP depth grids to account for potential sedimentation. It is recommended that subdivision development follow policy AF2 where feasible.

All development within an active alluvial fan area should be conducted using sound drainage engineering principles and must include a flowpath uncertainty assessment. If the proposed development is within a completed ADMP study area, the ADMP study hydrologic and hydraulic data should be used as the basis for the existing conditions drainage assessment. If the topographic mapping data used in the ADMP is greater than 5-years old, it is recommended that updated mapping be conducted to adequately represent the existing conditions terrain.

2.5 SHEET FLOODING

2.5.1 Hazard Description

Sheet flooding is a type of surface water runoff that occurs on broad, unconfined floodplains with low lateral relief (Figure 2-6). Sheet flooding can occur in urban, rural, and natural areas. Because sheet flooding often occurs in areas that lack defined stream channels, identification of sheet flood areas can be difficult.

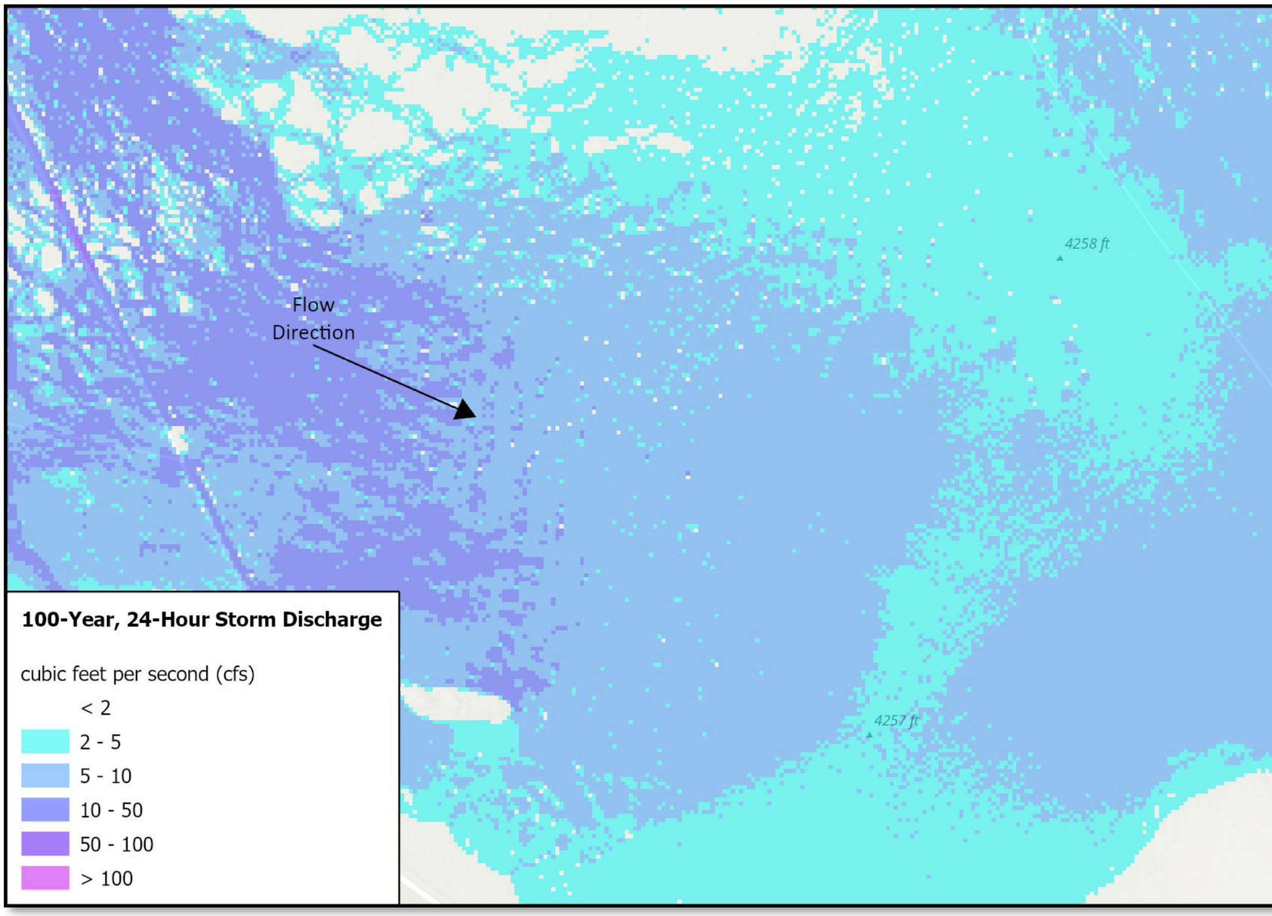

Figure 2-6. Example of sheet flooding (Stagecoach ADMP)

2.5.2 Definitions

Sheet flooding is a loosely defined term. In general, the term "sheet flooding or sheet flow" may refer to any form of unconfined runoff that occurs over a broad, expansive area. This broad definition of sheet flooding incorporates several more narrowly defined flow types, including natural (classic) sheet flooding, urban sheet flooding, agricultural sheet flooding, overland flow, perched flow, anastomosing flow, and distributary flow. The variety of terms used for sheet flooding probably reflects the variety of flow types that occur within specific geographic regions of the county. For this study, the term "sheet flooding" will be used generically, to include all types of sheet flooding that occur in Lyon County.

In general, sheet flooding has the following characteristics:

- The primary identifying characteristic of sheet flooding is that a significant part of flood water is not conveyed in a single, well-defined channel. Flood flow is conveyed over the unchannelized land surface.
- Water moving over a smooth stable surface does not move as a uniform film. If the surface is broad, the sheet differentiates into parallel streams of greater depth and relatively rapid flow, separated by shallower bands of relatively sluggish flow; and at the same time, both streams and intervening bands differentiate into series of transverse waves which move forward more rapidly than the body of the undifferentiated sheet.

- Sheet flooding over poorly vegetated surfaces often can transport large sediment volumes over relatively large distances across low slopes. Although often characterized by low depths, sheet flooding can possess enough stream power to cause significant erosion around structures such as building foundations.
- Sheet flooding has markedly different hydraulic characteristics for sediment laden and sediment deprived flows. Sheet flooding may not have gradually varied or steady flow and may have a strong two-dimensional character.
- Significant loss of flow volume may occur during sheet flooding due to infiltration and other abstractions.
- Sheet flooding often enters a larger channel or drainage system that intersects its flow but occasionally dissipates due to infiltration or other loss mechanisms before ever reaching a channel. There are many closed basin watersheds within Lyon County. In this environment, sheet flooding will often occur on the shallow slope surfaces surrounding a playa before terminating within the playa pool area.

2.5.3 Types of Sheet Flooding

- Natural sheet flooding occurs in undeveloped areas and consists of flowing water characterized by a tendency to spread widely in relatively shallow sheets over gently sloping areas with low topographic relief which lack defined drainage systems.

- Urban sheet flooding occurs where development has obscured natural drainage patterns or where urban drainage facilities are severely undersized. Urban sheet flooding areas differ from natural sheet flooding areas in that the identifying soil and vegetative characteristics may be obscured by development. Urban sheet flooding areas are usually identified from historic records of unconfined flooding. Urban sheet flooding areas occasionally may be identified by detailed topographic maps that show low relief in known flooding areas.

- Agricultural sheet flooding occurs on land surfaces that have been graded or flattened for agricultural use. Lack of topographic variation within the field areas creates sheet flooding conditions. Agricultural sheet flooding areas differ from natural sheet flooding areas in that soil and vegetative identifying characteristics may be obscured by regrading or leveling for irrigation and crop development. Agricultural sheet flooding areas may be identified from pre-development photographic or topographic data, or from historic records of flooding.

- Overland flow is the movement of water resulting from rainfall on hill slopes in upper watershed areas prior to entering defined channels. The development guidelines in this document should not be applied to overland flow areas.

- Perched flow originates along well-defined channels where overbank flooding becomes separated from the main flowpath and develops hydraulic characteristics unique from the main channel. Perched flow is not considered sheet flooding, unless it meets other characteristics described above.

- Distributary flow occurs where flow within a well-defined channel or floodplain is divided into separate flowpaths created by shifting patterns of sediment deposition. Distributary flow is not a form of sheet flooding (see Section 2.3).

2.5.3.1 Technical References:

- Federal Emergency Management Agency (FEMA), 2003, Guidelines and Specifications for Flood Hazard Mapping Partners –Appendix E: Guidance for Shallow Flooding Analyses and Mapping. Available at: www.fema.gov/library.

- Arizona Department of Water Resources (ADWR). State Standards for Floodplain Management: http://www.azwater.gov/dwr/Content/Publications/default.htm
    - (SS4-95) Standard for Development Within Sheet flooding Areas

2.5.4 Development Guidelines for Sheet Flooding Areas

Policy SF 1: Single Lot Site Conveyance. For single-lot development in sheet flooding areas, flows should not be concentrated beyond a typical shallow swale around the structure. Swales shall daylight and broaden to the natural flow conditions on the downstream side of the proposed structure. Diverting concentrated flow away from structures and onto adjacent properties must be avoided. Concentrated flows shall be returned downstream to the natural flow condition prior to exiting the property. This may be accomplished through onsite detention or other structural improvements.

Policy SF 2: Subdivision Flow Concentration. Drainage design in sheet flooding areas shall limit the concentration of flows and preserve overland flowpaths. Where flows are concentrated or channelized, appropriate scour and erosion protection shall be applied to the channelized areas. Concentrated flows shall be returned downstream to the natural flow condition prior to exiting the property. This may be accomplished through onsite detention or other structural improvements.

Policy SF 3: Drainage Master Plan. A drainage master plan should be developed for any subdivision located in a sheet flooding area. Among other requirements, the drainage master plan should demonstrate that the roadway network that serves the divided property has no adverse impact to drainage patterns and runoff concentration. In general, the street layout should be designed to cross perpendicular to the primary flow direction to prevent capture and diversion of overland flow.

Policy SF 4: Finished Floor Elevation. For non-subdivision development, elevate the lowest finished floor elevation of habitable structures to a minimum of 1.5 feet above the 100-year, 24-hour flow depth as determined from the ADMP depth grids. Note that significant backwater conditions may occur in sheet flooding areas upstream of roadways with drainage structures that are not sized for the 100-year flood. Flood depths resulting from these backwater conditions may exceed depths indicated by local geomorphology or field conditions. In such areas, the finish floor elevations should be elevated at least 0.5 foot above the elevation of the roadway which creates the backwater condition. For subdivisions planned in sheet flooding areas, finished floor elevations should be established by detailed engineering analyses, which may require two-dimensional modeling.

Policy SF 5: Structure Alignment. Homes in sheet flooding areas should be aligned parallel to the primary flow direction. Streets in sheet flooding areas should be oriented perpendicular to the primary flow direction.

Policy SF 6: Development Density. Zoning densities higher than 1 residence per acre (RAC) are not recommended in designated sheet flooding areas unless drainage studies that analyze potential concentration of flow and downstream impacts are completed or regional flood control facilities are constructed. Development restrictions in low density sheet flooding areas should include restrictions on perimeter fencing and limitation of site grading to specific building envelopes.

All development within sheet flooding areas should be conducted using sound drainage engineering principles. If the proposed development is within a completed ADMP study area, the ADMP study hydrologic and hydraulic data should be used as the basis for the existing conditions drainage assessment. If the topographic mapping data used in the ADMP is greater than 5-years old, it is recommended that updated mapping be conducted to adequately represent the existing conditions terrain.

2.6 Development Modified

The Development Modified flooding type is used for areas where developments with high density zoning exist prior to the area being studied with an ADMP. This type of development significantly alters the natural flood regime such that the development guidelines discussed previously would likely not apply. Future development within the Development Modified areas should be processed using the current Lyon County Development Standards[7] and ordinances. An example of a Development Modified area is shown in Figure 2-7.

[7] https://www.lyon-county.org/993/Development-Standards

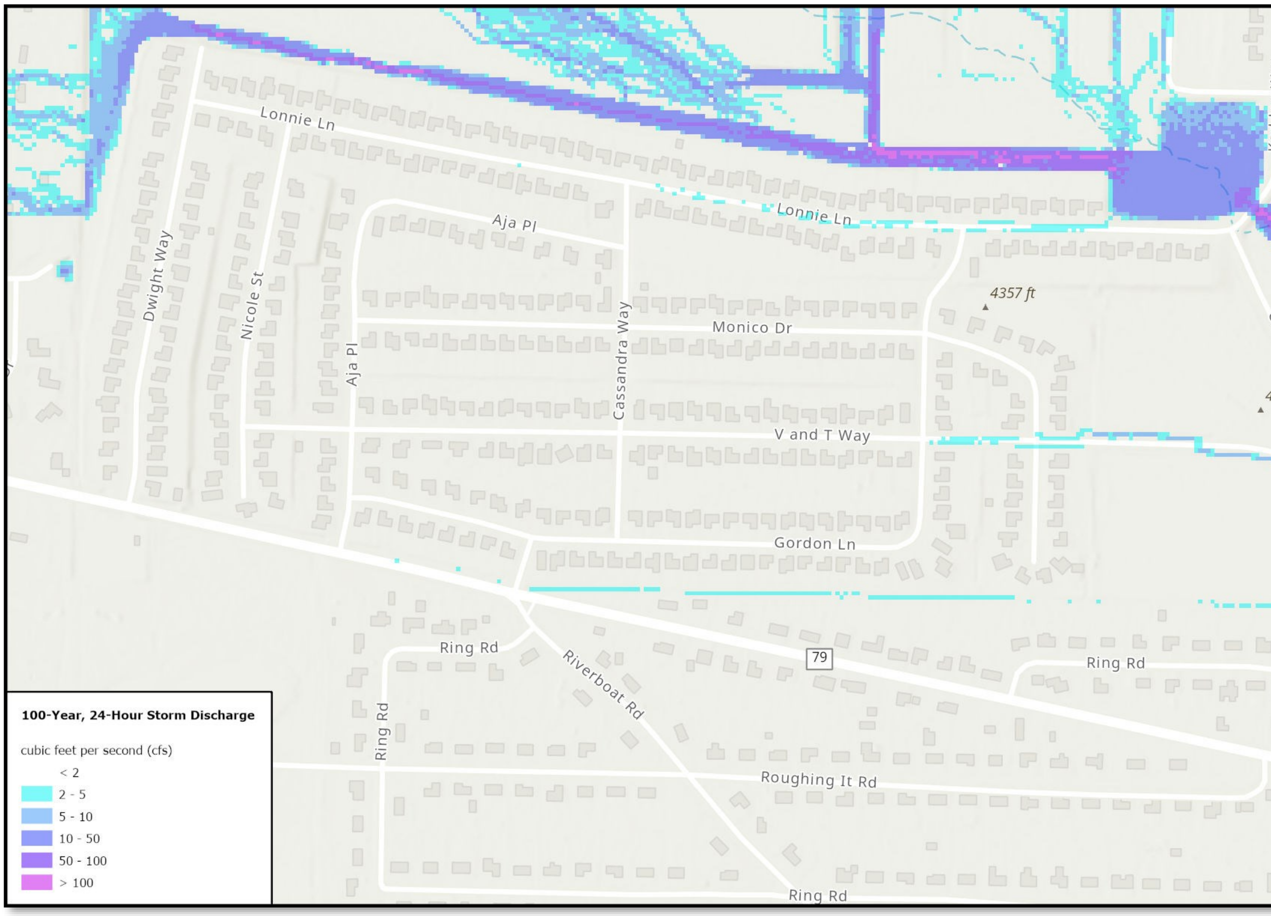

Figure 2-7. Example of a Development Modified area (Dayton Valley ADMP)