Prepared For:

REGIONAL FLOOD CONTROL DISTRICT

2023 Las Vegas Valley Flood Control Master Plan Update

Clark County Regional Flood Control District

Volume I

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Prepared For:

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2023 Las Vegas Valley Flood Control Master Plan Update

Clark County Regional Flood Control District

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Executive Summary

In response to flooding problems in Clark County, the Nevada Legislature authorized the creation of the Clark County Regional Flood Control District (RFCD) in 1985. Among other activities, the RFCD is responsible for developing and implementing a comprehensive flood control master plan to reduce flooding within Clark County. Starting with the original flood control master plan in 1986 that encompassed the entire county, the RFCD has reviewed and updated flood control master plans at least every five years in accordance with Nevada Revised Statute (NRS) 543.596. The 2023 Las Vegas Valley Flood Control Master Plan Update (MPU) is one of those updates. Master Plan Updates for Las Vegas Valley were prepared and adopted in 1991, 1997, 2002, 2008, 2013, and 2018. The purpose of the update is to add new relevant information, to assess progress towards fulfillment of the Master Plan, to identify obstacles in completing the Plan, and to recommend changes resulting from growth and development. The 2023 MPU has been developed to satisfy these requirements.

The study area for Las Vegas Valley MPU is 1,651 square miles and is divided into twelve hydrologic planning areas or watersheds to facilitate the implementation of the flood control plan. Each watershed is analyzed using consistent criteria and methodology. The 2023 MPU and previous MPUs are based on assumptions about future growth and development in Las Vegas Valley to represent the ultimate hydrologic condition and to aid in the planning of future flood control facilities. The ultimate hydrologic condition uses land use data that represents the full “build out” condition. To facilitate the use of this condition, an Ultimate Development Boundary (UDB) was generated for the Las Vegas Valley that factors in the mountainous terrain that surrounds the Valley and the locations of protected lands. Future land use and existing soil data are used in conjunction with the 100-year frequency flood event to develop hydrologic models that establish peak flow rates and flow volumes for drainage corridors. These peak flow rates and flow volumes are then used to analyze the flood control system to identify deficiencies in the existing flood control plan. The final flood control facility plan is then recommended to mitigate these identified deficiencies.

The 2023 MPU serves as a planning tool for implementation of the flood control system in Las Vegas Valley and the planning of future flood control facilities. The flood control system identified and described in this MPU may be subject to further amendments and revisions in the future as more detailed analyses are completed for facilities during pre-design, design, and other activities that may warrant modification of the flood control plan. The hydrologic analyses developed with the 2023 MPU are intended to aid in the planning of the flood control system in the Las Vegas Valley. Therefore, more detailed hydrologic analyses should be completed during the design phase of flood control facilities.

The 2023 MPU was developed in close coordination with RFCD staff and representatives of four local entities: City of North Las Vegas, City of Las Vegas, City of Henderson and Clark County Public Works Departments. Progress meetings were held, and representatives of these agencies were informed of project progress and given the opportunity to provide input. These

agencies were also provided with the opportunity to review and comment on the information collected and developed for the master plan, which included information on the major master plan tasks such as data collection, hydrology, and facility planning. Representatives of the agencies reviewed the master plan information, and their comments and assistance toward development of the 2023 MPU are greatly appreciated.

Modifications made to the flood control plan during development of this 2023 MPU are based on the following:

- Identification of flood control facilities constructed after the 2018 MPU
- Modifications made, through Master Plan Amendments, to the flood control plan after the 2018 MPU
- Updates to UDB and land use data including changes reflecting the passage of Assembly Bill 356 (AB 356) which requires the removal of non-functional turf by 2026
- Incorporation of the 2022 National Resources Conservation Service (NRCS) soils data
- Updates to the hydrologic methodology
- Revisions to watershed and subbasin boundaries
- Updates to hydrologic models that reflect changes in the watershed that have occurred since the 2018 MPU was completed
- Revisions to facility sizes and alignments due to changes in flow rates and volumes generated from the updated hydrologic models
- Addition of new facilities where deemed necessary to better address flood hazards

The 2023 MPU is based on current information available during its development in late 2022, and 2023. The resulting plan should be viewed as a living document capable of being adjusted in response to changing conditions and priorities.

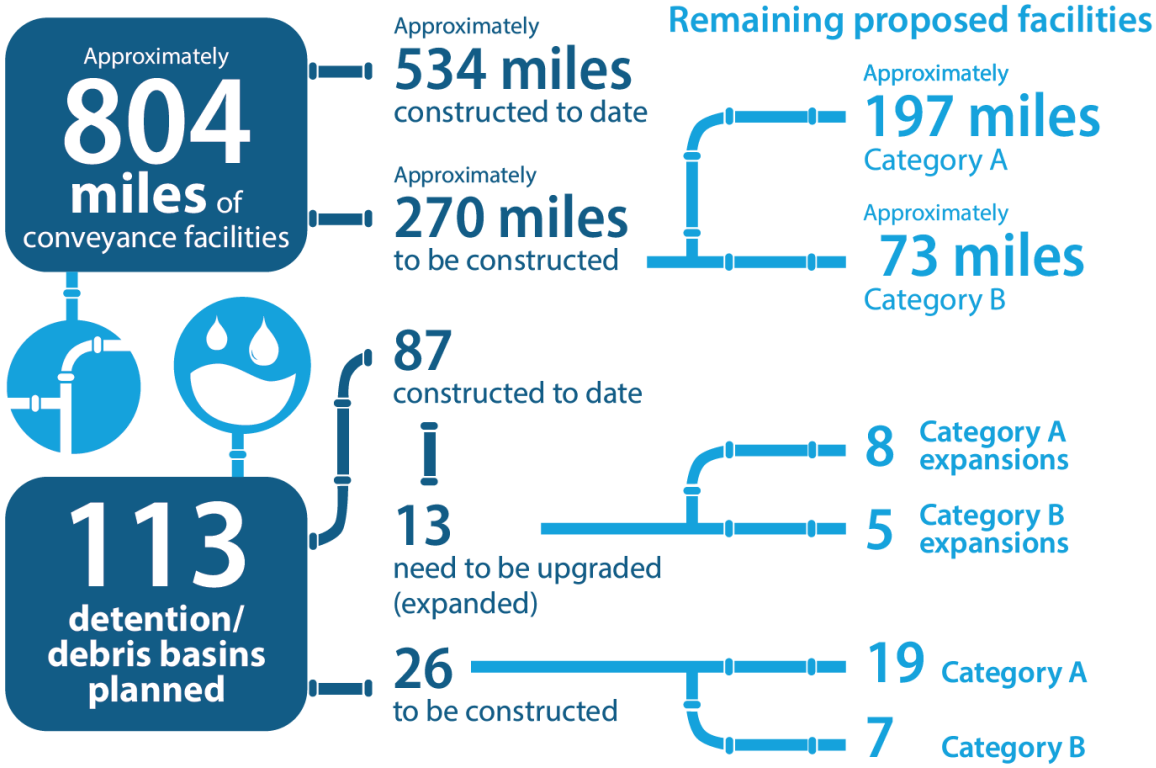
Key enhancements and updates that were made in the 2023 MPU include:

- Employed a GIS-based master planning approach by utilizing a cloud-based, multi-user, GIS database that served as a foundation for all aspects of MPU development and presentation such as data collection, hydrology, facility planning, cost estimation, quality assurance/control and report creation.
- Compatibility updates to a previously developed GIS-based curve number tool which utilizes a subbasin layer, land use layer and soils layer to automatically calculate curve numbers for each subbasin.
- Updates to the hydrologic methodology: revisions were made to the hydrologic parameters such as percent impervious, open space distribution, land use and soils data. Land use assumptions were modified to reflect the passage of AB 356 which requires the removal of non-functional turf by 2026. The details of the updates are included in **Chapter 2** of this report.

- Compatibility updates to a previously developed GIS-based facility sizing tool that computes facility conveyance capacity and proposed sizes.
- Updates to the Cost Estimation Tool include:
    - Updated unit costs equations based on recent construction bid tabulations.
    - Compatibility updates to a previously developed GIS-based Cost Estimation Tool that computes costs.
- Updates to Watershed Maps (W-Maps) W-Maps include revised land use, subbasin delineations, concentration points, flow arrows, soils data and aerial imagery.
- Utilized ESRI ModelBuilder tools to facilitate the generation of facility inventory tables that accompany the F-Maps.

Below is a summary of the existing and proposed conveyance facilities and detention basins for the 2023 MPU.

LAS VEGAS VALLEY PLANNING AREAS IN THE 2023 MPU INCLUDE:



CONSTRUCTED SINCE THE 2018 MPU WITHIN THE LAS VEGAS VALLEY PLANNING AREAS

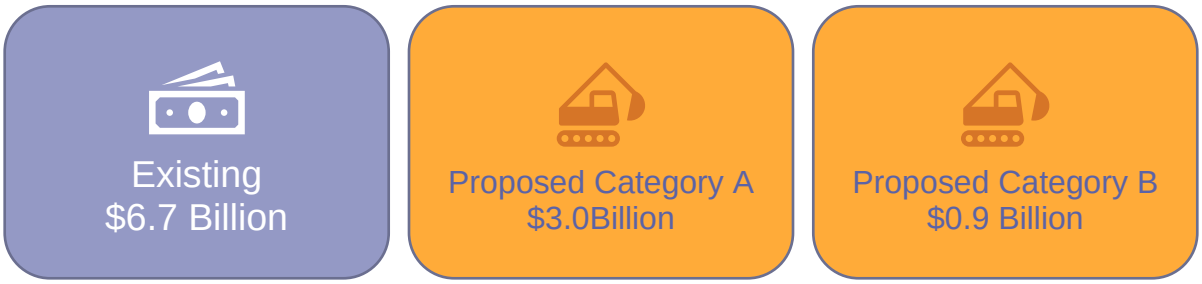
Approximately **57 miles** of conveyance facilities

9 detention basins

1. Total length for facilities does not include floodways, natural washes, or existing facilities that are planned to be replaced.
2. Category A - Given priority for RFCD funding over Category B.
3. Category B - Primarily located in undeveloped areas to protect land or eventually replace an existing facility which provides a high level of flood protection but cannot convey the entire 100-year peak flow.

Category A proposed facilities are given priority for RFCD funding over Category B facilities. Category A facilities are considered essential for the protection of existing development and constitute around 74 percent of all proposed facilities. Category B facilities are either located in undeveloped areas and primarily protect undeveloped land (that is planned to be developed in the future) or they will eventually replace an existing facility which provides a high level of flood protection but cannot convey the entire 100-year peak flow. Category B facilities associated with future development are not expected to require public funds for implementation.

The estimated value of all existing regional flood control facilities in the Las Vegas Valley and the estimated construction costs of proposed Category A and B facilities are shown below.



The total estimated construction cost of Category A and Category B proposed facilities has increased from that estimated in the 2018 MPU by $931 million and can be attributed to both the rising construction costs and modifications made to the flood control facility plan (see **Section 2.6** for more detailed information). The total estimated value of existing flood control assets has increased from that estimated in the 2018 MPU by $2.2 billion.

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Acronyms and Abbreviations

AB	356Assembly Bill 356
ACEC	Areas of Critical Environmental Concern
ac-ft	Acre-Feet
AMC	Antecedent Moisture Condition
AML	Appropriate Management Level
ASTM	American Society for Testing and Materials
BLM	Bureau of Land Management
BMP	Best Management Practices
BO	Biological Opinion
CAA	Clean Air Act
CCI	Construction Cost Indexes
CCPW	Clark County Public Works Departments
CCWRD	Clark County Water Reclamation District
CERCLA	Comprehensive Environmental Response, Compensation Liability Act of 1980
CFR	Code of Federal Regulations
cfs	Cubic feet per second
CIP	Capital Improvement Project
CLV	City of Las Vegas
CNLV	City of North Las Vegas
CO	Carbon Monoxide
COH	City of Henderson
CWA	Clean Water Act
cuyd	Cubic-Yards
EA	Environmental Assessment
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
ESA	Endangered Species Act
ESRI	Environmental Systems Research Institute
D&A	Design and Administration
DARF	Depth-Area Reduction Factor
FEIS	Final Environmental Impact Statement
FEMA	Federal Emergency Management Agency
Fps	Feet Per Second
FR	Federal Register
ft	Feet
GIS	Geographic Information System
HAP	Hazardous Air Pollutants
HEC	Hydrologic Engineering Center
HMA	Herd Management Area
HMS	Hydrologic Modeling System
HOA	Homeowners Association
HUA	Herd Use Area
IP	Individual Permit
LOP	Letter of Permission
LVVWD	Las Vegas Valley Water District
MBTA	Migratory Bird Treaty Act
MPU	Master Plan Update
MSHCP	Multiple Species Habitat Conservation Plan

NAAQS	National Ambient Air Quality Standards
NAC	Nevada Administrative Code
NAIP	National Agriculture Imagery Program
NAFB	Nellis Air Force Base
NDEP	Nevada Division of Environmental Protection
NDF	Nevada Division of Forestry
NDOT	Nevada Department of Transportation
NDOW	Nevada Department of Wildlife
NHPA	National Historic Preservation Act
NNHP	Nevada Natural Heritage Program
NLVDB	North Las Vegas Detention Basin
NOAA	National Oceanic and Atmospheric Administration
NO_x	Nitrous Oxides
NPDES	National Pollutant Discharge Elimination System
NRCS	National Resource Conservation Service
NRS	Nevada Revised Statutes
NWP	Nation Wide Permit
O&M	Operation and Management
O_3	Ozone
Pb	Lead
PM	Particulate Matter
PMF	Probable Maximum Flood
PSD	Prevention of Significant Deterioration
RCA	Reinforced Concrete Arch
RCAC	Reinforced Concrete Arch Culvert
RCB	Reinforced Concrete Box
RCBC	Reinforced Concrete Box Culvert
RCP	Reinforced Concrete Pipe
RFCD	Clark County Regional Flood Control District
RMP	Resource Management Plan
RGP7	Regional General Permit 7
RPW	Relatively Permanent Waters
RRCNCA	Red Rock Canyon National Conservation Area
SARA	Superfund Amendments and Reauthorization Act of 1986
SCS	Soil Conservation Service
SDN	Storm Distribution Number
SEIS	Supplemental Environmental Impact Statement
SHPO	State Historic Preservation Office
SIP	State Implementation Plan
SNWA	Southern Nevada Water Authority
SO_2	Sulfur Dioxide
SQMC	Stormwater Quality Management Committee
SRDB	Silverado Ranch Detention Basin
STATSGO	State Soil Geographic
SWPPP	Stormwater Pollution Prevention Plan
TC	Total Cost
TCP	Traditional Cultural Property
TCS	Toxic Chemical Substances
TNW	Traditional Navigable Waterways
UC	Unit Cost
UDB	Ultimate Development Boundary

ULVWDB	Upper Las Vegas Wash Detention Basin
UPRR	Union Pacific Railroad
U.S.	United States
USACE	United States Army Corps of Engineers
USC	United States Code
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Society
VOC	Volatile Organic Compounds
WOTUS	Waters of the United States

CHAPTER 1

Introduction

1.1. General

In response to flooding problems in Clark County, the Nevada Legislature authorized the creation of the Clark County Regional Flood Control District (RFCD) in 1985. Among other activities, the RFCD is responsible for developing and implementing a comprehensive flood control master plan to reduce flooding within Clark County. Starting with the original flood control master plan in 1986 that encompassed the entire county, the RFCD has reviewed and updated flood control master plans at least every five years in accordance with Nevada Revised Statute (NRS) 543.596. Master Plan Updates for Las Vegas Valley were prepared and adopted in 1991, 1997, 2002, 2008, 2013, and 2018. The 2023 MPU has been developed to satisfy this state requirement.

The 2023 MPU and previous MPUs were developed using the ultimate condition as a basis for analysis. The ultimate condition assumes that the full “build out” condition has been reached; all available land within the Las Vegas Valley has been fully developed, and all proposed RFCD MPU facilities have been constructed. Runoff from the “build out” condition is used as the basis for recommendations for improvement to existing or new proposed master planned facilities. This condition is assumed such that facilities built today will have capacity into the future. To facilitate the use of this condition, an Ultimate Development Boundary (UDB) was generated for the Las Vegas Valley. The limits of this boundary are based on the mountainous terrain that surrounds the Valley and the locations of protected lands. The ultimate condition is used in conjunction with the 100-year frequency flood event to develop hydrologic models that establish peak flow rates and flow volumes for drainage corridors. These peak flow rates and flow volumes are then used as the design event to preliminarily size flood control facilities. The 100-

year frequency flood event is defined as having a 1 percent chance of being equaled or exceeded in any given year.

The 2023 MPU serves as a planning tool for the implementation of the flood control system in the Las Vegas Valley and the design and construction of master plan facilities. The flood control system identified and described in this MPU may be subject to further amendments and revisions in the future as more detailed analyses are completed for facilities during predesign, design, and other activities that may warrant modification of the flood control plan.

Modifications made to the flood control plan during development of this 2023 MPU are based on the following:

- Identification of flood control facilities constructed after the 2018 MPU
- Modifications made, through Master Plan Amendments, to the flood control plan after the 2018 MPU
- Updates to the UDB and land use data including changes reflecting the passage of Assembly Bill 356 (AB 356) which requires the removal of non-functional turf by 2026
- Incorporation of the 2022 NRCS soil survey data
- Updates to the hydrologic methodology
- Revisions to watershed and subbasin boundaries
- Updates to the hydrologic models that reflect changes in the watershed that have occurred since the 2018 MPU was completed
- Revisions to facility sizes and alignments due to changes in flow rates and volumes generated from the updated hydrologic models
- Addition of new facilities where deemed necessary to better address flood hazards

The flood control facility system and other information provided in this MPU represent current conditions and was developed with cooperation and review of the local entities and stakeholders previously listed.

1.2. Climate

The climate in Las Vegas Valley is typical of southern Nevada desert, with hot, dry summers and mild winters. The average annual precipitation is 4.49 inches and generally occurs as the result of two storm types:

- Longer-duration, low-intensity winter events
- Shorter-duration, high-intensity summer thunderstorms

Winter storms in the area are regionally associated with broad low-pressure systems that develop over the Pacific Ocean and move easterly. Precipitation from these storms is generally widespread and is intense only on rare occasions.

Summer storms, on the other hand, typically occur between July and September, and are characterized as localized convective thunderstorms and can often be intense. During these hot summer months, moist unstable air from the Gulf of Mexico is rapidly forced upward by hot air currents. The dynamics of this process often result in spectacular displays of lightning in the desert sky. Too often, they also cause severe thunderstorms with intense rainfall on steep mountain slopes and armored desert surfaces. The rainwater runs off rapidly and concentrates in the urbanized areas at lower elevations. These types of events can often cause flash floods that are extremely dangerous for anyone within or adjacent to the path of flood waters.

As the climate is changing the precipitation estimates seen in the past can change and become a moving target. Predictive future rainfall estimates are currently being developed to address this uncertainty. As new data becomes available it will be evaluated for possible inclusion in future MPUs.

1.3. Flood History

An examination of past storm events provides valuable insight in planning flood control facilities. Rainfall data, storm centerings, runoff, flow rates in channels, property damage, and loss of life are all significant factors in determining the effectiveness of existing facilities and in evaluating the need for new and/or improved facilities. **Table 1-1** below includes highlights of storm events that resulted in significant rainfall, runoff, flow rate in channels, property damage, or loss of life over the past 10 years. The data listed below were taken from the RFCD reports. They can be viewed in further detail on the RFCD website (https://www.regionalflood.org/).

Table 1-1 - History of Flooding from 2013 - 2023

Date of Flood	Impact Area	Approx. Duration (hrs)	Max Rainfall (in)
August 25, 2013	**Northwest Las Vegas Valley -** This may have been the most intense rainfall event in Clark County since the creation of RFCD. Kyle Canyon Detention Basin Area	4	4.10
September 8, 2014	**Southwest Las Vegas Valley –** There were reports of localized street flooding as well as the need for several swift water rescues. Minor damage to flood channel.	7	1.85
June 30, 2016	**Henderson Area –** No reports of flooding of residences or businesses. Two flood-related deaths based on this storm event.	5	1.89
August 4, 2017	**Spring Mountains Area –** No loss of life in Spring Mountains but one death did occur in the Flamingo Wash. Minimal damage to public roads.	5	2.17
March 12-13, 2020	**Entire Las Vegas Valley –** Multiple swift water rescues with two deaths attributed to drowning. Already saturated ground contributed to rapid runoff from consecutive events.	3	3.08

Date of Flood	Impact Area	Approx. Duration (hrs)	Max Rainfall (in)
July 17, 2023	**Henderson Area –** Back-to-bask storms in the McCullough Range south of Henderson, creating additional rainfall in places already experiencing runoff.	2	0.87
August 1, 2023	**Western Las Vegas Valley –** Storms started in the Springs Mountains not reflected on rain gages, the storm moved southeastward towards Summerlin and Red Rock areas. The rainfall intensity at Brownstone Canyon (Gauge 4329) was the equivalent of a 25-year return interval event. Summerlin NW (Gauge 4209) reported a rainfall rate exceeding the 100-year return interval.	1	1.85
August 18-21, 2023	**Tropical Storm Hilary –** Widespread rainfall over the whole valley generally ranging from 0.25 to 0.75 inches in a 24 hr period. Majority of storm impacts occurred in the Spring Mountains. 12 structures with minor damage and 2 with major damage. 2 individuals and one pet needed rescue, 1 suspected drowning. Multiple road segments were washed out, electricity was cut off, and a boil water order is in place for residents.	72	5.67
August 23, 2023	**The Strip –** Isolated thunderstorm with moderate precipitation occurred around the Las Vegas strip. One individual rescued on East Flamingo Road. Additional report of two individuals needed rescue were not verified.	1	1.34
September 1-2, 2023	**Strong Monsoon –** Back-to-back storms drifting eastward over the Spring Mountains creating a rainfall over runoff event. Waters impacted many streets. Three flood-related deaths due to this storm event.	34	2.48

1.4. Project Team and Coordination

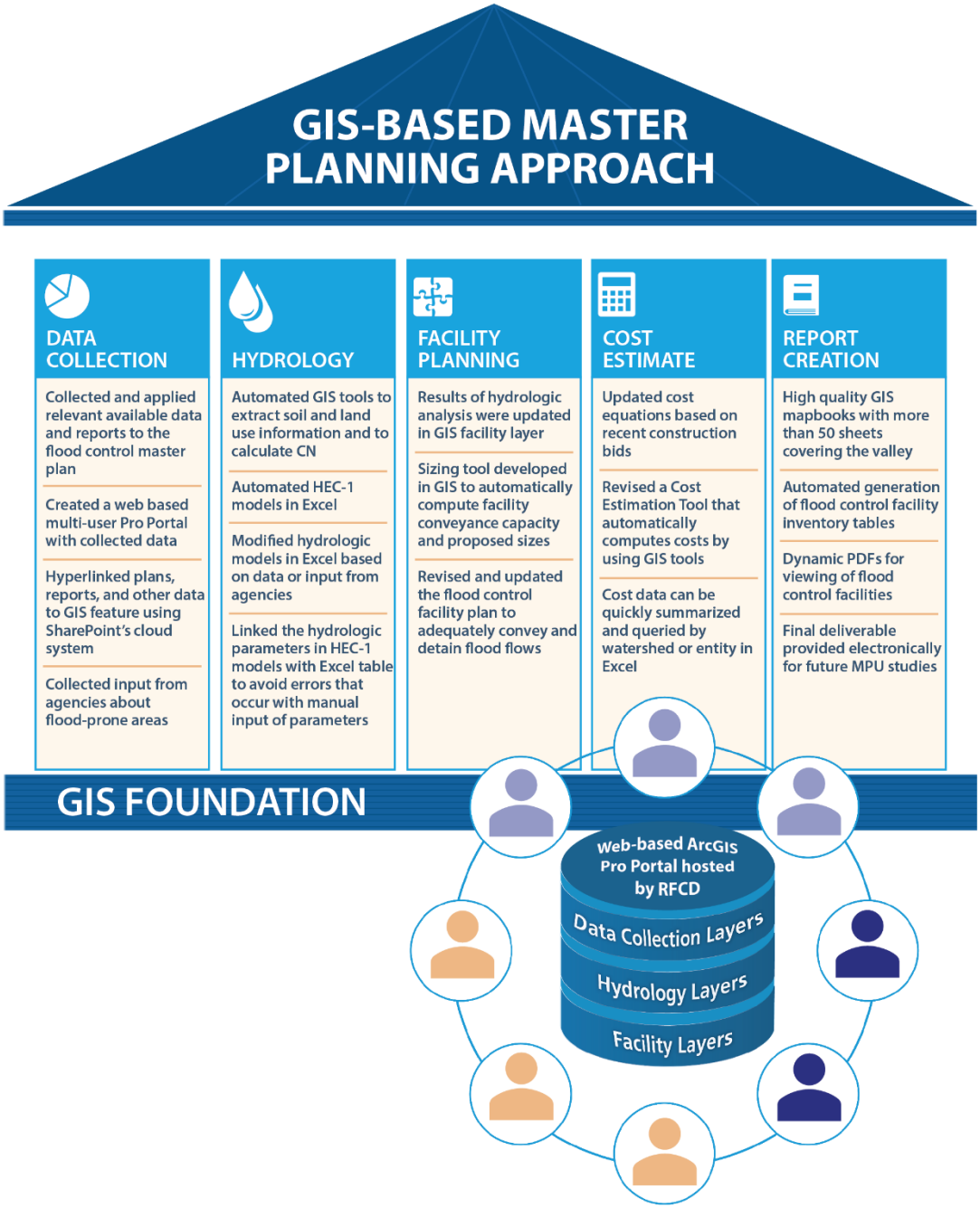
The 2023 MPU was developed by AtkinsRéalis in association with Westwood and Atlas. As a Prime Consultant, AtkinsRéalis has the general responsibility for the management and development of the MPU.

The 2023 MPU was developed in close coordination with the RFCD staff and representatives of four local entities: City of North Las Vegas, City of Las Vegas, City of Henderson and Clark County Public Works Departments. Progress meetings were held, and representatives of these agencies were informed of project progress and given the opportunity to provide input. These agencies were also provided with the opportunity to review and comment on the information collected and developed for the master plan, which included information on the major master plan tasks such as data collection, hydrology, and facility planning. Representatives of the agencies reviewed the master plan information, and their comments and assistance toward development of the 2023 MPU are greatly appreciated.

1.5. Project Approach

The 2023 MPU approach builds upon the significant amount of effort and resources that has already been invested in the Las Vegas MPU. A Geographic Information System (GIS)-based approach was used to execute most tasks to maintain efficiency and accuracy. The five key components of the MPU are built upon a GIS foundation, as shown in **Figure 1-1** (see **Section 1.9** for further explanation for each component).

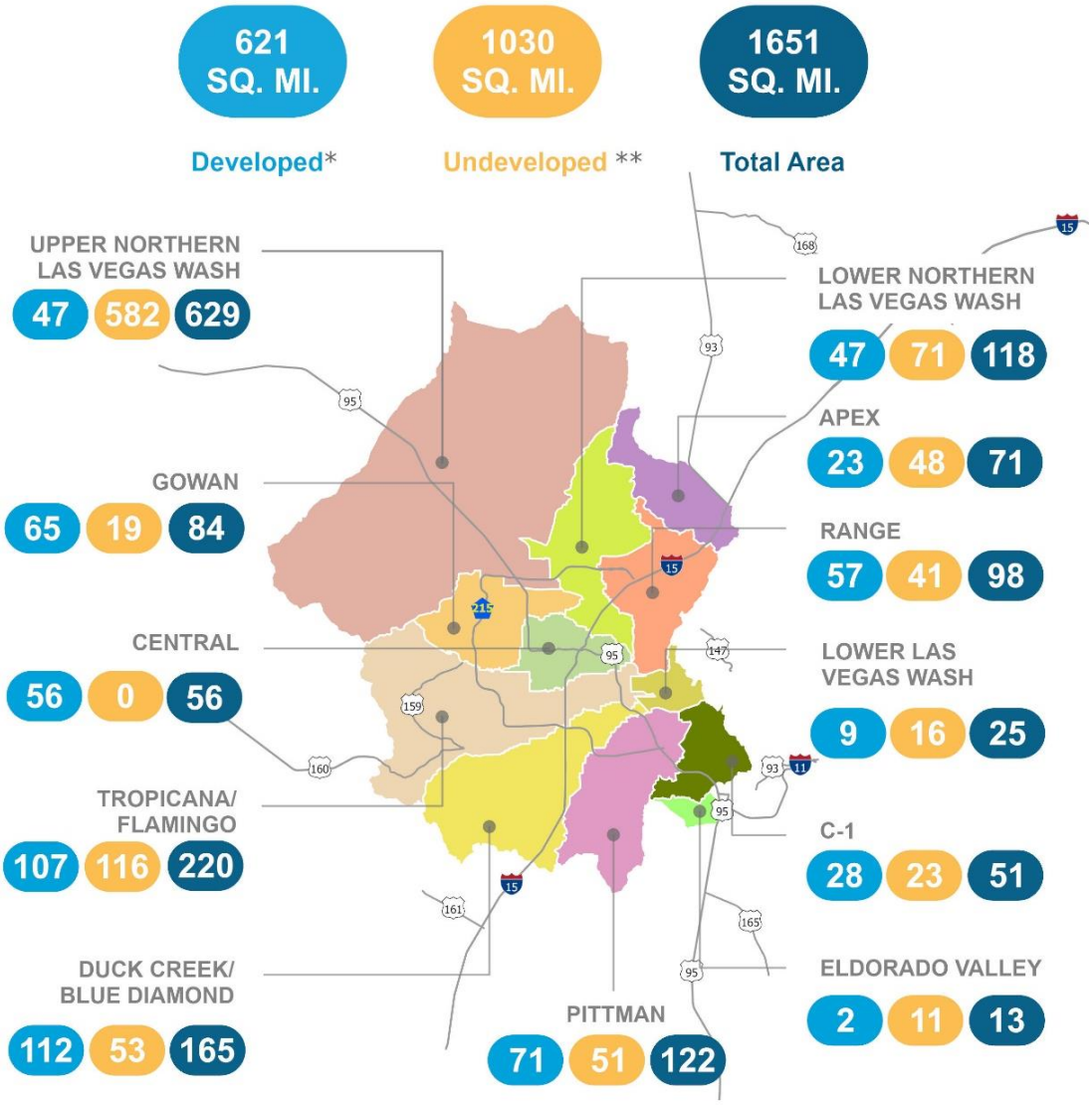
Figure 1-1 - GIS-Based Master Planning Approach



To facilitate the completion and presentation of the information collected and developed in the tasks listed above, the Las Vegas Valley has been subdivided into twelve major watersheds.

LAS VEGAS VALLEY WATERSHED AREAS

Ultimate Condition



*Includes undeveloped areas (Land Use category 1) less than 2 square miles within the UDB
**Denotes undeveloped areas outside the UDB and undeveloped areas (Land Use category 1) greater than 2 square miles within the UDB

1.6. Summary of Results

Approximately 804 miles of conveyance facilities are included within the Las Vegas Valley planning areas in the 2023 MPU. Of these, 534 miles of facilities have been constructed to date, and 270 miles of facilities are proposed to be constructed. The proposed facilities include approximately 197 miles of Category A and 73 miles of Category B facilities.

Within the Las Vegas Valley planning area in the 2023 MPU, 113 detention/debris basins are included, with 87 detention/debris basins having been constructed to date. Thirteen existing detention/debris basin need to be upgraded (expanded), of which 5 are Category B expansions. Similarly, of the remaining 26 proposed detention/debris basins, 7 are Category B basins.

Approximately 57 miles of conveyance facilities and 9 detention basins have been constructed within the Las Vegas Valley planning area since the 2018 MPU. Please refer to **Section 2.5.2** for a detailed description of Category A and Category B facilities.

1.7. Implementation

The Las Vegas Valley is divided into twelve hydrologic planning areas or watersheds. The RFCD is the lead entity for overall development and management of the master plan and associated facilities for all twelve watersheds. Implementation of the master plan including predesign, design, construction, and maintenance of facilities is primarily the responsibility of the local entities and is coordinated by the RFCD. The local entities in the Las Vegas Valley that are responsible for the implementation of the master plan include the City of Las Vegas, City of North Las Vegas, City of Henderson and Clark County. Each watershed is assigned to one of the local entities based on corporate boundaries and the impact of flooding from each watershed on the community or local entity (**Table 1-2**). The local entity is then responsible for the prioritization of proposed flood control design and construction projects within their assigned watersheds. The priority of flood control design and construction projects is based on established criteria within the RFCD Policies and Procedures Manual.

Table 1-2 - Entity Assignment

Local Entity	Responsible Watersheds
Clark County	Flamingo/ Tropicana, Duck Creek/ Blue Diamond
City of Henderson	Pittman, C-1, Eldorado Valley
City of North Las Vegas	Range, Lower Northern Las Vegas Wash, Lower Las Vegas Wash, Apex
City of Las Vegas	Upper Northern Las Vegas Wash, Gowan, Central

1.8. Developer Implementation of the Facilities

Private funding has been used in the past to design and construct several master plan facilities in the Las Vegas Valley. Private funding usually comprises a portion of the total cost of these facilities with the remainder of the cost being supplied by the RFCD. Private funds are provided by development companies that realize a significant benefit through the construction of the

master plan facility due to the flood protection it affords the adjacent private land held by the development company. Construction of master plan facilities that use private funding sources must meet all design and construction standards and review processes established by the RFCD. Additional information regarding developer participation in the implementation of master plan facilities is available in the RFCD Policies and Procedures Manual.

1.9. Report Organization

This report consists of general project information, the RFCD policies regarding the master plan and associated facilities, criteria and methodology used to develop the master plan, general information regarding each of the twelve watersheds, descriptions of the major changes between the 2018 and 2023 MPUs, environmental permitting information as it relates to the construction of master plan facilities, and construction cost estimates for master plan facilities in each watershed.

Individual watershed chapters are written to describe hydrology, master plan progress and flood control facility updates and cost estimates for each watershed.

The Appendix includes General Maps (G-Maps), Facility Maps and Tables (F-Maps and F-Tables) and Watershed Maps (W-Maps). G-Maps present land ownership and environmentally sensitive areas. F-Maps and F-Tables include facility location, facility description, length, flow rates, HEC-1 model names, and HEC-1 node names for each flow rate listed on the table. Both G-Maps and F-Maps are provided as 11” x 17” maps and are included in Volume 2 of the printed Report.

W-maps show all of the hydrologic information at a watershed level and consist of flow arrows, subbasins, soils, land use, and street names.

Cost tables and equations, curve number matrix and supporting curve number calculations are also included in the appendix**.**

The electronic data collected and developed for the 2023 MPU can be found at the RFCD website for digital download, including hydrologic data, environmental data, facility cost data, facility planning data, electronic copies of the report, and all GIS data.

CHAPTER 2

Watershed Analysis

2.1. General

This chapter includes information regarding the criteria, methodology, and analyses performed for the 2023 MPU watershed analysis. These criteria, methodology, and analyses are consistent with the Hydrologic Criteria and Drainage Design Manual (RFCD Design Manual) and the RFCD Policies and Procedures Manual. Any deviations from these standard RFCD documents resulted from either a lack of available information for specific areas or an effort to simplify the analyses when appropriate for master planning purposes and are noted when they occur. Required deviations are discussed in detail for each specific area or watershed in Chapters 3 through 14.

This chapter provides an overview of the criteria, methodology, and analyses used for the following MPU tasks:

- Data Collection
- Hydrology
- Facility Planning
- Cost Estimate
- GIS Data Development

The 2023 MPU represents a modification of the 2018 MPU based on the following completed tasks:

- Updates to the Ultimate Development Boundary
- Updates to future land use assumptions

- Revisions to percent impervious and open space distribution for the land use categories. Values were modified to be more consistent with the RFCD Design Manual and to reflect the passage of Assembly Bill 356 (AB 356) which requires the removal of non-functional turf by 2026.
- Incorporation of latest soil survey data
- Modifications to facility alignments to be consistent with new infrastructure and developments
- Construction of master plan facilities since the 2018 MPU
- Updates to the facility costs
- Discussions with the RFCD, City of Las Vegas, City of North Las Vegas, City of Henderson, and Clark County.

The 2023 MPU is based on current information available during its development in late 2022 and 2023. The resulting plan should be viewed as a living document capable of being adjusted in response to changing conditions and priorities.

2.2. Data Collection

Planning studies, drainage reports, and construction plans completed since the 2018 MPU were collected and reviewed in development of the 2023 MPU. Other documents considered pertinent to MPU development were also identified and collected. Pertinent data were extracted based on relevancy to the MPU with input from the RFCD and affected entities. The following documents were considered during the MPU development:

- Master Plan Amendments
- Design Reports and Construction Plans for State and Local Projects
- Technical Drainage Studies for regionally significant Land Development Projects
- Capital Improvement Projects

All the collected documents were saved in a SharePoint site that could be easily accessible to all involved in the project. An ArcGIS Pro portal was created to hyperlink the collected data for quick reference. The cloud-based data allows multiple users to access and work simultaneously on the same GIS database regardless of office location. The collected data was reviewed with respect to the following:

- Verification of the 2018 MPU data
- Consistency with facility information in GIS
- Impacts on regional drainage patterns and facilities
- Continuity of drainage basin boundaries, flow patterns, and hydrologic parameters
- Accuracy of study information and validity of assumptions/approximations
- Local and secondary drainage facilities

Information considered appropriate for master planning was extracted from the documents and incorporated into the 2023 MPU to the fullest extent possible without exceeding the level of detail established by the RFCD. Any documents that were incorporated into 2023 MPU were flagged in the GIS database for future reference. A list of studies collected along with maps of the study locations are provided in **Appendix F**.

2.3. Hydrology

The hydrologic analyses and models completed with the 2018 MPU served as the basis for the 2023 MPU hydrologic analyses and modeling effort. The hydrologic parameters were revised to incorporate all new data collected and/or developed for the 2023 MPU.

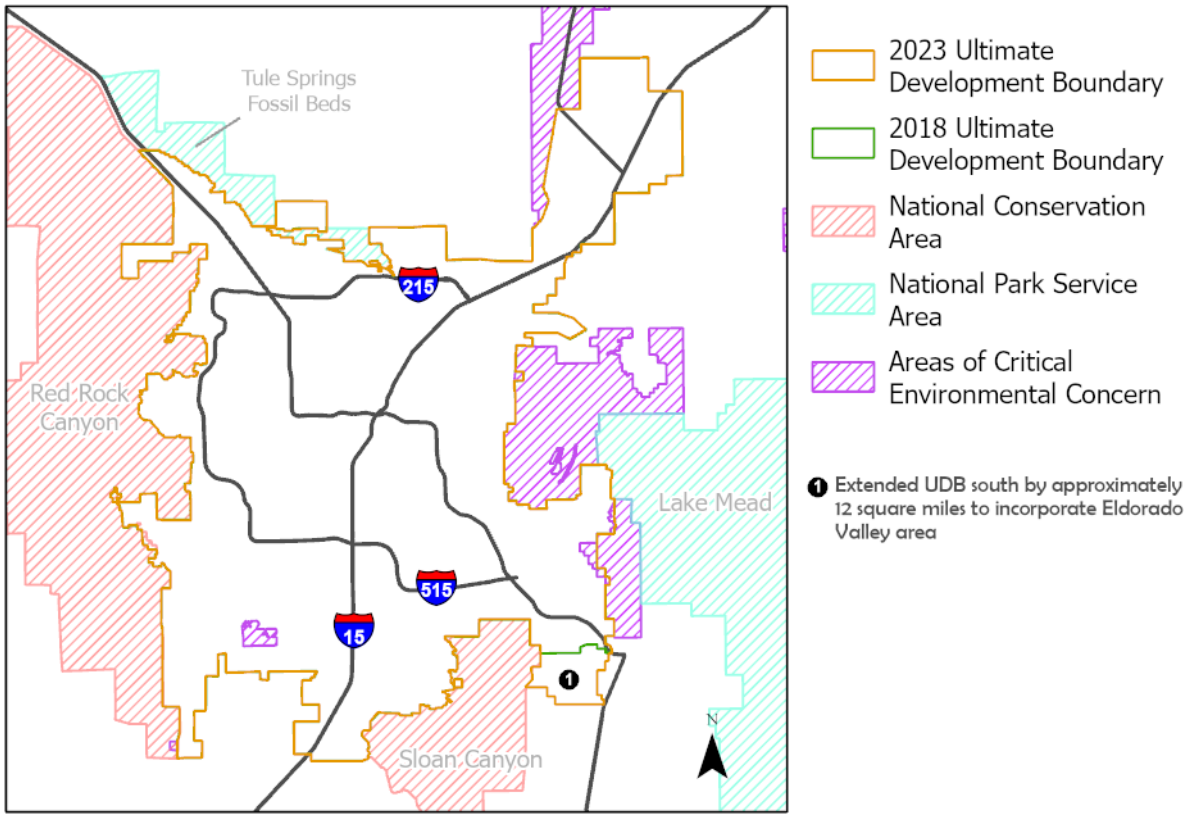
The hydrologic analyses developed with the 2023 MPU assume all RFCD MPU facilities are constructed and are intended to aid in the planning of the flood control system in the Las Vegas Valley. Therefore, more detailed hydrologic analyses should be completed during the design phase of flood control facilities to determine systems in detail and potential interim conditions impacts.

The subsections below discuss the criteria, methodology, and assumptions applied to the 2023 MPU hydrologic analysis.

The hydrologic analyses developed with the 2023 MPU are intended to aid in the planning of the flood control system in the Las Vegas Valley. Therefore, more detailed hydrologic analyses should be completed during the design phase of flood control facilities.

2.3.1. Ultimate Development Boundary

The MPU methodology is based on assumptions about future growth and development in Las Vegas Valley to represent the ultimate hydrologic condition and to aid in the planning and preliminary design of future flood control facilities. The ultimate hydrologic condition uses land use data that represents the full “build out” condition and assumes all proposed RFCD MPU facilities have been constructed. To facilitate the application of this condition, an ultimate development boundary (UDB) was generated for the Las Vegas Valley to define the limits of where development is expected to occur. The limits of this boundary are based on the mountainous terrain that surrounds the Valley and locations of protected lands. The UDB remains unchanged for the majority of entities in the valley with the exception of City of Henderson. The UDB limits from the 2018 MPU boundary were adjusted for the 2023 MPU to incorporate the Eldorado Valley area annexed into the City of Henderson. The extended boundary incorporating the Eldorado Valley was based on the updated City of Henderson Zoning and Planning. The Eldorado Valley area is located southeast of the Las Vegas Valley bordering Boulder City, Nevada.



2.3.2. Non-Functional Turf Removal

In June 2021, the Nevada Legislature passed AB 356, effective January 1, 2027, prohibiting the use of Colorado River water delivered by the Southern Nevada Water Authority (SNWA) to irrigate non-functional turf not zoned exclusively for single-family residences. In accordance with AB 356, also known as the Grass Removal Mandate, business owners and managers of industrial, commercial and office park properties, HOAs, and churches are required to remove non-functional turf by the end of 2026.

The implementation of the Grass Removal Mandate will require the removal of approximately 4,000 acres of non-functional turf, which will impact existing land covers and therefore change the land use assumptions and curve numbers previously used in the 2018 MPU.

The hydrology has been updated to account for the grass removal mandate (i.e. less grass and more desert landscaping). The 2018 MPU land use accounted for desert landscaping in all land use categories however this new mandate limits the grass even more and requires its removal in developed parts of the valley. The land use categories affected include the right-of-way areas (major streets), Public Facilities, and Schools. These areas were modified to show a reduction in the percentage of grass cover compared to what was used in the 2018 MPU. See **Section 2.3.3** for specific changes including changes to the percentage split between grass and desert landscaping between the 2018 and 2023 MPU. Overall, this had a minor effect on the Curve

Numbers calculated in the Las Vegas Valley. This is due to the previous assumptions already accounting for limited grass for the majority of the land use categories.

2.3.3. Land Use

Land use data used for the 2023 MPU is a crucial component of the overall plan. Land use densities and the associated impervious areas directly affect the amount of runoff that will occur for a given area. Impervious area increases as land use densities increase, which in turn increases both the volume and rate of runoff.

The 2023 MPU land use GIS coverage was revised based on city- and county-wide zoning maps, existing/planned development per the GIS parcel data, entity input, master planned drainage studies and the Near Maps 2023 aerial photos. Representatives from each entity were given the opportunity to review the updated land use data and provide input.

Percent impervious and open space distribution were reviewed for each land use category. Manual checks were performed at several locations to determine average lot size within residential communities, and to measure the impervious area using aerial imagery. Several changes were made to the 2018 MPU land use categories, and they are as follows:

1. Land use descriptions for residential areas were updated to be more consistent with the Curve Number Table (Table 602A) in the RFCD Design Manual. Descriptions now include average lot sizes instead of units/acre. Land use descriptions changed for seven categories as shown in **Table 2-1**:

Table 2-1 - Land Use Description Changes

Land Use Index	2018 MPU Land Use Description	2023 MPU Land Use Description
3	Rural, 0.5-1 units per acre (uses 1 unit/acre)	Rural, 40,000 sq ft lots
4	Low-Density Residential, 1-2 units per acre (uses 2 units/acre)	Low-Density Residential, 20,000 sq ft lots
5	Medium-Density Residential, 2-4 units per acre (uses 3 units/acre)	Medium-Density Residential, 14,000 sq ft lots
6	High-Density Residential, 4-8 units per acre (uses 6 units/acre)	High-Density Residential, 7000 - 10,000 sq ft lots (avg.)
7	Public Facility and Residential, 8-12 units/acre	Apartments/Condos
8	Very High-Density Residential, 12 units/acre or more	Townhouses/6,000 sq ft lots
9	Commercial, Retail, Casino, High Rise Condominiums	Commercial, Retail, Casino, High Rise Condominiums & Less than 6000 sq ft lots

2. Impervious percentages have been updated to be consistent with the Curve Number Table (Table 602A) in the RFCD Design Manual. Impervious percentages changed for two categories as shown in **Table 2-2.**

Table 2-2 – Land Use Percent Impervious Changes

Land Use Index	Land Use Description	2018 Impervious %	2023 Impervious %
6	High-Density Residential, 7000 - 10,000 sq ft lots (avg.)	52	53
8	Townhouses/6,000 sq ft lots	80	69

3. Open desert shrub in fair hydrologic condition (30% to 70% ground cover) represents pervious areas in all developed land use categories. The SNWA turf conversion rebate program requires that the desert landscape plants (when mature) cover at least 50% of the converted area.

4. The open space (pervious) land cover distribution is divided into two groups: open landscaping (grass) and open desert shrub (desert landscaping). Based on the SNWA grass removal mandate, 50% open landscaping (grass) in good condition and 50% desert shrub in fair condition are still reasonable for open space in residential areas (land use categories 3 through 8). New turf is prohibited in multi-family residential, high-rise condominiums and non-residential developments per the SNWA drought ordinance; and non-functional turf must be removed in industrial, commercial and office park properties, HOAs, Right-of-Way and churches. As a result, light industrial, heavy industrial, commercial areas, churches, public facilities, and Right-of-Way (land use categories 9 through 11 and 15) are assumed 100% fair condition desert shrub for the open space distribution. For parks/golf courses (land use categories 2), values of 70% open landscaping (grass) in good condition and 30% fair condition desert shrub for the open space distribution was assumed. For schools (land use category 12) values of 60% open landscaping (grass) in good condition and 40% fair condition desert shrub for open space distribution were assumed. The pervious split for parks/golf courses and schools was determined after reviewing the Near Map 2023 aerial imagery.

5. Right-of-Way for residential areas or minor roadways were incorporated into their surrounding land use categories to more closely match the directly connected impervious area percentages for each land use category. Right-of-Way for Major streets (Major streets defined as functional class “Collector” or higher) are categorized as a new land use category 14.

6. An additional land use category was added for Solar Manufacturing on Bare Ground (land use category 14) which represents newly graded areas (pervious areas only, no vegetation).

It should be noted that undeveloped land, open desert (land use category 1) will continue to use 100% poor condition desert shrub (<30% ground cover).

The directly connected impervious area percentages and corresponding open space distribution of each land use category is presented in **Table 2-3**.

The land use data used with the 2023 MPU is shown on the W-Maps.

Table 2-3 - Land Use Categories

Land Use Index	Land Use Description[1]	Directly Connected Impervious[2] (%)	Open Landscape Good Condition Grass (%)	Open Desert Shrub Fair Condition Desert Landscaping (%)
1	Undeveloped Land, Open Desert	0	0	100[3]
2	Parks, Golf Courses	5	66.5	28.5
3	Rural, 40,000 sq ft lots	20	40	40
4	Low-Density Residential, 20,000 sq ft lots	25	37.5	37.5
5	Medium-Density Residential, 14,000 sq ft lots	30	35	35
6	High-Density Residential, 7000 - 10,000 sq ft lots (avg.)	53	23	24
7	Apartments/Condos	72	14	14
8	Townhouses/6,000 sq ft lots	69	15	16
9	Commercial, Retail, Casino, High Rise Condominiums & Less than 6000 sq ft lots	85	0	15
10	Light Industrial, Churches and Public Facility	72	0	28
11	Heavy Industrial	85	0	15
12	Schools	50	30	20
13	Lakes	0	0	0
14	Solar Manufacturing on Bare Ground	5	0	95[4]
15	Right-Of-Way	85	0	15

[1] Lot size descriptions represent the size of the average lot and not the gross acreage divided by the number of lots.

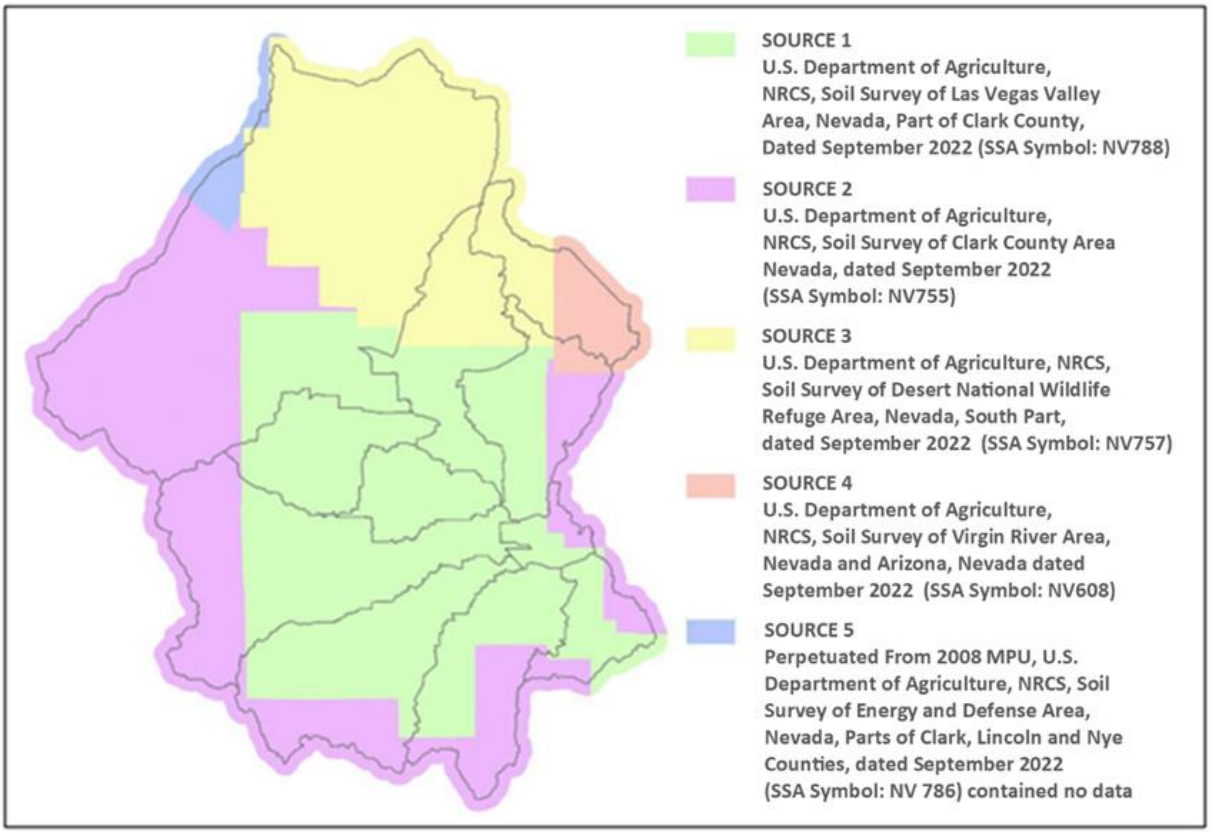
[2] Impervious areas are directly connected to the drainage system, actual percent impervious should be compared to selected land use type.

[3] Open Desert Shrub Poor Condition is applied for Undeveloped Land, Open Desert (Land Use Index Number 1)

[4] Newly graded areas (pervious areas only, no vegetation)

2.3.4. Soils

The latest soil survey data from the Natural Resources Conservation Service (NRCS) dated 2022 was used in the 2023 MPU. The soil data used is a composite of the following soil survey data sources:



The soil survey data was downloaded in GIS format from the NRCS website. The GIS data delineates each soil map unit area and has a corresponding map unit number. Since several soil survey areas are combined in the 2023 MPU, these original map unit numbers were modified to have unique identifiers for each soil type in the study area.

For Source 1, the original map unit number was used with a preceding number of 1. For example, for Source 1, if the original map unit number was 112, it became 1112. Generally, for Sources 2 and 3, a preceding number of 2 or 3, respectively, was added to the original map unit number. For Source 4, some of the original map unit numbers are letters. For example, one soil map unit number used was RTF which became 4RTF in the composite GIS layer.

For Source 5, no delineated map units were available because a detailed soil survey was not performed in the Department of Defense and Department of Energy area. Therefore, 2008 MPU soils data was perpetuated in the area within Source 5. A preceding number, 5, was added to the remaining last three digits of the 2008 MPU soil map unit numbers. For example, if the 2008 MPU map unit number was 3385, it became 5385.

Thus, the source of the soils information can be identified by the map unit number as follows:

Source 1: Map unit numbers 1000 to 1999
Source 2: Map unit numbers 2000 to 2999
Source 3: Map unit numbers 3000 to 3999
Source 4: Map unit numbers 4000 to 4999 and 4XXX
Source 5: Map unit numbers 5000 to 5999

NRCS methodology divides soils into four hydrologic soil groups as defined below:

Type A. High infiltration rate, low runoff potential

Type B. Moderate infiltration rate, moderately low runoff potential

Type C. Low infiltration rate, moderately high runoff potential

Type D. Very low infiltration rate, high runoff potential

Each soil type (map unit number) is made up of a certain percentage of hydrologic soil groups A, B, C, and D. In some cases, the soil type is also comprised of rock outcrop in addition to the four hydrologic soil groups. Most soil types do not include all four hydrologic soil groups or rock outcrop, and very few soil types consist entirely of a single hydrologic soil group or rock outcrop. Certain percentages of soil components did not contain an assigned hydrologic soils group in the soil survey data. For these components, hydrologic soils groups were assigned manually based on engineering judgement. Two Map Units in Source 4 (4BRB and 4CTC) have a component which was classified as Unnamed soil. These components were assigned a HSG based on the dominant HSG in the map unit. Information on soils data is shown in the W-Maps. The percentages of hydrologic soil groups for each map unit is located in the curve number matrix in **Appendix D.5**.

2.3.5. Curve Numbers

Rainfall losses due to soil infiltration, depression storage, and other factors were calculated using the NRCS curve number method, which is a function of soil type, land cover, and antecedent moisture condition. Based on the RFCD Design Manual, the average antecedent moisture condition (AMC II) is used for computing losses.

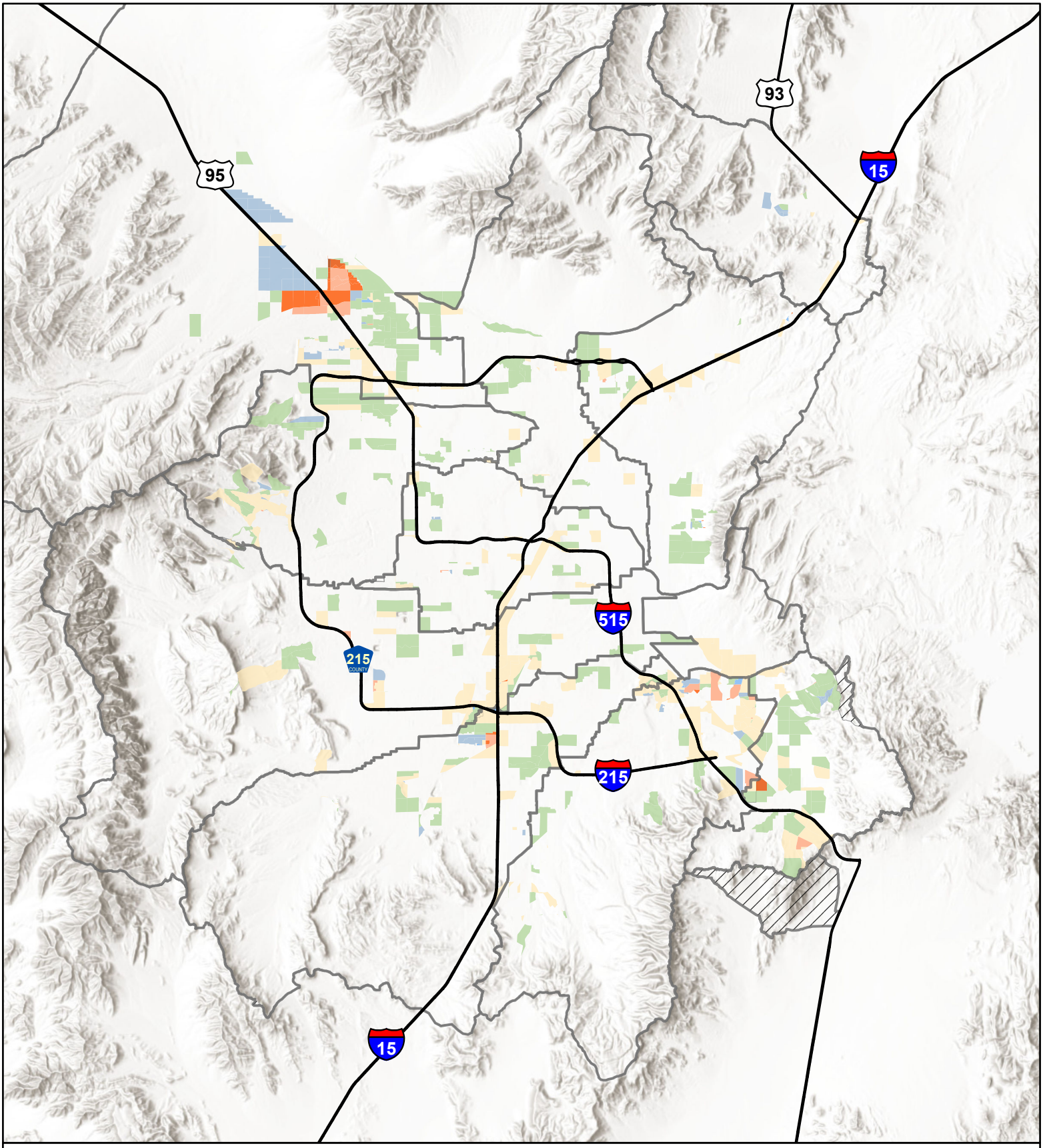
To develop curve numbers, the subbasin delineations, soil map unit, and land use layers were intersected in GIS to create a new GIS layer. Curve numbers were generated from a curve number matrix that calculates a soil-weighted curve number for each combination of soil map unit and land use type (see **Appendix D.5**). The weighted curve numbers were then summed for each subbasin to calculate a composite curve number for each subarea (see **Appendix D.6**).

Table 2-4 summarizes the curve numbers of each land cover type and hydrologic soil group combination based on the RFCD Hydrologic Criteria and Drainage Design Manual (Table 602). In addition, a curve number of 90 is assumed for rock outcrop and a curve number of 98 is assumed for directly connected impervious areas across all soil types.

Figure 2-1 shows the changes in the curve numbers since the 2018 MPU. This is the overall change due to changes in Land Use methodology and soils data.

Table 2-4 - Runoff Curve Numbers

Land Cover Type	Curve Number				
	A	B	C	D	Rock Outcrop
Desert Shrub Poor Condition	63	77	85	88	90
Desert Shrub Fair Condition	55	72	81	86	90
Landscaped Good Condition	39	61	74	80	90
Newly Graded Areas	77	86	91	94	90



N

0 1.5 3 6

Miles

1 in = 6 miles

2023 LAS VEGAS VALLEY
FLOOD CONTROL
MASTER PLAN UPDATE

FIGURE 2-1
CHANGE IN CURVE NUMBER
SINCE THE 2018 MPU

Change in Curve Number (CN)*

- New Areas
- -60 - -30
- -30 - -20
- -20 - -10
- -10 - -5
- -5 - -1
- -1 - 1
- 1 - 5
- 5 - 10
- 10 - 20
- 20 - 30
- 30 - 40

REGIONAL FLOOD CONTROL DISTRICT

AtkinsRéalis

Westwood

* Change in CN based on subbasin composite CN values using 2023 subbasins minus 2018 MPU subbasin CN values.

2.3.6. Computer Modeling

HEC-1 Version 4.1 (dated June 1998) was used to simulate the rainfall-runoff process for the 2023 MPU. The same version of HEC-1 was also used for the 2018 MPU hydrologic analysis. The HEC-1 flows, nodes, and model names associated with each flood control facility are tabulated in the facility inventory tables included in the F-maps in **Appendix C**.

HEC-1 models were developed in Excel by linking the parameters to a table that is imported from GIS. The development of models using Excel help achieve efficiency and avoid errors that may occur with manual input of parameters.

2.3.7. Design Storm

The design storm for the 2023 MPU is the 6-hour, 100-year frequency rainfall event. The rainfall used for hydrologic modeling of MPU facilities is intended to produce runoff discharges with an expected 100-year recurrence interval. A 100-year recurrence interval is defined as having a 1.0 percent chance of being equaled or exceeded in any given year.

2.3.8. Precipitation

Rainfall data published by the National Oceanic and Atmospheric Administration (NOAA) in *NOAA Atlas 2, Precipitation–Frequency Atlas of the Western United States*, Volume VII – Nevada (*NOAA 1973*) and their subsequent modification by the United States Army Corps of Engineers (USACE) Los Angeles District (1988) were used for the 2023 MPU. The rainfall depths were obtained from the NOAA Atlas map (Figure 506 in RFCD Design Manual) and multiplied by an adjustment factor of 1.43 (see Table 501 in RFCD Design Manual) in accordance with established the RFCD methodologies. The adjusted 100-year, 6-hour rainfall depths range from approximately 2.4 inches to 4.3 inches in the Las Vegas Valley watersheds. Most areas have a rainfall depth of 2.77 inches or higher except for the extreme northwest portion of the Valley between the Sheep and Spring Mountains.

Rainfall depth information used for the 2023 MPU was originally developed during the 1996 MPU. For the 1996 MPU, a rainfall depth layer was created using GIS. The NOAA Atlas rainfall depths with the adjustment factor were scanned into a GIS format. GIS was then used to develop a grid of rainfall depths for the entire Las Vegas Valley. The rainfall grid and GIS polygon processing were expanded in the 2023 MPU to include the Eldorado Valley Watershed and additional drainage area in C1 Watershed. The expanded rainfall was used in the 2023 MPU to calculate a weighted average rainfall depth for each subbasin in the new hydrologic models.

2.3.9. Storm Distribution

The rainfall depths discussed in the previous section were distributed over the 6-hour design storm period using three different storm distributions. Storm Distribution Numbers (SDN) 3, 4, and 5 are used for the 2023 MPU. For drainage areas less than 8 square miles in size, SDN 3 was used. For drainage areas greater than or equal to 8 and less than 12 square miles in size,

SDN 4 was used. SDN 5 was used for drainage areas greater than or equal to 12 square miles in size. The storm distributions are referenced from Table 503 of the RFCD Design Manual.

2.3.10. Depth-Area Reduction Factors

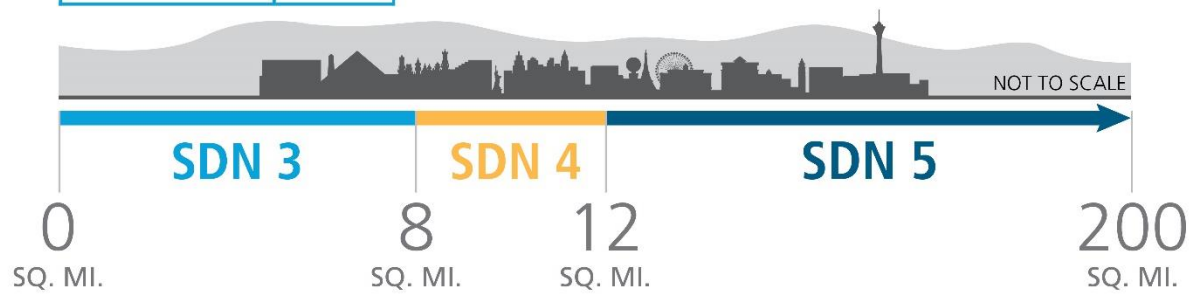
Precipitation depths obtained from NOAA Atlas 2 represent rainfall frequency at isolated points. Storms, however, cause rainfall to occur over widespread areas simultaneously, with the most intense rainfall typically occurring near the center of the storm. To account for the rainfall variation, standard precipitation analysis methods require adjusting point precipitation depths downward in order to better represent the average depth of rainfall over the entire storm area. This is done using depth-area reduction curves that relate point precipitation reduction factors to storm area and duration. The reduction factors cause the rainfall depth to decrease as the tributary area increases.

Depth-area reduction factors (DARFs) were applied to the rainfall depths in the hydrologic models at each concentration point based on upstream tributary area. Due to the number of concentration points used in the hydrologic models, an average DARF value was used for a range of tributary areas. DARF values generally used for each SDN in the hydrologic models are summarized below. Some exceptions were made to the use of the DARFs where the areal extent of the hydrologic model was large (greater than 20 square miles) and the number of concentration points of interest was relatively small (DARFs may have been added or modified to decrease the range of tributary area for each DARF).

Area (SQ. MI.)	SDN 3
0≤ - <0.5	0.99
0.5≤ - <1	0.975
1≤ - <2	0.95
2≤ - <3	0.925
3≤ - <4	0.915
4≤ - <5	0.908
5≤ - <6	0.903
6≤ - <7	0.895
7≤ - <8	0.885

Area (SQ. MI.)	SDN 4
8≤ - <9	0.875
9≤ - <10	0.865
10≤ - <11	0.857
11≤ - <12	0.85

Area (SQ. MI.)	SDN 5
12≤ - <16	0.832
16≤ - <20	0.804
20≤ - <30	0.765
30≤ - <40	0.725
40≤ - <50	0.695
50≤ - <100	0.64
100≤ - <150	0.58
150≤ - <200	0.53



2.3.11. Storm Centerings

The storm centerings used for the 2023 MPU have been classified into three general categories: Series A, B, and C. The three storm centering series are generally defined as follows:

- **Series A**. Storm centering for the entire watershed with SDN 3, 4, and 5 hydrologic models. This series of storm centerings will control many areas of the watershed, especially in the upper portions of the watershed upstream of detention basins.
- **Series B**. Storm centering for the entire watershed with SDN 3, 4, and 5 hydrologic models, which is the same as Series A, except that the discharge from all detention basins is diverted out of the hydrologic models. This series of storm centerings will control most areas of the watershed downstream of detention basins. Note that the tributary area displayed in the hydrologic models for many of the concentration points downstream of detention basins may not be the actual tributary area representing the peak flow at a given location. This is due to the fact that even after detention basin discharge has been diverted out of the model, the tributary area to the detention basin is still carried with the downstream flow.

  The facility inventory tables, shown in **Appendix C**, provide the calculated tributary area that produces the peak flow, and provide a good reference when reviewing/updating the Series B storm centering HEC-1 models.
- **Series C**. These storm centerings are used only to model special cases where the peak flow for a given location may not be produced by the Series A or B centerings. These storm centerings may include some detention basins, while others are diverted out of the model. Any Series C storm centerings used are described in **Chapters 3 through 14**.

The maximum storm centering size used for the MPU is approximately 200 square miles. The maximum storm centering size applies only to the Upper Northern Las Vegas Wash Watershed and the Lower Las Vegas Wash Watershed, because these are the only two watersheds that have total tributary areas greater than 200 square miles. The storm centerings for the Upper Northern Las Vegas Wash Watershed and the Lower Las Vegas Wash Watershed are described in **Chapters 4 and 12**, respectively.

2.3.12. Subbasin Delineations

Each of the twelve watersheds was subdivided into hydrologic subbasins. Subbasins are reasonably homogeneous and drain to a single concentration point. Subbasin boundaries generally follow delineations made in previous MPU hydrologic models. New subbasin delineations were made in areas where new developments and new information from master plan amendments, other major hydrologic studies, aerial photos, topography, and field investigation give evidence that old delineations are either obsolete or inaccurate. Further revisions to subbasin boundaries were a result of the revisions made to the alignment of the existing and proposed flood control facilities and the UDB.

For the hydrologic methodology used in Las Vegas Valley, the peak outflow computed by a multi-basin hydrologic model is sensitive to the size of its constituent subbasins. The smaller

the average subbasin, the larger the modeled peak flow rate from a watershed. In some cases, the peak flow from a one square-mile watershed can increase by 50 percent when the watershed is subdivided into subbasins with an average of 0.1 square miles. To minimize this effect, subbasins delineated in urban areas (inside the UDB) were generally kept between 0.25 and 0.50 square miles. Undeveloped areas (outside the UDB) were generally kept the same as the 2018 MPU and are generally much larger than those for urban areas. Future changes to the subbasin delineations for the undeveloped areas are not anticipated because the topography and drainage patterns in these areas are not expected to be modified by development. **It is recommended that more detailed hydrologic analyses should be completed during the design phase of flood control facilities. It is also recommended that during the more detailed hydrologic analyses the subbasin sizes used in the 2023 MPU be perpetuated in the design of the main line of a regional facility.** Smaller subbasin sizes may be used as needed to size inlet facilities, laterals, and local drainage facilities.

All subbasin delineations for the 2023 MPU were mapped using GIS and are available electronically on RFCD website. Hydrologic maps (W-Maps) for each of the twelve watersheds that show all the subbasins are included **Appendix B**.

2.3.13. Lag Times and Routing

Lag times were calculated for subbasins over one square mile using the U.S. Bureau of Reclamation Method. During review of the RFCD Design Manual the USBR Equation did not match the referenced source. It was RFCD recommendation to use the updated equation for the 2023 MPU as it will soon be changed in the RFCD Design Manual.

U.S. Bureau of Reclamation Method

The lag time for basins over one square mile is calculated as follows:

$$T_{lag} = 24\, K_n\, (L\, L_c / S^{1/2})^{0.38}$$

Where:

T_{lag}=Lag time (hours)

L =Length of longest watercourse (miles)

L_c = Length along longest watercourse measured upstream to a point opposite the centroid of the basin (miles)

S =Average slope of the longest watercourse (feet/mile)

K_n =Manning's roughness for the basin channels.

Discussion of the methodology taken from RFCD Design Manual for calculating lag times and routings is included in **Appendix D.**

2.3.14. Concentration Points

Concentration points for the combining of subbasins were inserted into the MPU hydrologic models to obtain peak flow rates for each MPU facility to the fullest extent possible considering the subbasin size limits discussed in **Section 2.3.12.** MPU facilities in the most upstream portion of a facility system may have direct tributary areas that are less than those allowed by the criteria set in **Section 2.3.12**. As a result, the nearest concentration point for these facilities may be further downstream in the facility system.

2.3.15. HEC-1 Model Format

Modeling formats such as nomenclature, input data structure, job title information, message cards, and significant digits were standardized for the MPU. Non-proprietary file formats were used with all models.

To help facilitate the use of the 2023 MPU hydrologic models, information has been included in the model input file that describes components of the input data. This information has been entered on the “ID” and “KM” cards for the components of each model input file. The sections below describe what type of information is included on the ID and KM cards of each HEC-1 model.

At the beginning of each model, several ID cards were used to provide a general description of the model. Information contained on the ID cards includes the following:

- Watershed name
- Input file name
- Input file date
- Design storm
- SDN
- Person (or Firm) responsible for completing the hydrologic modeling
- Storm centering description
- Previous hydrologic models/studies referenced
- DARF used

Information contained on the KM cards for each hydrologic model component is includes the following

Muskingum-Cunge and Muskingum Routings

- Identifier names for the beginning and ending nodes of the routing
- Description of facility system the flow is being routed through
- Facility ID-Mile(s) the flow is routed through
- Facility lining or facility type the flow is routed through
- If the flow is not routed through a facility, then a street name is provided.

Concentration Points or Nodes

- Identifier names of what is being combined at each combination point or node
- Description of the intersection where the combination point is located, usually using street names

Detention Basins

- Description of detention basin facility system
- Facility ID-Mile(s) for the detention basin
- Storage volume of the detention basin at the spillway elevation
- Description of the outlet structure
- 100-year peak flow discharge
- Spillway length (if applicable)
- Spillway height (if applicable)
- Spillway crest elevation (if applicable)
- Spillway type (if applicable)
- Probable maximum flood (PMF) discharge (if applicable)
- Top of embankment elevation (if applicable)

In addition to the information included on the ID and KM cards of the input files, a consistent naming convention was used to facilitate the use of the hydrologic models. Routing and combination point identifiers were named by inserting an “R” or “C,” respectively, in front of the previous subbasin identifier. An example of this naming convention for subbasins named “X” and “Y” is as follows:

X–input subbasin X parameters

RX–route subbasin X

Y–input subbasin Y parameters

CY–combine subbasin Y and routed subbasin X

RCY–route combined subbasins Y and X

2.4. Facility Planning

The facility planning completed with the 2018 MPU and subsequent changes by RFCD served as the basis for the 2023 MPU facility planning effort.

The subsections below describe the types of facilities that are planned as part of the 2023 MPU and the difference between regional (referred to as MPU facilities) and local facilities.

2.4.1. Regional versus Local Facilities

Regional Facilities

Regional facilities are generally described as flood control facilities required to safely convey and detain major flood flows with a minimum 100-year frequency flood event flow of 500 cfs or a minimum contributing drainage area of 1 square mile. Regional facilities within the Las Vegas Valley are displayed in the F-Maps in **Appendix C**. Existing regional facilities are displayed in blue, proposed Category A facilities are shown in red, and the proposed Category B facilities are green. Please refer to **Section 2.5.2** for a detailed description of Category A and Category B facilities.

Some existing regional facilities included in previous MPUs do not meet the RFCD conveyance criteria described above. These facilities have been "grandfathered" into the flood control plan and continue to be identified as regional facilities in the 2023 MPU so that they are eligible for maintenance funding.

Funding for regional facilities is generally completed through an interlocal contract between the RFCD and the lead local governmental entity for the project (see RFCD Policies and Procedures Manual). Funding for regional facilities may include costs associated with design, right-of-way acquisition, environmental, construction, construction management, operations and maintenance, FEMA flood map revisions.

Local Facilities

Several local or neighborhood flood control master plans have been completed by local entities in the Las Vegas Valley. The purpose of these local master plan projects is to complement the regional master plan through the analysis and development of a local drainage system that acts as a collection system for the network of regional facilities. Many neighborhood surface streets in the Valley act as conveyance corridors for flood flows during major storm events. Local facilities help to decrease the volume of water conveyed to regional facilities via surface streets thereby lessening the impact of surface flow on adjacent properties and allowing for the safe passage of vehicular traffic during a major flood event. Many local master plan projects also analyze an existing condition that does not include proposed regional and local facilities that have not yet been constructed. Analyzing this condition helps determine what areas may be prone to flooding before the construction of future flood control facilities and helps prioritize future facility construction. The existing local facilities (best available information as obtained from all the local entities) are also shown on the F-Maps in **Appendix C**. The existing local facilities are shown in black.

2.4.2. Detention, Retention, and Debris Basins

Detention Basins

Detention basins provide temporary storage of floodwaters during flood events. These facilities accept high inflow rates that are usually of a relatively short duration (usually 1 to 12 hours) and discharge flow at a lower rate than the inflow (usually 5 to 20 percent of the inflow for a 100-

year event) for a relatively longer period of time (usually 24 hours to several days). The reduction in flow rate between the inflow and outflow requires that a significant volume of water be stored. Storage volume is obtained by constructing a dam embankment or excavating below grade, or a combination of both.

Detention basins provide several benefits to the overall flood control system and the downstream areas they protect which include:

- They provide flood storage that attenuates flood flows and mitigates the flood risk to businesses and communities downstream
- They control the release of flood flows resulting in a major reduction in the required conveyance capacity of downstream facilities
- Can combine flood flows from several different drainage corridors into one downstream discharge point
- They capture sediment from upstream areas and can improve water quality
- Relatively inexpensive to construct (though they often require the acquisition of significant land area to provide enough storage volume).
- Many detention basins have been used for parks or other recreational amenities
- Relatively easy to maintain considering that major flood events in the Las Vegas area are infrequent

Retention Basins

Retention basins are similar to detention basins with a few exceptions. They include:

- Retention basins don't release incoming flow from the basin or it is released at an insignificant rate
- Retention Basins require larger storage volume than detention basins which results in larger right-of-way acquisition and construction costs
- Soil expansion, siltation and lack of infiltration capacity can lead to ponding/standing water that could become a nuisance to the general public and increase facility maintenance costs
- Retention basins are more vulnerable to flood events that occur in series over short periods; these events can overwhelm the storage capacity of the basin due to lengthy storage times

For these reasons, retention basins are not recommended in Clark County.

Debris Basins

Debris basins are used to capture sediment and other debris from upstream areas. Debris basins are generally used where the upstream watershed is expected to produce large volumes of sediment and other debris. Sediment and debris can create problems in downstream facilities by clogging culvert and bridge openings, depositing in channel bottoms, or creating sediment bulking, all of which reduce facility conveyance capacity. Usually, debris basins do not significantly reduce peak flood flows conveyed by downstream facilities.

2.4.3. Multi-use Facilities

The primary purpose of all flood control facilities is the safe detainment and conveyance of flood flows. Public safety and the proper functioning of flood control facilities are paramount and cannot be compromised by other uses; however, multi-use opportunities exist with many master plan facilities. Therefore, the RFCD policy is to encourage early planning to identify and take advantage of multi-use opportunities afforded by flood control facilities included in the Master Plan.

Recreation is the principal multi-use opportunity. Recreational uses of flood control facilities include parks, trail systems, and environmental preserves. Recreational improvements are usually implemented near the end of a flood control construction project, and some existing flood control facilities have been modified to accommodate recreational amenities.

Available flood control facility construction monies are in high demand to implement the Master Plan, which improves the protection of life and property. It is therefore the RFCD policy that other funding sources be obtained to facilitate the construction of recreational or other multi-use components of regional flood control facilities. As stated above, many existing facilities can be modified to include recreational or other multi-use components as funding becomes available from other sources. In addition, access roads for many linear flood control facilities could be used as trails in conjunction with a larger trail system.

The RFCD has developed policy statements and criteria to regulate the use of Master Plan facilities for recreation or other multi-use opportunities. These policy statements and criteria are available in the RFCD Design Manual.

2.4.4. Storm Drains versus Open Channels

Using storm drains or open channels to convey flood flows is normally governed by whether the required right-of-way is available for an open channel, the cost of the right-of-way, surface use, and the location of the right-of-way relative to existing or future roadways. Construction costs for open channels are generally less expensive than construction costs for storm drains and it is easier to collect the flow via an open channel than a storm drain. For these reasons, open channels are usually preferred to storm drains. In some areas, however, right-of-way is not available or is too expensive, especially if the flood control facility is being constructed in a developed area. During the preliminary design phase of a project, an analysis should be completed to determine which type of facility best suits the location where it is being proposed.

2.4.5. Channel Lining and Erosion Protection

The primary purpose of flood control channels is the safe conveyance of flood flows; therefore, channel linings should be selected that will fulfill this purpose. The RFCD Design Manual specifies maximum allowable flow velocities for each channel lining type.

Channel Lining

It is desirable, where possible, to use natural washes or other "soft linings" to convey flood flows provided it can be done in a manner that ensures a proper level of protection for adjacent properties. Unfortunately, due to steep slopes and subsequently high flow velocities (greater than 10 to 15 feet per second) and the inability of the natural system to safely convey flood flows, riprap, gabion and concrete lined channels are recommended in many areas. Concrete channels convey flood flows effectively and efficiently and, when designed properly, eliminate the potential for erosion hazards. Concrete-lined channels also require little maintenance when compared to other channel lining types such as gabion, riprap, grass, or earthen. However, the aesthetic value and environmental benefits of concrete channels are minimal. With the implementation of AB 356 Grass Removal Mandate no new grass lined channels are proposed in the MPU. The Mandate allows grass in existing channels up to the 100-year flood extents so existing grass lined channel are not proposed to be replaced with other lining types.

Scour and Deposition Issues

There are some areas within the Las Vegas Valley where the 2023 MPU recommends that natural wash corridors should be maintained. There is a potential of erosion and scour within these existing natural washes generally when flow velocities exceed 5 feet per second (fps). This means that a high concentration of sediment will be transported via these natural washes, which will eventually be deposited when flow velocities decrease sufficiently, such as at the entrances to culverts, grate inlets, and channel bends. Scour and deposition can cause significant damage to flood control facilities and in some cases, can make the facility completely ineffective. This can cause flows to take drainage paths that are damaging to both public facilities and private property. Therefore, it is critical that scour and sedimentation be considered when designing flood control facilities. This includes, but is not limited to, the construction of sediment basins, over-sizing culverts to account for sediment clogging, freeboard in detention basins and channels to account for sediment bulking, and smooth transitions from channels to culverts to eliminate sedimentation and hydraulic jumps. Natural washes should also be studied, monitored and appropriate mitigation and maintenance actions taken to ensure the long-term viability of their flood conveyance requirements as part of the overall regional flood control system.

2.5. Facility Analysis

2.5.1. Existing Facilities

Existing MPU facilities in the Valley were analyzed to determine whether they can adequately detain and/or convey the 100-year peak flow rates[1] generated from the MPU hydrologic analyses.

The capacity of the existing conveyance facilities was determined based on normal depth calculations. More accurate hydraulic calculations or design capacities were used for existing conveyance facilities when available. Proposed mitigation for existing conveyance facilities without adequate capacity was deemed necessary when the full flow capacity of a channel or storm drain was exceeded by more than 500 cfs. Mitigation for existing conveyance facilities was generally achieved by proposing parallel facilities, removal and replacement, modification of the existing facility, or reducing runoff to the existing facility (e.g. upstream detention or diversion of runoff) whichever appeared to be the most viable option.

In some areas of the Valley, existing local facilities were adopted by the MPU as regional facilities if the peak flow rate in these facilities is greater than 500 cfs or if the facilities have a tributary area of one square mile or more. Including these facilities in the master plan paints a more complete picture of the existing level of flood protection in the Valley and allows these facilities to qualify for the RFCD maintenance funding.

Existing detention basins were evaluated to determine whether they have adequate storage capacity to detain the 100-year flow. Upgrade or expansion were proposed to the existing detention basins if and only if they do not have capacity for 100-year clear water storage volume. If the existing detention basins did not have adequate capacity, then the existing detention basins were proposed to be expanded (upgraded). Upgrades to the detention basins typically include: 1) increasing the storage volume below the spillway (or below the top of the detention basins for the below-grade detention basins), and/or 2) raising the top of the spillway.

All existing regional facilities are graphically displayed on the W and F maps found in **Appendix B** and **Appendix C**, respectively. Generally, all regional facilities that were completed, under construction, or approved for funding at the time of publication are shown as existing on the exhibits.

[1] Generally, the peak flow associated with the downstream hydrologic node (HEC-1 node) was used to determine flow impacting the existing conveyance facilities. However, in some cases it was more realistic to use the upstream hydrologic node to determine the peak flow impacting the existing conveyance facility.

2.5.2. Proposed Facilities

Proposed facilities are categorized as two types:

- Category A - These facilities are considered essential for the protection of existing development, and thus, are given priority for the RFCD funding. They are designated with a P status in the MPU tables and GIS data.
- Category B – These facilities consist of planned flood control improvements that are not required to protect existing development (as they are generally located in undeveloped areas) or they will eventually replace an existing facility which currently provides a level of flood protection but cannot convey the entire 100-year peak flow. Many category B facilities do not require public funding for implementation. They are designated with a P0 status in the MPU tables and GIS data.

Proposed 2023 MPU facilities in the Valley were analyzed to determine whether they would adequately detain and/or convey the 100-year peak flow rates[2] generated from the 2023 MPU hydrologic analyses. Capacity of the proposed facilities was determined based on normal depth calculations with applicable freeboard. The proposed facility alignments were also evaluated based on the best available development and infrastructure information to determine whether other locations and alignments of facilities could more efficiently facilitate the implementation of the flood control plan. Proposed facility sizes, types, and alignments were modified as necessary based on the information collected and developed for the 2023 MPU.

New proposed facilities have been added to the flood control facility system in addition to what was included in the 2018 MPU. Most of the new facilities added to the flood control plan were required to have a peak 100-year flow rate of at least 500 cfs or have a tributary area of one square mile or more. Facilities added to the master plan have been coordinated between the respective entity and the RFCD and have been approved by the RFCD.

Proposed detention basins account for sediment in the basin by adding 10% to the peak clear-water storage based on results from HEC-1. This 10% sediment volume is added to the clearwater storage to calculate a total storage planned for the detention basins. Proposed detention basins also account for 1-foot freeboard.

It should be noted that the hydraulic analysis is approximate in nature and assumes all flow is conveyed by the proposed facility. During detailed design, it is fully expected that all features in an urban setting, e.g., street flow, will be used to minimize project costs.

[2] Generally, the peak flow associated with the downstream hydrologic node (HEC-1 node) was used to size the proposed conveyance facilities. However, in some cases it was more realistic to use the peak flow associated with upstream hydrologic node to size the proposed conveyance facility.

2.5.3. Hydraulic Analysis

The following criteria, in general, were used for hydraulic calculations to size proposed facilities based on the discharges developed by the 2023 hydrologic models:

Channels

Capacity for channels was based on the following criteria:

- Depth and velocity were determined using normal depth calculations and Manning's equation
- Freeboard was based on Subcritical Equation 741 and Supercritical Equation 747 from the RFCD Design Manual
- Design slope was based on the ground slope
- Minimum side slope =
    - 0:1 for concrete
    - 2:1 for riprap/gabion
    - 3:1 for grass*

Manning's n is based on **Table 2-5.**

Table 2-5 - Manning's n for Channels

Channel Type	Manning's n	Maximum Velocity (ft/sec)
Concrete	0.015	>15
Soil Cement	0.025	15
Gabion or Earthen/Unlined	0.030	15
Riprap	0.040	10
Grass*	0.030	8

*No new grass lined channels are proposed in the MPU.

Storm Drains

Reinforced concrete pipe (RCP) capacity was based on the following:

- Manning's Equation
- Non-pressure full flow
- Pipe conveys the entire 100-year discharge
- Increase proposed pipe size to next standard pipe size at 6-inch intervals to account for minor losses
- Design slope = Ground slope

Reinforced concrete box (RCB) capacity was based on the following:

- Manning's Equation
- Non-pressure full flow
- Conduit conveys the entire 100-year discharge.
- The proposed depth was increased by a minimum of 15 percent and then rounded to the nearest whole number to account for minor hydraulic losses.
- Design slope = Ground slope

Proposed RCB culverts were sized using the following:

- The bridge criteria outlined in the RFCD Design Manual, which states that there is to be a minimum of two feet of freeboard between the 100-year water surface and the low chord of the culvert.

Design slope was based on ground slope. Manning's n for the various storm drain types are shown in **Table 2-6**:

Table 2-6 - Manning's n for Storm Drains

Storm Drain Type	Manning's n
Reinforced Concrete Pipe (RCP)	0.013
Reinforced Concrete Arch Pipe (RCAP)	0.013
Reinforced Concrete Pipe Culvert (RCPC)	0.013
Reinforced Concrete Arch Culvert (RCAC)	0.013
Horizontal Elliptical Reinforced Concrete Pipe (HERCP)	0.013
Reinforced Concrete Box (RCB)	0.015
Corrugated Metal Pipe (CMP)	0.024
Corrugated Metal Arch Pipe Culvert (CMAP)	0.024
Corrugated Metal Pipe Culvert (CMPC)	0.024

Bridges

Capacity of bridges was determined using the following:

- Depth and velocity were determined using normal depth and Manning's Equation
- Freeboard was based on RFCD Design Manual minimum of two feet of freeboard between 100-year water surface and the low chord of the bridge
- Design slope was based on ground slope.

Levees

Levees were sized using the following procedure:

- Develop a channel cross section adjacent to the levee using a normal depth calculation that keeps the water depth at 3 feet or less
- Assume the channel is unlined unless the channel is also a master planned facility for which channel lining would be used.

- Choose a lining for the levee that is consistent with the normal depth velocity of the channel.
- Size the levee using the following relationship:

$$Ht = Df + Dd + Fb + Vh$$

Where: Ht = Height of dike (feet)

Df = Depth of flow (feet)

Dd = 1.3 x Df = Depth of sediment deposition (feet)

Fb = 3 (ft) = FEMA freeboard criteria

Vh = Velocity head (feet)

This equation was used to size the proposed levees in the sizing tool; however, in many cases, the adjacent channel depth exceeded 3 feet. When this was the case, a channel was added as an MPU facility adjacent to the levee. The proposed levee height is then the height of dike (based on the above equation) minus the depth of the adjacent channel.

Detention Basins

Detention basins were analyzed using the following procedure:

- Choose detention basin site and approximate limits.
- Calculate approximate stage/storage/discharge curve based on outlet size and impoundment area.
- Calculate approximate storage volume.

  Storage: Clear water storage volume required (runoff) is determined by hydrologic model (Modified Puls Method)

  Outlet: Maximum discharge = 5 to 15 percent of peak inflow depending on existing downstream facility capacity

  Outlet capacity: Equation 1202 (RFCD Design Manual)

  Sediment: Additional volume when required (sediment volume) 10% of the clear water storage or storage volume required. This is not a requirement for detention basins with a fully developed urban drainage area.

- Design emergency spillway

  Spillway elevation = 1 foot above peak 100-year stage (clear water + sediment)

  Design storm = PMF (10 x 100-year discharge)

Debris Basins

Debris basins were analyzed using the following procedure:

- Calculate approximate sediment storage

  Storage: Sediment volume required = 3.5 ac-ft/square mile of tributary watershed area

Outlet:Maximum Discharge = 100-year peak inflow

- Design Emergency Spillway

  Spillway elevation = 100-year peak stage

  Design storm = PMF (10 x 100-year discharge)

A GIS-based Facility Sizing Tool was developed to automatically compute facility conveyance capacity and proposed sizes. The facility sizing tool and user manual can be found on the RFCD website with the Master Plan files and models.

2.6. Cost Estimation

The Cost Estimation Tool developed during the 2018 MPU was updated for the 2023 MPU. The Cost Estimating Tool unit cost equations for the major and minor components have also been updated to reflect construction cost data compiled over the past 6 years. The program has been converted to Microsoft Excel and a GIS Tool. The major update made to the 2018 MPU Cost Estimation Tool includes updating the unit cost equations using construction cost bid tabulation data for projects constructed between July 1, 2016 and June 30, 2022.

The Cost Estimation Tool was updated in five steps:

1. Compile construction cost bid tabulation data from RFCD funded projects, which were used as the basis for the facility estimates.
2. Develop new cost equations using best-fit curves generated from plots of construction cost bid tabulation data
3. Apply inflation adjustment to facility types lacking sufficient construction cost bid tabulation data
4. Update cost calculations within GIS-based and Microsoft Excel tools and compute updated costs.
5. Verify the accuracy of the cost estimates and compare the results to the 2018 MPU.

A complete version of the Cost Estimation Tool is provided on RFCD website with the Master Plan files and models. The sections below describe the steps used to update the Cost Estimation Tool.

2.6.1. Unit Cost Development

Unit costs were developed for the following major facilities, referred to as major components:

- Channels
- Dikes
- Bridges
- Basins (detention, retention, and debris)

- Spillways
- Storm drains
- Culverts

The unit costs for the major components are used by the Cost Estimation Tool to calculate the "basic facility cost".

For a specified major component, costs are also calculated for related secondary construction items, referred to as minor components. Unit costs were developed for the following minor components: basin excavation, channel excavation, reinforced concrete, Type II aggregate base, soil cement, gabion baskets, riprap, fencing, manholes, drop inlets, lateral pipes, roadway replacement, and safety rail.

The basic facility and above minor component facility costs, plus other percentage-based minor component costs, constitute the construction cost (CC). The percentage-based minor component facility costs may include mobilization, traffic control, quality control, utility relocation, structure removal, and lateral collectors.

$$CC = Basic\ Facility\ Cost + Minor\ Component\ Facility\ Costs + Other\ Minor\ Component\ Costs \quad (2.6.1)$$

The total cost (TC) of the facility is the combined cost of construction (CC), design and administration (D&A), and right-of-way (R/W).

$$TC = CC + D\&A + R/W \quad (2.6.2)$$

2.6.2. Source of Cost Data

Information from several sources was collectively used to develop the unit costs (UC), right-of-way cost, and other items contributing to the overall facility cost estimate. Backup data for the development of the unit cost data are included in **Appendix E** of this document.

The primary sources of data were bid tabulations for 48 regional flood control projects constructed between July 1, 2016 and June 30, 2022. Construction costs were extracted from the lowest bid for each project and grouped into separate tables according to the specified construction item. Construction items obtained from the bid tabulations were used directly to determine the unit costs for riprap, detention basins reinforced concrete boxes, pipe, manholes, drop inlets and utility relocation.

Other sources of information used to develop unit cost include the 2018 MPU cost estimation tool and local standards for engineering cost estimates.

Unit costs from the bid tabulations were analyzed to determine whether there was evidence of a trend relating the unit cost to the facility dimensions or quantities. If a statistical relationship was found to exist, regression equations relating the unit cost to the appropriate dimension or quantity were developed. Then goodness-of-fit statistical tests were performed to determine whether the best predictor equation was a linear or power fit of the data. Where no trend in the

data was apparent, unit costs from the bid tabulations were averaged to arrive at a single unit cost for the construction item.

Unit costs were not developed for all facilities or construction items relevant to the Master Plan. Facilities with complex geometry, such as energy dissipators or junction structures, were externally estimated and entered manually into the Cost Estimation Tool.

2.6.3. Major Component Costs

The unit cost equations for Riprap Dikes, Riprap Channels, Detention Basins, Reinforced Concrete Box Storm Drains and Box Culverts, Pipe Storm Drain and Pipe Culverts were updated based on the collected bid data. Limited recent bid data was available for the remaining Major Components; therefore, cost equations and prices were adjusted by multiplying the 2018 MPU equations or costs by a factor of 1.24. This factor represents an 24% national escalation factor to account for inflation between 2017, when the 2018 MPU cost tool equations were developed, and 2022.

Riprap Cost Data

Forty-nine (49) data points related to riprap rock were obtained from the bid tabulations provided. The actual unit cost ($/cuyd) ranged from $40 to $533. A plot of UC vs. Volume (V_m) in cubic yards was generated and goodness-of-fit tests were performed based on power and linear relationships. The results indicated that the best predictor equation was a power fit of UC vs. V_m.

The plot of UC vs. V_m is presented in **Appendix E**. The plot produced the following predictor equation:

$$UC = 349.23{V_m}^{-0.202} \quad (2.6.3)$$

A minimum value of $50/cy was applied in the cost tool so the predictor equation would not underestimate the unit cost for large volumes of riprap.

A coefficient of determination (R^2) of 0.322 does not indicate a strong correlation or predictable relationship; however, this method is based on best-available cost data and is consistent with 2018 MPU approach. Thus, it is considered acceptable for master planning purposes. Evaluation of the data using the prediction equation resulted in the prediction errors in **Appendix E** with a standard deviation of $97.66/cuyd and a standard error of $13.95/cuyd.

Reinforced Concrete Box Cost Data

The prediction equation for RCB storm drain and culverts was developed from one hundred twenty-five (125) data points obtained from the bid tabulations provided. The box sizes ranged from 6 ft x 2 ft RCB to 22 ft x 8 ft RCB, and unit cost ($/ft) from $370 to $3,000. A plot of unit cost ($/ft) vs. RCB cross-sectional area (Ac) in square feet was plotted. Statistical tests were performed based on power and linear relationships and the results indicated that the best predictor equation was a linear fit of UC vs. A_c.

The plot of UC vs. A_c is presented in **Appendix E**. The plot produced the following predictor equation:

$$UC = 11.011A_c + 437.18 \quad (2.6.5)$$

A coefficient of determination (R^2) of 0.560 indicates that the power curve fits the data relatively well with some degree of correlation, which was further substantiated by the goodness-of-fit tests. Evaluation of the data using the prediction equation resulted in the prediction errors in **Appendix E** with a standard deviation of $384.66/ft and a standard error of $19.61/ft.

Reinforced Concrete Pipe Cost Data

The prediction equation for RCP (circular, elliptical, and arch) and corrugated metal pipe was developed from two hundred fourteen (214) data points obtained from the bid tabulations provided. The pipe sizes ranged from 18-in RCP to 72-in RCP, and unit cost ($/ft) from $100 to $790. A plot of the adjusted unit cost ($/ft) vs. pipe cross-sectional area (Ac) in square feet was plotted. Goodness-of-fit statistical analyses were performed based on power and linear relationships and the results indicated that the best predictor equation was a linear fit of UC vs. A_c.

The plot of UC vs. A_c is presented in **Appendix E**. The plot produced the following predictor equation:

$$UC = 11.432 + 221.65 \quad (2.6.6)$$

A coefficient of determination (R^2) of 0.247 does not indicate a strong correlation or predictable relationship; however, this method is based on best-available cost data and is consistent with 2018 MPU approach. Evaluation of the data using the prediction equation resulted in the prediction errors in **Appendix E** with a standard deviation of $128.87/ft and a standard error of $10.03/ft.

Basins

The unit cost for detention, retention, and debris basins was developed from an analysis of seven (7) basins. The bid tabulations provided were reviewed to pull out cost components which were only attributed to the basin ID-mile, including excavation, embankments, depth gauges, flood control monitoring station, riprap, and fencing. The total cost of the components were related to the basin storage volume to determine a unit cost per cuyd of $8.00/cuyd.

Spillways

The predictor equation for spillways is based on the 2018 MPU cost estimation tool (UC, $/cfs vs. the design flow, Q) plus a 24 percent adjustment factor for inflation.

$$UC = 585Q^{-0.19} \quad (2.6.8)$$

Trapezoidal Concrete Channels

The predictor equation for trapezoidal channels is based on the 2018 MPU cost estimation tool plus a 24 percent adjustment factor for inflation.

$$UC = 34.798{A_c}^{0.5341} \text{(2.6.7)}$$

Rectangular Concrete Channels Cost Data

Eleven (11) data points related to rectangular concrete channels were obtained from the bid tabulations provided. This was not enough data to update the equation based on the bid tabulations over the last 5 years. The predictor equation for rectangular channel is based on the 2018 MPU cost equation tool plus a 24 percent adjustment factor for inflation.

$$UC = 1.99A_c + 916.38 \text{ (2.6.4)}$$

2.6.4. Minor Component Costs

The unit costs for manholes, drop inlets, and lateral pipes were updated based on the collected bid data. The major component cost equation for riprap was also used for the minor component unit cost for riprap. The remaining unit costs for other minor components were adjusted based on the 2018 MPU costs and increased by a 24 percent adjustment factor to account for inflation. No change was made to the percentage-based costs for mobilization, quality control, traffic control and structural removal. The 5 percent cost for utility relocation was confirmed to still be reasonable based on recent bid data. The unit cost equations and prices for the minor components are summarized in **Appendix E**.

Chain Link and Safety Fences

Chain link and safety fence (e.g., railing) unit costs were based on the 2018 MPU cost tool plus a 24 percent adjustment factor for inflation. The unit costs employed by the cost estimation tool were $18.60 per foot for chain link fence and $31 per foot for safety rail. The GIS tool assumes that all open channels will require chain link fencing on both sides and that trapezoidal channels will have safety railing on both sides for the entire channel length.

Manholes, Drop Inlets and Lateral Pipe Cost Data

Manhole and drop inlet unit costs were developed from mean values calculated using data obtained from the RFCD bid tabulations. These data are presented in **Appendix E**. The unit costs employed by the cost estimation tool were $8,000 per manhole, $1,900 per foot for drop inlets, and $295 per foot for lateral pipes. The GIS tool assumes that all storm drains (RCP, RCB, and RC arch pipe) will require manholes, drop inlets, and lateral pipes.

Manholes were assumed to be spaced at 400-ft intervals and the number of manholes N_m is determined from:

$$N_m = N\frac{L}{400} \text{ rounded to the nearest whole number(2.6.9)}$$

where L is the length of the storm drain and N is the number of pipes or boxes.

The cost of the drop inlets is based on the length of the inlet (L_d). The length of inlet required for any major component was assumed to be 10% of the total facility length. The cost tool estimates the length of drop inlet from:

$$L_d = 0.1L \quad \text{rounded to the nearest foot} \quad (2.6.10)$$

Lateral pipes were assumed to cost $295 per foot with a 40 cfs capacity (roughly equivalent to a full flowing 30-inch RCP sloped at 0.015 ft/ft). The number of lateral pipes required depends on the required drop inlet length. It was assumed that one lateral pipe is required for each 20 feet of drop inlet. The length of individual laterals was assumed to be 50 feet, see below:

$$N = \frac{L_d}{20} \quad \text{rounded to the nearest whole number} \quad (2.6.11)$$

$$L_l = N(50) \quad \text{rounded to the nearest foot} \quad (2.6.12)$$

Combining equations 2.5.10, 2.5.11, and 2.5.12 above, the equation for total length of lateral pipe can be simplified as total facility length divided by 4 ($L_t = L / 4$)

Utility Relocation Cost Data

Appendix E presents the utility relocation costs associated with the conveyance facilities for which bid tabulations were provided. Utility relocation for recent bids accounted for an average of 4.3 percent of the total project cost. The 5 percent utility relocation cost from the previous MPU cost tools was maintained for the 2023 Cost Tool to be consistent and conservative since there is a lot of variability in utility relocation costs depending on the nature of the project. The GIS tool automatically applies this percentage as a minor component to channels, bridges, culverts, and storm drains.

Lateral Collector Cost

The lateral collector minor component is used to estimate the construction cost for lateral collection facilities that are within a ¼ mile of a major component. The same procedure as the 2018 MPU was used to determine the lateral collector cost. The cost tool assumes that the lateral collection cost is 12.5 percent of the construction cost and that channels, culverts and storm drains have lateral collectors.

Other Cost Data

The costs for Type II aggregate base, roadway replacement, basin/channel excavation, gabions, soil cement, and reinforced concrete were obtained from the 2018 MPU cost estimation tool, adjusted by a 24 percent inflation factor, and are presented in **Appendix E**.

Percentage Cost

Mobilization, quality control, traffic control, structural removal, lateral collector and utility relocation were assumed to be a percentage of the cost for the main facility plus the non-percentage based minor components. **Table 2-7** summarizes the cost tool percentage values for the above-mentioned minor components.

Table 2-7 - Percentage Based Costs

Minor Component	Multiplier (%)
Mobilization	7
Quality Control	1.5
Traffic Control	2
Structural Removal	5
Lateral Collector	12.5
Utility Relocation	5

Design and Administration (D&A)

Costs related to facility D&A were estimated as a percentage of the construction cost. For proposed facilities, the design and administration cost was assumed to be 20 percent of the total construction cost.

Right-of-Way

The right-of-way estimation uses the same procedure as the 2018 Master Plan Update. Right-of-Way is calculated for each proposed facility at 16% of the total construction cost.

Operation and Maintenance Cost

In addition to construction costs, right-of-way costs, and design and administration costs, RFCD also provides funding for the ongoing operation and maintenance (O&M) of flood control facilities to maximize their useful life and assure that facilities operate to their intended design capacity. RFCD works with the member entities to establish an annual budget and maintenance work plan that sets forth the type and quantity of maintenance to be performed during the year. These O&M costs are not factored into the cost equations or cost tool and are coordinated outside the MPU process through interlocal contracts between each member entity and RFCD. Refer to the RFCD's *Operation and Maintenance Manual* for more information.

2.6.5. Cost Estimation GIS Tool

The Cost Estimation Tool is programmed using GIS Tools and Python to be used in ArcGIS Pro. This allows the costs to be calculated and automatically updated within the GIS database. This tool is included on the RFCD website with a User's Manual.

2.6.6. Cost Estimation Excel Tool

The Cost Estimation Tool is also programmed in Excel using Visual Basic. This tool is included on the RFCD website with a User's Manual.

2.6.7. 2023 MPU Cost Estimates

Table 2-8 presents the cost estimate for existing, proposed Category A, and Category B facilities by watershed generated by using the 2023 MPU Cost Estimation Tool and the 2023 Facilities.

Table 2-8 - 2023 MPU Facilities' Cost using 2023 MPU Cost Tool

Watershed	2023 MPU Facilities x 2023 Cost Tool ($ x 1000)		
	Existing Facilities	Category A	Category B
Range	$357,303	$302,678	$51,087
Upper Northern Las Vegas Wash	$670,041	$286,542	$134,827
Lower Northern Las Vegas Wash	$590,947	$272,650	$128,257
Gowan	$737,432	$123,562	$118,621
Central	$777,694	$710,520	$44,979
Flamingo/Tropicana	$1,341,319	$249,904	$78,230
Duck Creek/Blue Diamond	$757,234	$556,161	$40,738
Pittman	$957,692	$188,944	$13,153
C-1	$289,760	$89,420	$985
Lower Las Vegas Wash	$224,249	$10,573	$738
Eldorado Valley	$0	$63,757	$37,351
Apex	$17,122	$173,903	$283,004
Subtotal	$6,720,793	$3,028,615	$931,969
Total	**$6,720,793**	**$3,960,585**	

Comparison of the 2018 MPU and 2023 MPU Cost Estimates

The estimated value of the existing facilities and the estimated cost of the proposed facilities (combinedly called cost here) increased from $7.5 billion in 2018 MPU to $10.7 billion in 2023 MPU, an increase of $3.2 billion or roughly 42% from the 2018 costs. To compare and understand the cost increase, the 2018 cost tool and the 2023 cost tool were both applied to the 2018 facilities, in addition to the 2023 cost tool being run on the 2023 facilities. The increase in cost is attributed to two factors.

First, $2.8 billion of the $3.2 billion total cost increase is attributed to changes to the updated unit cost and associated revisions to the cost equations. Second, the remaining $400 million is attributed to the modification of the facility plan which includes the construction of MPU facilities, adoption of existing facilities for maintenance funding, modification (length, size, and alignment) to the proposed MPU facility, and addition of new proposed facilities.

Table 2-9 presents a comparison of the 2018 MPU and the 2023 MPU cost estimates per watershed, which was prepared in order to evaluate the change in cost between the two reports.

Table 2-9 - Comparison of 2018 and 2023 MPU Cost Estimates

Watershed	2023 MPU Costs ($ x 1000)			2018 MPU Costs ($ x 1000)		
	Existing Facilities	Category A	Category B	Existing Facilities	Category A	Category B
Range	$357,303	$302,678	$51,087	$198,388	$281,832	$102,991
Upper Northern Las Vegas Wash	$670,041	$286,542	$134,827	$398,527	$203,559	$160,230
Lower Northern Las Vegas Wash	$590,947	$272,650	$128,257	$420,935	$182,764	$123,235
Gowan	$737,432	$123,562	$118,621	$447,692	$127,416	$107,862
Central	$777,694	$710,520	$44,979	$570,388	$518,916	$52,682
Flamingo/ Tropicana	$1,341,319	$249,904	$78,230	$903,607	$130,986	$61,039
Duck Creek/Blue Diamond	$757,234	$556,161	$40,738	$489,457	$301,092	$85,810
Pittman	$957,692	$188,944	$13,153	$627,639	$144,761	$67,321
C-1	$289,760	$89,420	$985	$199,673	$20,504	$9,234
Lower Las Vegas Wash	$224,249	$10,573	$738	$200,657	$40,639	$561
Eldorado Valley	$0	$63,757	$37,351	$0	$0	$0
Apex	$17,122	$173,903	$283,004	$10,557	$76,029	$230,321
Subtotal	**$6,720,793**	**$3,028,615**	**$931,969**	**$4,467,520**	**$2,028,498**	**$1,001,286**
Total		**$3,960,585**			**$3,029,784**	

Conclusion

In summary, the existing value of the MPU facilities increased from **$4,467,520,000** to **$6,720,793,000;** a difference of **$2,253,273,000**. The cost of the proposed facilities increased from **$3,029,784,000** to **$3,960,585,000;** a difference of **$930,801,000.** The differences are attributed to changes in the revised cost equations, updated unit costs, inflation, and modifications to the facility plan.

2.7. GIS Data Development

GIS software was used extensively during the 2023 MPU to update the flood control facility inventory, to compute hydrologic input parameters for the hydrologic models, and to facilitate the completion and presentation of the information collected and developed throughout the MPU

process. This section of the report describes the attributes of the main GIS layers and provides a brief overview of how the GIS Data was used in the creation of the maps and figures included in the Appendix.

The majority of the 2023 MPU geographic information has been incorporated into a file geodatabase. The file geodatabase is the native data structure for ArcGIS and is the primary data format used for editing and managing data. The 2023 MPU file geodatabase is essentially a collection of datasets (primarily feature classes) that can store, query, and manage both spatial and nonspatial data. The file geodatabase used and updated during the 2023 MPU was stored using ArcGIS Enterprise Web Services within a cloud-based, RFCD-hosted storage platform for multi-user interfacing allowing multiple editors to manipulate data simultaneously. GIS data developed as part of the 2023 MPU are included electronically on the RFCD website for digital download.

2.7.1. Hydrologic Data

GIS feature classes developed for the 2023 MPU hydrologic analysis include precipitation depths, subbasin delineations, land use, flow direction arrows, soil groups, watersheds, ultimate development boundary, and USACE boundary. The important attribute fields associated with each of the hydrologic layers are described below.

Rainfall:

- RAIN_INCH – Rainfall depth in inches (refer to **Section 2.3.8**)

Subbasins:

- BASINID – Basin identifier
- AREA_SQFT – Area of subbasin in square feet
- AREA_SQMI – Area of subbasin in square miles
- WCN – Weighted (composite) curve number
- RAIN – Average rainfall depth in inches for each subbasin
- FLOW_2023 – 100-year flow in cfs for the subbasin
- WATERSHED – Name of watershed
- MPU – MPU Name

Land Use:

- LU_INDEX – 2023 MPU Land Use Category (1 through 15, see **Section 2.3.3**)
- IMPERV – Percentage impervious area
- MPU – MPU Name
- MPU_yr – MPU year

Flow Direction Arrows:

- WATERSHED – Name of Watershed
- MPU – MPU Name

There is one flow direction arrow layer which shows the direction of routed flow for all the subbasins. Lines are drawn in the direction of flow, symbology should place arrow at end of line.

Soils:

- MUSYM_MPU – Polygon identifier (map unit symbol) representing a certain soil type and corresponding source (refer to **Section 2.3.4**)
- MUSYM – Polygon identifier (map unit symbol) in 2022 NRCS soil survey data representing a certain soil type and corresponding source
- MUKEY – Polygon identifier (map unit key) in 2022 NRCS soil survey data representing a certain soil type and corresponding source
- HSG – Predominant hydrologic soils group – A, B, C, or D
- HSG_A_CMP – Percentage of hydrologic soil group A
- HSG_B_CMP – Percentage of hydrologic soil group B
- HSG_C_CMP – Percentage of hydrologic soil group C
- HSG_D_CMP – Percentage of hydrologic soil group D
- ROCK_CMP – Percentage of rock outcrops
- AREASYMBOL – Soil Survey Area Symbol
- MPU – MPU Name

Watersheds:

- WATERSHED – Watershed Name
- MPU – MPU Name

Concentration Points:

- COMB_PT – Node identifier. Same as HEC-1 node.
- WATERSHED – Watershed Name
- flow_2018 – 2018 100-year flow in cfs associated with COMB_PT
- MPU – MPU Name
- FLOW – 100-year flow in cfs associated with COMB_PT

Ultimate Development Boundary:

The UDB represents the boundary of the full “build out” condition. It is assumed that all available land within the UDB has been fully developed. No MPU data is stored in the attribute table for this layer.

USACE Boundary:

A portion of the Flamingo/Tropicana Watershed upstream of and including the Tropicana Detention Basin is referred to as the USACE Watershed. This feature class represents the boundary between the USACE Watershed and facilities and the remainder of the Flamingo/Tropicana Watershed. No MPU data is stored in the attribute table for this layer. For a more detailed explanation of this watershed area, please refer to **Chapter 8.**

Pittman Duck Overlap

A portion of the Pittman Watershed drains to Duck Creek/Blue Diamond Watershed at Bermuda Road/St. Rose Parkway. The Outfalls from Pittman North Detention Basin is diverted north to Duck Creek/Blue Diamond watershed via a proposed regional facility along Bermuda Road. Although the Pittman North Detention Basin Outfalls drain to Duck Creek/Blue Diamond watershed, the tributary area of this detention basin lies within Pittman Watershed and is under the jurisdiction of the City of Henderson. This feature class represents the boundary between the Duck Creek/Blue Diamond hydrologic watershed and the Pitman hydrologic watershed which is different from the planning areas which are represented in the Watershed layer. For more detailed explanation of this overlap, please refer to **Chapters 9 and 10.**

2.7.2. Flood Control Facility Data

For the purpose of updating the facility inventory data, the Consultant Team shared maps with each of the entities showing existing and proposed regional flood control facilities obtained from the RFCD. The Consultant Team requested that the entities identify on the maps where existing and proposed facilities needed to be updated as well as any areas of known flooding issues (hotspots). In addition, the Consultant Team requested and received facility design plans from the entities that were used to update the GIS regional flood control facility layer. The facility layer has been updated by the Consultant Team for all existing and proposed facilities built since 2018 MPU based on input from the entities, 2023 MPU hydrologic models and engineering judgment. The facility layer represents the final 2023 MPU flood control facility plan.

Regional facilities are generally described as flood control facilities required to safely convey and detain major flood flows with a minimum 100-year frequency flood event flow of 500 cfs or a minimum contributing drainage area of 1 square mile.

Three GIS layers (polygons, polylines, and points) are used to represent all existing and proposed regional flood control facilities in the Las Vegas Valley. Polygons represent detention, retention, and debris basins. Polylines represent linear flood control facilities such as channels, storm drains and crossings. Points were created from the polylines to represent many of the shorter crossings (bridges or culverts) for display purposes only. All facility information is stored within polygon and polyline layers.

Updates to the facility inventory data included updating ID-Miles, populating attribute tables, and realigning the spatial representations where needed. The attribute fields associated with each facility layer are generally the same and are briefly described below. If the ID-Mile was

changed since 2018, the old ID-Mile was preserved in the shapefile. For more details on the values and codes used within each field, please refer to the GIS metadata and documentation included on RFCDs website accompanying the Master Plan Documents.

- ID_MILE – 8-digit facility identification ID
- ID_MILE_18 – Corresponding 2018 MPU ID-Mile if applicable
- STATUS_MPU – MPU facility status
- STATUS* – the RFCD facility status (construction or programming)
- FAC_DESC – Text description of facility
- FACTYPE – Integer code representing facility type
- FACNAME – Facility name (system)
- LENGTH_FT – Facility length (ft)
- ACRE_FT – Detention basin storage volume at the spillway elevation or the top of the detention basin for the below-grade detention basins (for existing and proposed detention basins) or volume of expansion (for proposed expansions to existing detention basins) in acre-ft. This field is used in the cost tools to calculate the facility major component cost.
- ACRE_FT_Total – Detention basin storage volume in acre-ft at the spillway elevation or the top of the detention basin for below-grade detention basins (This will match the ACRE_FT field for existing and proposed detention basins. This represents the total volume after expansion for proposed expansions to existing detention basins.)
- D_H_FT – Diameter/Height of facility (ft)
- W_FT – Width of facility (ft)
- BARRELS – Number of pipes/boxes in parallel if applicable
- SS_H_V – Channel side slope (X:1, horizontal to vertical)
- SLOPE_FTFT – Longitudinal slope of facility (ft/ft)
- WATERSHED – Watershed name in which facility is located
- FCFUPD* - Date of attribute update
- AMEND_DATE* – Date of Master Plan Amendment
- CONSTYR* – Year of scheduled construction
- DESIGNYR* – Year of scheduled design
- MPU – Name of MPU facility is included in
- CORPS* – Identifies USACE projects

- MULTIUSE* – Multiuse facility
- SYSTEM* – Identified system of facilities
- HEC1_MODEL – HEC-1 model where facility flow was derived
- HEC1_NODE – HEC-1 node where facility flow was derived
- HEC1_FLOW – 100-year facility flow (cfs)
- TRIB_AREA – Area tributary to the facility (square miles)
- RR_PARALEL – Remove and replace/parallel facility code
- COST_DA – Estimated design & administration cost
- COST_ROW – Estimated right-of-way cost
- COST_CONST – Estimated construction cost
- COST_TOTAL – Total Estimated Cost

** Attribute fields that were part of the original RFCD facility coverage at the time the 2023 MPU began and were only populated for facilities that were not modified during this update.*

Available information received from the entities as of December 2023 for existing and proposed local flood control facilities was also collected and incorporated into a separate file geodatabase. The existing local facility GIS data is separated into GIS layers that correspond to the general geographic boundaries of the four local entities in the Las Vegas Valley (City of North Las Vegas, City of Las Vegas, Clark County, and City of Henderson). There may be some areas in the Valley where not all the local facilities are included in the GIS layers, since much of the information required to create these GIS layers is difficult to obtain and providing a complete inventory of all local facilities would require a level of effort beyond the intended scope of this project. The local facility file geodatabase is included on the RFCD website with the Master Planning files and models.

2.7.3. Other GIS Data

Other GIS data collected or developed for the MPU includes aerial photos, topography, land ownership, land parcel boundaries, and environmentally sensitive area locations. Aerial photos were accessed online through the Clark County Nearmap subscription, and topography data were collected and used to facilitate MPU development and production. Land ownership, and land parcel boundaries data were collected from available sources and used to create **Figure G-1** in **Appendix A.1**. Environmentally sensitive areas information was collected from available sources and was used to create **Figure G-2** in **Appendix A.2**, which provides a general reference for environmentally sensitive areas in the Valley that may affect the implementation of many master plan facilities. Two separate file geodatabases were created for the land ownership data and environmentally sensitive area locations. These file geodatabases are included on the RFCD website with the Master Planning files and models.

2.7.4. GIS Considerations and Cartographic Representation

The General (G-Maps), Watershed (W–Maps) and Facilities (F–Maps) are provided in PDF format.

Below includes GIS considerations and cartographic representations made for the 2023 MPU maps:

- **2018 MPU ID-Miles**. The 2018 MPU ID-Miles were perpetuated when possible. However, in some instances it was necessary to revise the 2018 MPU ID-Mile based on the updates made to the facility plan. The 2018 MPU ID-Mile attribute field (ID_MILE_18) was populated with the old 2018 MPU ID-Mile whenever an existing ID-Mile had to be revised during the 2023 MPU. This field can be used by the RFCD to identify historical ID-Miles associated with contracts, as-builts plans, and other important documents in cases where the original ID-Mile assigned to the facility no longer exists in the database. ID-Miles are shown in F-Maps and can be turned on in W-Maps.
- **Remove and Replace Facilities**. The existing facility (the one which will be replaced or expanded) is assigned a code of RE or REB (if proposed replacement is Category B facility) in the RR_PARALEL field in the attribute table. The proposed facility (expansion or replacement) is assigned a code of RP in the RR_PARALEL field. These codes were then used to display both the existing and proposed “Remove and Replace” facilities as a single dashed line on the F and W-Maps. It should be noted that the proposed (replacement) facility ID-Mile was used to label the dashed line on the F-Maps, although both the existing and proposed facility are included in the facility inventory tables.
- **Parallel Facilities.** Parallel facilities are somewhat similar to “Remove and Replace” facilities, in that there are two arcs in GIS – one for the existing facility and one for the proposed parallel facility. The difference between parallel facilities and “Remove and Replace” facilities is that the existing facility will not be replaced. For parallel facilities, the existing facility is assigned a code of PE or PEB (if proposed parallel facility is Category B) in the RR_PARALEL field in the attribute table. The proposed parallel facility is assigned a code of PP in the RR_PARALEL field. These codes were used to display both the existing facility and the proposed parallel facility as a single dashed line on the F and W-Maps. The ID-Mile labels for both the existing and parallel facility are displayed on the F-Maps for these facilities.
- **Crossings.** A point layer was created in GIS for all culverts and bridges with facility length less than 250 feet. This point layer is intended for display purposes only on the F and W-Maps since short arcs were not easily visible.
- **Annotations.** Several annotation layers were created in GIS and used in F and W-Maps to label important features and locations. The annotation layers include labels for subbasin, major streets, hydrologic soil groups, and facility ID-Miles. The annotation layers have been combined in a geodatabase and are provided on the RFCD website with the Master Plan files and models.

2.7.5. Automated Facility Inventory Tool

An automated facility inventory tool, which facilitates the generation of the facility inventory tables that accompany the F-Maps in **Appendix C**, was updated during the 2023 MPU to be compatible with the latest software and scripting tools. The tool creates facility inventory tables by importing pertinent facility data (i.e., ID-Mile, facility description, length, flow, HEC-1 node, HEC-1 model, tributary area, and channel slope) from GIS into Microsoft Excel. A user's manual for these tools is included on the RFCD website with the Master Plan files and models.

CHAPTER 3

Range Watershed

3.1. Introduction

This chapter presents the information developed for the 2023 MPU for the Range Watershed, which is in the northeastern portion of the Las Vegas Valley. The watershed includes portions of the City of North Las Vegas, Nellis Air Force Base (NAFB), and unincorporated Clark County. The City of North Las Vegas is responsible for programming flood control funds for Range Watershed. The Range Watershed is a major tributary to Las Vegas Wash. The watershed is bounded on the west by the Lower Northern Las Vegas Wash Watershed; on the north by the Sheep and Las Vegas Range Mountains and the Range Wash Diversion Berm; on the east by the Frenchman Mountains; and to the south by Las Vegas Wash. This watershed discharges into the Sloan Channel which is a major tributary to the Las Vegas Wash.

A large portion of the northern part of the watershed is currently undeveloped. The Las Vegas Motor Speedway is the major existing development in this area. Additionally, at some future date the University of Nevada, Las Vegas is planning to open a campus north of the 215 Beltway between Pecos Road alignment and Lamb Boulevard alignment. The portion of the watershed south of the 215 Beltway, west of Range Road and north of NAFB is expected to develop in the near future. Another area experiencing rapid development is south of I-15 between Hollywood Blvd and Range Rd. The eastern part of the watershed that includes the Dunes Recreation Area and Sunrise Mountain Instant Study Area is currently undeveloped and is expected to remain that way. Most of the area downstream of the Confluence Detention Basin is developed.

The total area of the Range Watershed is approximately 98 square miles. Drainage facilities within the watershed consist primarily of detention basins inter-connected by conveyance facilities.

3.2. Drainage Characteristics

Drainage patterns in the Range Watershed generally flow from north to south. The watershed is characterized by three distinct land types: mountainous, alluvial fan, and urban developed. The mountainous regions of the watershed are steep and rocky with limited vegetation. The mountainous regions are in the far north and eastern portions of the watershed. The alluvial fan areas lie below these mountainous areas. The alluvial fan areas are characterized by alluvial deposits and braided channels of an avulsive nature. Vegetation consists of desert shrubs and grasses.

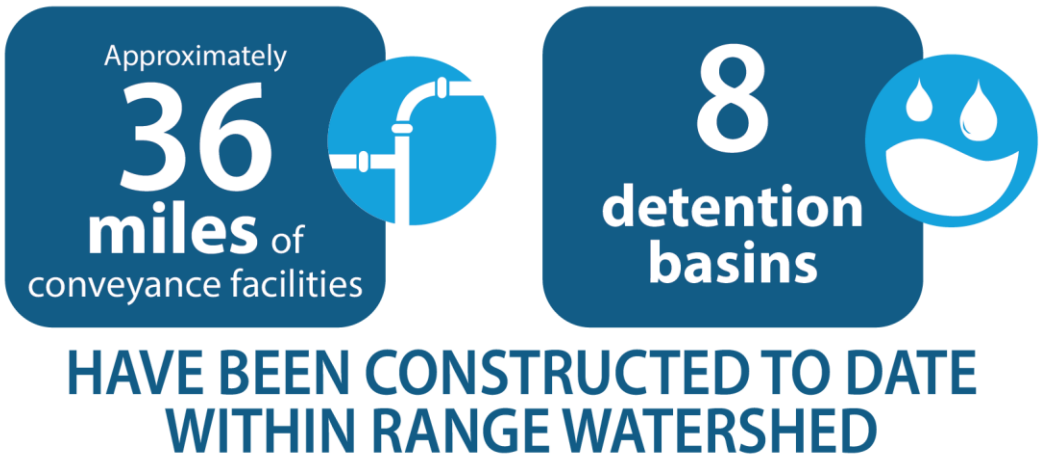
3.3. Master Plan Progress

Some progress has been made on the implementation of the Master Plan since the 2018 MPU through the construction of various flood control facilities. Construction of approximately 11 miles of conveyance facilities has been completed since the 2018 MPU. Major flood control facilities constructed or adopted into the plan since the 2018 MPU include the following:

- Alto Conveyance (RWAL 0117) near Cartier Avenue and Los Feliz Street was adopted to the MPU so it is now considered a regional facility and is eligible for maintenance funding.
- The second phase of construction of the Range Wash – Ann Branch storm drain (RWAN 0001, 0045, and 0050) south of Tropical Parkway along Mt. Hood Street, and along Ann Road, east of Mt. Hood Street.
- The Beltway Detention Basin and Channel project constructed Range Wash – Railroad Channel along the north side of the UPRR east of Lamb Boulevard (RWRR 0107, 0143, 0189, 0194, 0200, 0204, 0224, 0228, 0244, and 0261) and Range Wash – Beltway East along the CC-215 between Lamb Boulevard and UPRR (RWBE 0000, 0002, 0010, 0076, and 0097).
- The second phase of construction of Hollywood system, Range Wash – Hollywood Branch (RWHW 0000, 0007, 0009, 0038, 0080, 0110, 0112, 0136, and 0173 and RWEA 0220) northeast of the Nellis Air Force Base, south of Las Vegas Boulevard and east of Hollywood Boulevard.
- The Hollywood System Centennial Parkway to Speedway #2 Detention Bains project, Range Wash – Hollywood System (RWHW 0300, 0355, 0369, and 0410) north of Centennial Parkway along Hollywood Boulevard, a short distance along Speedway Boulevard, and directly north connecting to Speedway #2 Detention Basin.
- The Vandenberg North Detention Basin and Outfall project, Range Wash – West Tributary between CC-215 and Tropical Parkway along Pecos Road (RWWE 0352, 0397, 0422, 0428, 0429, and 0430) and the Vandenberg North Detention Basin and upstream facilities (RWWE 0407, 0409, 0439, and 0454) east of Pecos Road and south of Deer Springs Way.

- Part of the Carey Avenue, Nellis Boulevard to Toiyabe Street roadway project constructed Range Wash – Sloan junction structure/culverts on the nearby Toiyabe Street and Carey Avenue (RWSL 0418, 0421, and 0424)
- The Jim McGaughey Detention Basin constructed the Owens Conveyance to Washington System (SLOW 0000) along Los Feliz Street going south of Owens Avenue and the connecting Washington Avenue Conveyance/Detention (SLWA 0130, 0140, 0150, 0151, 0152, 0153, 0175, and 0180) west of Los Feliz Street, south of Owens Avenue.

In total, the following facilities have been constructed to date in the Range Watershed[3].



3.4. Hydrologic Analysis

The hydrologic analysis and models completed with the 2018 MPU served as the basis for the 2023 MPU hydrologic analysis and modeling effort. The delineations for a large portion of this watershed were based on the 2018 MPU subbasin delineations and remain unchanged with the following exceptions:

- Subbasins were revised east of Las Vegas Boulevard/Hwy 91 and north of the UPRR based on Miners Mesa Access Road Technical Drainage Study
- Subbasins east of Las Vegas Boulevard between UPRR and I-15 were revised based on Vantage North Industrial Park Drainage Study
- Subbasins were revised south of the I-15 between Range Road and Hollywood Boulevard, down to Las Vegas Boulevard based on Tropical Industrial Park, Tropical Speedway Commerce Center II, and Range Wash – Ann Branch

[3] Total length for facilities does not include floodways, natural washes, or existing facilities that are planned to be replaced.

- Subbasins south of Ann Road, east of Sloan Lane were revised based on Project Jackpot Drainage Study
- Subbasins were revised south of the Deer Springs Way between Pecos Road and Lamb Boulevard based on Vandenberg North Detention Basin & Outfall Technical Drainage Report
- Subbasins revised east of Pecos Road along Tropical Parkway based on Tropical Parkway/Walnut Road Drainage & Roadway Improvements Technical Drainage Study
- Subbasins along Hollywood Boulevard and east towards the Frenchman Mountains between Lake Mead Boulevard and Washington Avenue were revised based on Jim McGaughey Detention Basin & Outfall Design Report

The 2018 MPU hydrologic parameters used in the models were reviewed and updated to incorporate the changes in criteria and methodology described in **Section 2.3**, which primarily include changes to soils data, percent impervious and distribution of open space, as well as changes in land use density. The hydrologic parameters were revised to incorporate all new data collected and/or developed for the 2023 MPU. The major drainage reports, technical drainage studies, and Master Plan Amendments reviewed and incorporated into the hydrologic analysis are tabulated in **Table 3-1**.

Table 3-1 - Range Watershed Major Hydrologic Studies

#	NAME OF STUDY
1	TECHNICAL DRAINAGE STUDY FOR MINERS MESA ACCESS ROAD (WESTWOOD, JAN 2020)
2	UPDATE #4 TO THE TECHNICAL DRAINAGE STUDY FOR VANTAGE NORTH INDUSTRIAL PARK (TANEY ENGINEERING, JUN 2023)
3	UPDATE TO THE TECHNICAL DRAINAGE STUDY FOR TROPICAL INDUSTRIAL PARK (AKA TROPICAL ASSEMBLAGE) (KIMLEY-HORN, OCT 2020)
4	TECHNICAL DRAINAGE STUDY FOR TROPICAL PARKWAY/WALNUT ROAD DRAINAGE & ROADWAY IMPROVEMENTS (POGGENMEYER DESIGN GROUP, MAR 2020)
5	VANDENBERG NORTH DETENTION BASIN AND OUTFALL FINAL TECHNICAL REPORT (ATKINS, AUG 2019)

Series A, B and C storm centerings were used for the Range Watershed (see **Section 2.3.11**). The following hydrologic models were developed for the analysis of Range Watershed:

- RW (Series A): Series A models were developed to represent storm centerings over the entire Range Watershed. These Series A models are named RW3, RW4, and RW5. The number used in the model names represents SDN 3, 4, and 5, respectively.
- RWSC (Series B): Series B models were developed to represent storm centerings for the portion of Range Watershed downstream of Speedway North, Speedway 2, Speedway 3, Vandenberg North, Beltway, Vandenberg, Dunes, Confluence, Owens, and Orchard Detention Basins. Discharge from these detention basins was diverted out of the models to prevent it from combining with areas downstream of the detention basins. These Series B

models are named RW3SC, RW4SC, and RW5SC. The number used in the model names represents SDN 3, 4, and 5, respectively.

- SPDWY (Series C): These Series C models are similar to RWSC models except that the discharge from Speedway 2, and Speedway 3 Detention Basins was not diverted out of the models. These models were used to compute the discharge just downstream of the Speedway 2 Detention Basin. These Series C models are named SPDWY3, SPDWY4, and SPDWY5. The number used in the model names represents SDN 3, 4, and 5, respectively.
- SLOAN (Series C): These Series C models are similar to the RWSC models except that the discharge associated with the Range Wash – Sloan facilities that bypass the Confluence Detention Basin were diverted out of the model. These models were used to compute the discharge in lower Sloan Channel near its confluence with Las Vegas Wash. These Series C models are named SLOAN3 and SLOAN4. The number used in the model names represents SDN 3 and 4 respectively.

3.5. Flood Control Facility Plan

The final flood control facility plan is similar to the 2018 MPU. A list of studies collected along with maps are provided in **Appendix F** for referring to studies mentioned in this section. Problem areas and major revisions to the plan since the 2018 MPU are described below.

Apex – Range Watershed East

Apex – Range Watershed East Detention Basin (APRE 0089) was removed from the facility plan based on meetings with CNLV as it was no longer needed with the implementation of local flood control facilities. This includes the connecting proposed Apex – Range Watershed East facilities (APRE 0000 – 0061).

Speedway Channel Facilities

Removed proposed facilities (RWSP 0364 – 0535) upstream of the proposed 124 ac-ft Speedway Channel Detention Basin based on meetings with CNLV as it was no longer needed with the implementation of local flood control facilities.

Vantage North Mass Grading

Speedway Channel Branch 1 Detention Basin (SP01 0076) from the 2018 MPU has been relocated south of the UPRR, downsized to 26 ac-ft, and renamed to the Vantage North Mass Grading Detention Basin 15 (SP01 0037) based on the technical drainage study update. The outfall and connecting facilities north of the UPRR culvert (SP01 0054) have also been removed. The outfall of SP01 0037 and downstream facilities have also been downsized to a 60” RCP and relocated west of the previous 2018 alignment.

Vandenberg Drive Facilities

Proposed RCB replacement facilities added for open concrete channel facilities from Range Wash – West Tributary system (RWWE 0089 – 0126) on Vandenberg Dr between Lone Mountain Rd and Craig Rd due to increased flow.

Los Feliz Detention Basin

Proposed (currently interim) 277 ac-ft Los Feliz detention basin (RWAL 0096) has been added to the MPU to alleviate the need to expand the Confluence Detention Basin (RWSL 0501). The previous proposed facility (RWAL 0068) along Alto Ave has been repurposed as the outfall to RWAL 0096 and downsized to 24" RCP based on the interim drainage study update. Tributary facilities RWAL 0170 and RWLM 0000 have been split to propose culverts under Armona Rd.

In addition to the above information, **Table 3-2** summarizes the analysis of all the existing and proposed detention basins within the Range Watershed.

Table 3-2 - Range Watershed Detention Basin Summary Table

Name of Detention Basin	ID MILE	Status*	100-Year Peak Inflow (cfs)	Existing Storage @ Spillway (ac-ft)	Expansion Required (ac-ft)	Total Storage Volume @ Spillway (ac-ft)	Spillway Elevation (ft)	100-Year Clear Water Peak Elevation (ft)	Freeboard (ft)	Time to Peak (hrs)
Speedway 2	RWHW 0411	EX	665	111	--	111	2090	2083.57	6.43	10.83
Speedway 3	RWSP 0025/0026	EXP	2332	120	134	254**	2130	2128.39	1.61	7.08
Speedway North	RWHW 0500	PROP	3257	--	--	770	25	20.58	4.42	7.42
Speedway Channel	RWSP 0362	PROP	2386	--	--	124	2394	2392.51	1.49	5.08
Vantage North Mass Grading	SP01 0037	PROP	808	--	--	25.85	2324	2323.04	0.96	3.92
Beltway	RWRR 0200	EX	795	--	--	23.8**	2025	2022.43	2.57	4.42
Dunes	RWDU 0077	PROP	2318	--	--	480**	2025	2023.71	1.29	7.83
Confluence	RWSL 0501/0503	EXP	11236	1025	920	1945**	1816	1815.02	0.98	6.92
Vandenberg	RWWE 0170	EX	2540	349	--	349	1932.7	1928.89	3.81	6.42
Vandenberg North	RWWE 0407	EX	3124	--	--	279.6**	2024	2021.54	2.46	6.33
Orchard	SLOR 0146	EX	1805	159	--	159	1846	1842.11	3.89	5.33
Jim McGaughey	SLWA 0153	PROP	1184	--	--	85	1988.5	1985.69	2.81	5.33
Los Feliz	RWAL 0096	PROP	2082	--	--	277	1912	1910.2	1.8	6.75
Railroad East Branch 1	RE01 0030	PROP	1549	--	--	78	2350.5	2348.56	1.94	4.25

*EX = Existing Detention Basin, EXP = Existing Detention Basin with Proposed Expansion, PROP = Proposed Detention Basin

** Total Storage Volume accounts for Sediment Load

3.6. Facility Cost Estimates

Cost estimates for all facilities have been derived using the Cost Estimation Tool described in **Section 2.6**. Construction cost estimates for proposed facilities have been divided into Category A and Category B. The total estimated current value of existing facilities and total estimated construction cost of proposed Category A and B facilities in the Range Watershed are as follows:

A detailed breakdown of current estimated values of existing facilities and construction cost estimates for proposed Category A and B facilities is included in **Appendix E**.

CHAPTER 4

Upper Northern Las Vegas Wash Watershed

4.1. Introduction

This chapter presents the information developed for the 2023 MPU for the Upper Northern Las Vegas Wash Watershed, which is located in the northwest portion of the Las Vegas Valley. The majority of the flood control facilities in Upper Northern Las Vegas Wash Watershed are located within City of Las Vegas jurisdiction. Thus, the City of Las Vegas is responsible for programming flood control funds for the Upper Northern Las Vegas Wash Watershed. The watershed is divided such that there are two discharge points from the Upper Northern Las Vegas Wash Watershed: (1) The Upper Las Vegas Wash Detention Basin outfall, and (2) where the Las Vegas Wash-Middle facilities and Ann Road Channel West facilities combine near the intersection of Ann Road and Ferrell Street.

Most of Upper Northern Las Vegas Watershed is undeveloped. The developed area (or future planned development area) of this watershed is primarily within the City of Las Vegas jurisdiction; however, it includes portions of the unincorporated Clark County and City of North Las Vegas. This watershed is bounded on the west by the Spring Mountains, on the north by the Sheep Mountains, on the east by Decatur Boulevard and Allen Lane, and on the south by the 215 Beltway and Ann Road.

Development is expected to steadily continue in this watershed. The boundary of Tule Springs National Monument area can be found in Environmentally Sensitive Areas (see **Figure G-2** in **Appendix A.2**). The northern and western portions of the watershed including the mountainous areas are primarily located on reserved federal land, either through environmental withdrawals or military purposes, and are not anticipated to be developed.

The total area of the Upper Northern Las Vegas Wash Watershed is approximately 629 square miles of which 582 square miles will remain undeveloped. Drainage facilities within the watershed consist primarily of detention basins connected by conveyance facilities.

4.2. Drainage Characteristics

The watershed extends to Charleston Peak on the west; to Decatur Boulevard and Allen Lane on the east; from Hayford Peak on the north; and to the 215 Beltway and Ann Road on the south. The Spring Mountain Range forms the northwestern boundary. The La Madre Range forms the southwestern drainage boundary, and the Desert and Sheep Mountains form the northern drainage boundary. Flows from the steep mountain slopes exit onto alluvial fans extending across the entire southern portion of the watershed. Drainage patterns in the lower portion of the Upper Northern Las Vegas Wash Watershed are generally from northwest to southeast.

4.3. Master Plan Progress

Significant progress has been made on the implementation of the Master Plan since the 2018 MPU through the construction of flood control facilities. Construction of approximately 8 miles of conveyance facilities and 1 detention basin has been completed since the 2018 MPU. Major flood control facilities constructed or adopted into the plan since the 2018 MPU include the following:

- The Skye Canyon Detention Basin 2 study constructed the Moccasin Outfall Detention Basin #2 (MOIR 0098) collection and outfall facilities (MOIR 0000 – 0099) located in the Skye Canyon Master Plan Area.
- The Skye Canyon South Arroyo Storm Drain Project and Skye Canyon II Phase 3A constructed the Moccasin – Hualapai Branch (MOHU 0026 – 0160) from Moccasin Outfall Detention Basin #1 to Iron Mountain Road.
- The Centennial Parkway Channel West, Farm Road – OSO Blanca to Tee Pee project constructed a portion of Centennial Parkway Channel West/ Farm Road Branch (CNFR 0000 & 0065) from Tee Pee Lane to Centennial Parkway Channel West U.S 95 Branch. An existing facility west of Hualapai Way (CNFR 0478) was also adopted to the MPU so it is now considered a regional facility and is eligible for maintenance.
- The Rancho Road System, Elkhorn – Grand Canyon to Hualapai project constructed a portion of Rancho Road System – Beltway (RCHB 0295).
- A portion of Rancho Road System – Beltway (RCHB 0083 – 0101 and 0122 – 0151) from Durango Drive to Oso Blanca along 215 Beltway has been constructed.
- The Moccasin Road, US 95/Kyle Canyon Rd interchange to Moccasin Rd/Skye Canyon Park project constructed a section of Moccasin – Log Cabin Branch (MOLC 0000 - 0157) from the US 95 Kyle Canyon Road Interchange to Las Vegas Wash – Moccasin. The

alignment of the facility changed slightly at the beginning at the U.S. 95 and Kyle Canyon off ramp to Moccasin Road compared to 2018 MPU. CNLV identified this area as a hotspot area and this construction will solve the flooding issue near N Skye Canyon Park.

- The Moccasin Road CCRFCD Flood Control Facility project constructed a portion of Las Vegas Wash – Moccasin Branch (LVMO 0000) from Skye Canyon to Durango along Moccasin Rd.

In total, the following facilities have been constructed to date in the Upper Northern Las Vegas Wash Watershed[4].

4.4. Hydrologic Analysis

The hydrologic analysis and models completed with the 2018 MPU served as the basis for the 2023 MPU hydrologic analysis and modeling effort. The delineations for a large portion of this watershed were based on the 2018 MPU subbasin delineations and remain unchanged with the following exceptions:

- Subbasin changes within the Skye Canyon Master Plan community due to detailed design studies.
- Subbasins near Brent Lane due to the Brent Lane Drainage System detailed design.
- Subbasin draining to Farm Road due to Centennial Parkway Channel West Farm Road detailed design.
- Subbasins in the Golden triangle area east of US 93 based on the BLM 940 Master Drainage Study.

[4] Total length for facilities does not include floodways, natural washes, or existing facilities that are planned to be replaced.

The 2018 MPU hydrologic parameters used in the models were reviewed and updated to incorporate the changes in criteria and methodology described in **Section 2.3**, which primarily include changes in soils data, percent impervious and distribution of open space, as well as changes in land use density. The hydrologic parameters were revised to incorporate all new data collected and/or developed for the 2018 MPU. However, the criteria and methodology used for areas outside the UDB and tributary to Upper Las Vegas Wash Detention Basin is different from **Section 2.3** and is described in detail in this section.

The major drainage reports, technical drainage studies, and Master Plan Amendments reviewed and incorporated into the hydrologic analysis are tabulated in **Table 4-1**.

Table 4-1 - Upper Las Vegas Wash Watershed Major Hydrologic Studies

#	NAME OF STUDY
1	CENTENNIAL PARKWAY CHANNEL WEST FARM ROAD - OSO BLANCA TO TEE PEE (JACOBS, 2022)
2	SKYE CANYON - PHASE 3B & 3C INFRASTRUCTURE UPDATE #2 (WESTWOOD, 2020)
3	SKYE CANYON SOUTH ARROYO STORM DRAIN (WESTWOOD, 2021)
4	MOCCASIN RD CCRFCD FLOOD CONTROL FACILITY US 95/KYLE CANYON RD INTERCHANGE TO MOCCASIN RD (SHG, 2019)
5	BRENT LANE DRAINAGE SYSTEM DURANGO DRIVE TO SKYE CANON PARK DRIVE DRAFT FINAL DESIGN REPORT (JACOBS, 2022)

The description of the hydrologic analysis completed for this watershed is subdivided into three sections: 1) Areas tributary to Kyle Canyon Detention Basin 2) Areas tributary to Upper Las Vegas Wash Detention Basin (ULVWDB), and 3) Areas downstream of ULVWDB

Areas upstream of Kyle Canyon Detention Basin

The tributary area draining to Kyle Canyon Detention basin is approximately 57 square miles. The areas tributary to the detention basin are outside of the UDB. The 2008 MPU used the hydrologic parameters and HEC-1 model directly from the Kyle Canyon Detention Basin Design Report (1991), since reliable soils data was unavailable in the area. The 2018 MPU used updated hydrologic methodology and updated soil survey published by the NRCS. For the 2023 MPU, subsequent updates to curve numbers were made in accordance with the loss methodology described in **Section 2.3**. All but one of the subbasins draining to Kyle Canyon Detention Basin are greater than 1 square mile in area. In the 2018 MPU, the lag time for these subbasins was referenced from the 1991 Drainage Report as the lag time for areas greater than 1 square mile is not dependent on curve numbers per the RFCD Design Manual. This assumption was perpetuated for the 2023 MPU. As a result, the lag time for these subbasins was not calculated using the updated USBR equation.

The Series A storm centering model (KYLEDB) was used to size Kyle Canyon Detention Basin and facilities immediately downstream of the detention basin. This model uses an SDN 5 pattern for concentration points with tributary area greater than 12 square miles.

Areas upstream of ULVWDB

As mentioned above, the hydrologic analysis completed for the Upper Northern Las Vegas Wash Watershed is consistent with the methodology described in **Section 2.3** for areas inside the UDB. However, for areas outside the UDB, curve numbers for the HEC-1 models were taken from the pre-design report for the Upper Las Vegas Wash Detention Basin. These curve numbers were used due to a lack of detailed soils data for this area. The available soils data and standard MPU methodology produced curve numbers and flow rates much higher than those calculated in the pre-design report. To further analyze what the expected flow rates are for this area, a paleoflood investigation was conducted with the 2002 MPU. The results of this investigation concluded that the expected flow rates for this area are much less than those calculated with the available soils data and associated curve numbers. Therefore, the curve numbers from the pre-design report were used instead of those calculated using the available soils data. The subbasins that use the referenced curve numbers are highlighted in curve number table that can be found in **Appendix D.6**.

Three storm centering models (Series C) were developed for analysis of the ULVWDB: SPRING, SHEEP, and LOWER. Storm centering sizes were limited to 200 square miles for hydrologic analysis and their areas are displayed on **Figure 4-1** and **Figure 4-2**. The SPRING storm centering model was used to size the detention basin and the facilities along U.S. 95 and Moccasin Road west of the Upper Las Vegas Wash and the ULVWDB. The SHEEP hydrologic model was used to size the proposed facilities north of the ULVWDB surrounding the Clark County Shooting complex. The LOWER storm centering model was used to size the facilities south of Moccasin Road in the Skye Canyon Master Plan area.

Areas downstream of ULVWDB

As mentioned above, the hydrologic analysis completed for the lower portion of the Upper Northern Las Vegas Wash Watershed is consistent with the methodology described in Section 2.3.

Series B and Series C storm centerings were used for areas downstream of ULVWDB (see **Section 2.3.11**). The below-mentioned hydrologic models include all subbasins within Lower Northern Las Vegas Wash Watershed and were also used to size facilities within that watershed. The following hydrologic models were developed for analysis of areas downstream of ULVWDB and downstream of Kyle Canyon Detention Basin:

- CWEST (Series B): Series B models were developed for the area downstream of Kyle Canyon Detention Basin and ULVWDB. These models represent storm centerings over areas downstream of all the detention basins (Fort Apache, Rancho, Elkhorn Springs, North Environmental Enhancement Area, South Environmental Enhancement Area, Lower Las Vegas Wash, North Las Vegas, Park Highlands West and Cheyenne Peaking Basin). Therefore, the outflow from the above-mentioned detention basins was diverted out of the models. Because Gowan Watershed and a portion of Central Watershed drain into Lower Northern Las Vegas Wash Watershed, the areas downstream of Gowan North Detention Basin (Gowan Watershed) and Carey-Lake Mead Detention Basin (Central Watershed)

were included in these models. These models were used to size the Ann Road Channel West from Ferrell Street to Rainbow Boulevard and the Las Vegas Wash Middle Branch from the 215 Beltway to Grand Teton Drive. The Series B models are named CWEST3, CWEST4, CWEST5A, and CWEST5B. The number used in the model names represents SDN 3, 4, and 5, respectively.

- WEST (Series C): These Series C models represent a storm centering over areas downstream of Kyle Canyon Detention Basin and ULVWDB. In addition, a portion of Gowan Watershed downstream of Gowan North Detention Basin and the northwestern portion of Central Watershed were included in these models. The flow from remaining detention basins was not diverted out in this model. These models were used to size most of the facilities downstream of the ULVWDB. These Series C models are named WEST3, WEST4, WEST5A, and WEST5B. The number used in the model names represents SDN 3, 4, and 5, respectively.
- CCWEST (Series C): This Series C model represents a storm centering over the areas downstream of Kyle Canyon Detention Basin, ULVWDB, and North Las Vegas Wash Detention Basin. In addition, the areas downstream of Gowan North Detention Basin (Gowan Watershed) and Carey-Lake Mead Detention Basin (Central Watershed) were included in this model. These Series C models are named CCWEST3, CCWEST4, CCWEST5A, and CCWEST5B. The number used in the model names represents SDN 3, 4, and 5, respectively.
- CLVMD (Series C): These Series C models are similar to the CWEST models except that the discharge associated with subbasins NW144E, NW147-E, NW155-C, NW164 and NW165 was diverted out of the model to produce a smaller storm centering. These Series C models are named CLVMD3, CLVMD4, CLVMD5A, and CLVMD5B. The number used in the model names represents SDN3, SDN 4 and 5, respectively. These models were used to size a small section of facilities upstream of Lower Las Vegas Detention Basin and the Cheyenne Peaking Basin.

4.5. Flood Control Facility Plan

The final flood control facility plan is similar to the 2018 MPU. A list of studies collected along with maps are provided in **Appendix F** for referring to studies mentioned in this section. Problem areas and major revisions to the plan since the 2018 MPU are described below.

Brent Drainage System Facilities

The proposed facility at the upstream end of the Brent Drainage System (BRDB 0181) has been extended to north to Ohare Road to help address flooding issues at the request of City of Las Vegas.

Kyle Canyon Facilities

The footprint of Kyle Canyon Sediment Basin (MOKC 0173) was reduced to match the parcel size for the basin. The reduction in size of the basin shifted MOKC 0166 and increased the length of MOKC 0222.

Rancho Moccasin Facilities

The alignment of proposed facility (MORC 0210) was changed to drain east to the Las Vegas Wash instead of south along US 95. The proposed facilities on US 95 south of this change (MORC 0000-0208) were downsized due to the change in the drainage pattern.

In addition to the above information, **Table 4-2** summarizes the analysis of all the existing and proposed detention basins within the Upper Northern Las Vegas Wash Watershed.

Table 4-2 - Upper Northern Las Vegas Wash Watershed Detention Basin Summary Table

Name of Detention Basin	ID MILE	Status*	100-Year Peak Inflow (cfs)	Existing Storage @ Spillway (ac-ft)	Expansion Required (ac-ft)	Total Storage Volume @ Spillway (ac-ft)	Spillway Elevation (ft)	100-Year Clear Water Peak Elevation (ft)	Freeboard (ft)	Time to Peak (hrs)
South Environmental Enhancement Area	BRDB 0032	EX	1616	450	--	450	2455.00	2448.16	6.84	6.33
Elkhorn Springs	EKDB 0070	EX	443	48	--	48	2400.00	2396.19	3.81	5.58
Kyle Canyon	LVMD 3315/3317	EXP	17147	3200	1143	4343**	3281.00	3277.08	3.92	9.25
Upper Las Vegas Wash	LVUP 0910/0911	EXP	13123	1836	1144	2980**	2374.60	2371.79	2.81	10.67
Moccasin Outfall #1	MOHU 0179	EX	889	67	--	67**	3037.00	3035.72	1.28	5.67
Moccasin Outfall #2	MOIR 0098	PROP	635	--	--	79**	3018.00	3002.73	15.27	5.33
Kyle Canyon Sediment	MOKC 0173	PROP	1865	--	--	71**	5.00	4.29	0.71	4.17
Ft. Apache	RCBC 0004	EX	788	76	--	76	2636.00	2628.93	7.07	5.33
Rancho Road	RCHO 0025	EX	1967	321	--	321	2390.84	2384.42	6.42	7.67
North Environmental Enhancement Area	TSDB 0011	EX	488	117	--	117	2434.00	2431.9	2.1	6.17

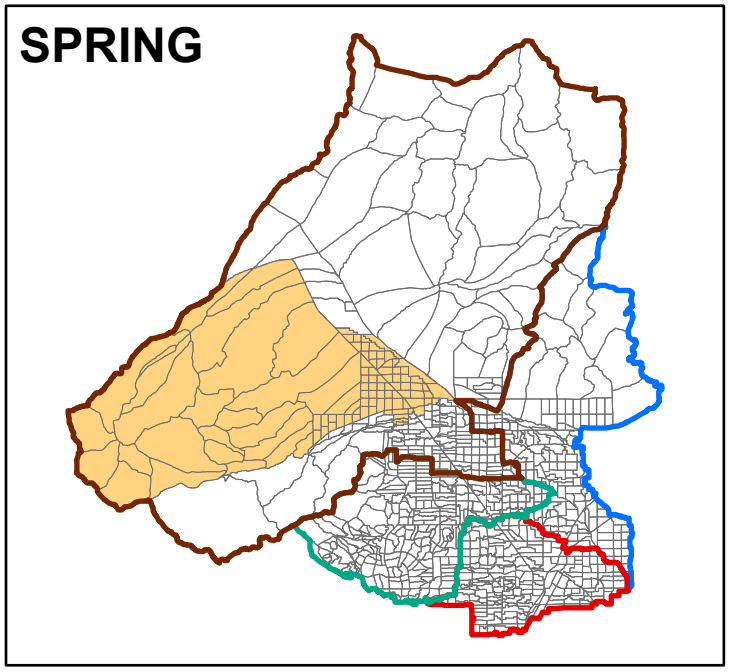
*EX = Existing Det Basin, EXP = Existing Det Basin with Proposed Expansion, PROP = Proposed Det Basin

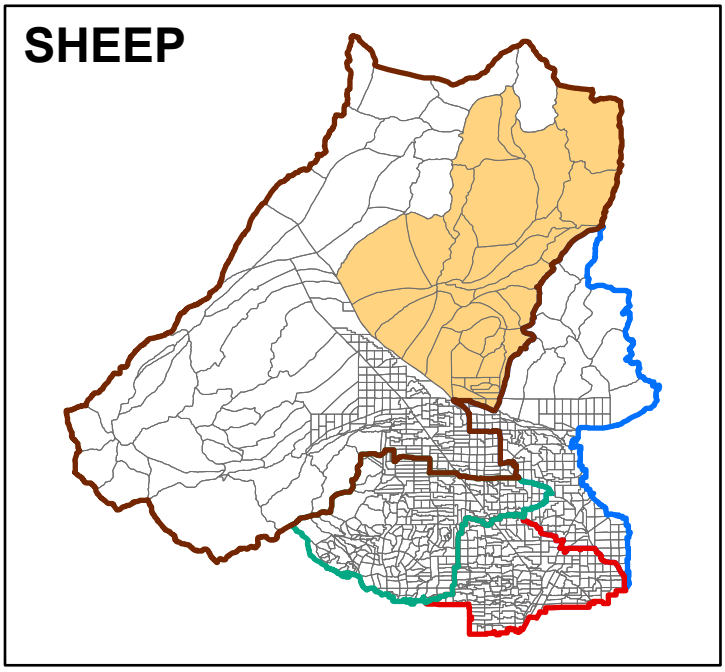
** Total Storage Volume accounts for Sediment Load

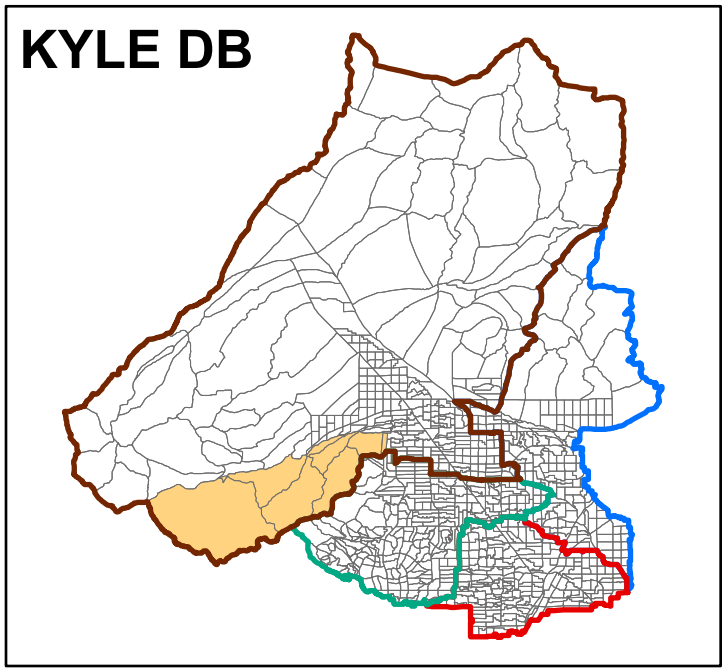
4.6. Facility Cost Estimates

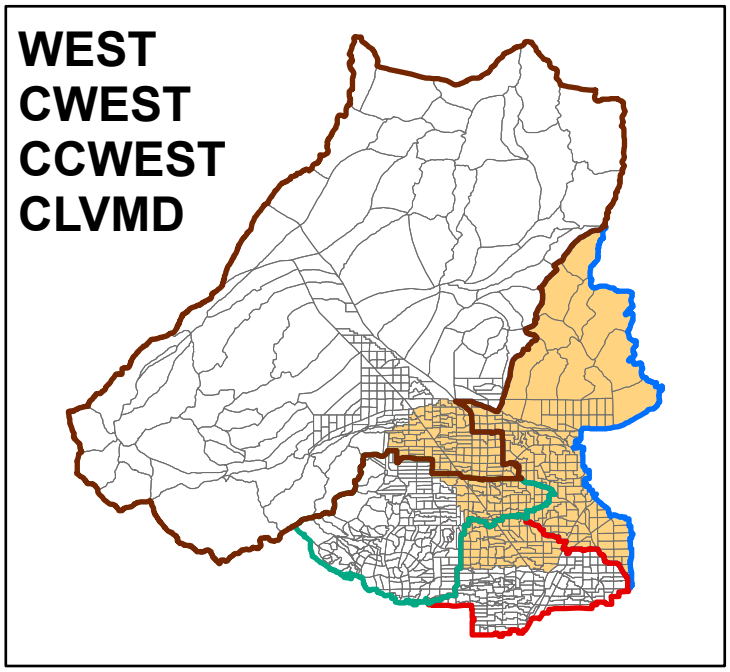
Cost estimates for all facilities have been derived using the Cost Estimation Tool described in **Section 2.6**. Construction cost estimates for proposed facilities have been divided into Category A and Category B. The total estimated current value of existing facilities and total estimated construction cost of proposed Category A and B facilities in the Upper Northern Las Vegas Watershed are as follows:

A detailed breakdown of current estimated values of existing facilities and construction cost estimates for proposed Category A and B facilities is included in **Appendix E.**









Storm centering models SPRING, LOWER and SHEEP are used to size Upper Las Vegas Wash Detention Basin

Storm centering models WEST, CWEST, CCWEST and CLVMD are used to size facilities downstream of Upper Las Vegas Wash and downstream of Kyle Canyon Detention Basin

Storm Centering model KYLEDB was used to size Kyle Canyon Detention Basin.

2023 LAS VEGAS VALLEY FLOOD CONTROL MASTER PLAN UPDATE

UPPER AND LOWER NORTHERN LAS VEGAS WASH STORM CENTERINGS FIGURE 4-1

Legend

- Central Watershed
- Gowan Watershed
- Lower Northern
- Upper Northern
- Subbasins
- Storm Centering Area

N

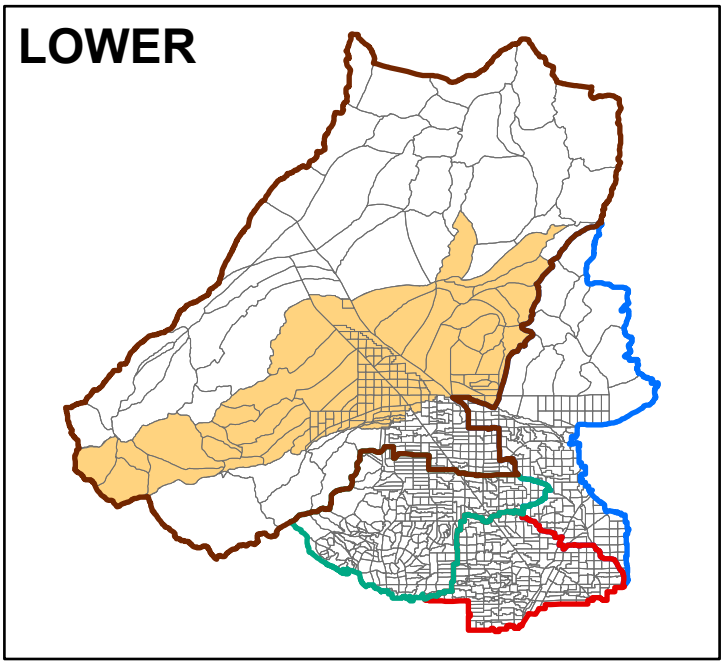
0 5 10

Miles

REGIONAL FLOOD CONTROL DISTRICT

AtkinsRéalis

Westwood



WEST

Includes all areas downstream of Upper Las Vegas Wash Detention Basin and downstream of Kyle Canyon detention Basin. In addition, a portion of Gowan Watershed downstream of Gowan North and South Detention Basins and the northwestern portion of the Central Watershed were included in this model.

CWEST

Same as WEST, but all detention basins in the area are diverted out.

CCWEST

Storm centering to compute discharge in Las Vegas Wash through Lower Northern Las Vegas Wash Watershed. Same as WEST except diverts out North Las Vegas and Cary-Lake Mead Detention Basins.

CLVMD

Same as CWEST. In addition, subbasins NW144E, NW147-E, NW155-C, NW164 and NW165 are diverted out of the model. This model is used to compute discharges for Las Vegas Wash Middle Branch.

REGIONAL FLOOD CONTROL DISTRICT

2023 LAS VEGAS VALLEY FLOOD CONTROL MASTER PLAN UPDATE

Legend

- Central Watershed
- Gowan Watershed
- Lower Northern
- Upper Northern
- Subbasins
- Storm Centering Area

N

0 5 10 20

Miles

UPPER AND LOWER NORTHERN LAS VEGAS WASH STORM CENTERINGS - II
FIGURE 4-2

AtkinsRéalis

Westwood

CHAPTER 5

Lower Northern Las Vegas Wash Watershed

5.1. Introduction

This chapter presents the information developed for the 2023 MPU for the Lower Northern Las Vegas Wash Watershed, which is located in the north portion of the Las Vegas Valley. As mentioned in **Section 4.1**, Lower Northern Las Vegas Wash Watershed contains the area downstream of the ULVWDB and the Las Vegas Wash Middle Branch at Ann Road. The City of North Las Vegas is responsible for programming flood control funds for Lower Northern Las Vegas Wash Watershed.

This watershed is primarily within the City of North Las Vegas jurisdiction; however, it includes portions of unincorporated Clark County. This watershed is bounded on the west by Decatur Boulevard and Allen Lane, on the north by the Sheep Mountains, on the east by Losee Road and Nellis Boulevard, and on the south by the Las Vegas Wash. This watershed discharges directly into the Las Vegas Wash.

There has been rapid growth in the middle portion of this watershed between Centennial Parkway and Grand Teton Drive. It is anticipated that the growth is likely to continue. The mountainous areas in the northern portion of the watershed are expected to remain undeveloped as it is reserved federal land. The majority of the remaining portion of this watershed, south of Centennial Parkway, is developed.

The total area of the Lower Northern Las Vegas Wash Watershed is approximately 117 square miles. Drainage facilities within the watershed consist primarily of detention basins connected by conveyance facilities.

5.2. Drainage Characteristics

Flows from the steep mountain slopes exit onto alluvial fans extending across the entire southern portion of the watershed. Drainage patterns in the lower portion of the Lower Northern Las Vegas Wash Watershed are generally from northwest to southeast.

5.3. Master Plan Progress

Some progress has been made on the implementation of the Master Plan since the 2018 MPU through the construction of flood control facilities. Construction of approximately 3 miles of conveyance facilities and one detention basin have been completed since the 2018 MPU. Major flood control facilities constructed or adopted into the plan since the 2018 MPU include the following:

- The Park Highland Grand Teton project constructed Park Highlands West detention basin (GTEA 0169) with a capacity of 137 ac-ft and the section of Grand Teton Drive System East, (GTEA 0141 – 0168) from Farm Road to the Park Highlands West Detention Basin outfall and from Decatur Blvd to Park Highland Basin inlet (GTEA 0192 – 0236) along Grand Teton Drive.
- The Aviary and Horse system facilities (AVHR 0000 – 0020 and 0041 – 0063) along Aviary Way and Horse Drive were adopted to the MPU so they are now considered regional facilities and are eligible for maintenance.
- The North 5th Street Collector Improvement project constructed a portion of the 5th Street Collector (LV5C 0002-0050) from Deer Springs Way to Centennial Parkway along 5th street.
- The Villages at Tule Spring Village 1 Phase 2A/2 Infrastructure Project constructed the Village at Tule Springs (VATS 0000-0047) along Revere Street north of CC-215.
- The Villages at Tule Springs Village 3 Infrastructure project constructed the extension of Centennial and Deer Springs (CNDS 0077) along Deer Springs to Gliding Eagle Road.
- Centennial Parkway Channel East facilities west of Revere Street (CNEA 0186-0204) to Seastrand Park were adopted to the MPU so they are now considered regional facilities and are eligible for maintenance.

In total, the following facilities have been constructed to date in the Lower Northern Las Vegas Wash Watershed[5].

5.4. Hydrologic Analysis

The hydrologic analysis and models completed with the 2018 MPU served as the basis for the 2023 MPU hydrologic analysis and modeling effort. The delineations for a large portion of this watershed were based on the 2018 MPU subbasin delineations and remain unchanged with the following exceptions:

- Villages at Tule Springs Master Plan area - extensive routing changes from the Centennial Parkway Channel East – Fifth Street collection based on the final drainage study in Tule Spring area.
- Nellis Boulevard – Subbasins were split along Marion Drive from Cheyenne Ave to Harris Road due to the addition of the new regional alignment.

The Lower Northern Las Vegas Wash watershed boundary was revised in the following locations:

- Boundary with Gowan Watershed was revised to follow road alignments near Simmons Street, which resulted in re-delineation of subbasin LV99A-1.
- Boundary with Central Watershed was slightly revised at Lake Mead Blvd, which resulted in re-delineation of subbasin LV1B-1 to match the detailed study for Lake Mead Storm Drain.

The 2018 MPU hydrologic parameters used in the models were reviewed and updated to incorporate the changes in criteria and methodology described in **Section 2.3**, which primarily include change in soils data, percent impervious and distribution of open space as well as

[5] Total length for facilities does not include floodways, natural washes, or existing facilities that are planned to be replaced.

changes in land use density. The hydrologic parameters were revised to incorporate all new data collected and/or developed for the 2023 MPU. The major drainage reports and technical drainage studies reviewed and incorporated into the hydrologic analysis are tabulated in **Table 5-1**.

Table 5-1 - Lower Northern Las Vegas Wash Watershed Major Hydrologic Studies

#	NAME OF STUDY
1	NORTH 5TH STREET COLLECTOR FINAL DRAINAGE STUDY (VTN, 2018)
2	FINAL HYDRAULIC TECNICAL MEMORANDUM LAKE MEAD STORM DRAIN LAS VEGAS WASH TO CIVIC CENTER (JACOBS, 2023)
3	LAS VEGAS WASH CARTIER CHANNELHYDROLOGY AND HYDRAULICS MEMORANDUM (CA GROUP, 2022)
4	UPDATE 3 FOR PARK HIGHLANDS GRAND TETON REGIONALFLOOD CONTROL FACILITY (SHG, 2019)
5	TECHNICAL DRAINAGE STUDY UPDATE, VILLAGES AT TULE SPRINGS VILLAGE 1 PHASE 2A/2 INFRUSTRUCTURE (SHG, 2019)

The same hydrologic models (CWEST, WEST, CCWEST and CLVMD) described in **Section 4.4** were used to size facilities within this watershed.

5.5. Flood Control Facility Plan

The final flood control facility plan is generally the same as the 2018 MPU. A list of studies collected along with maps are provided in **Appendix F** for referring to studies mentioned in this section. Problem areas and major revisions to the plan since the 2018 MPU are described below.

Las Vegas Wash Cartier Channel System

The proposed storm drain system (LVCC 0000 – 0125) was modified based on the latest design plans along Las Vegas Boulevard from Lake Mead Boulevard to the Cartier Channel, where it eventually flows into the Las Vegas Wash Middle Branch.

Las Vegas Wash- Marion

A proposed storm drain system (Las Vegas Wash Marion “LVMA”) was added to the 2023 MPU along Marion Dr to Harris Ave, where it eventually flows into the Las Vegas Wash Middle Branch. This area was identified as a hotspot by the City of North Las Vegas. This facility will mitigate flooding in Nellis Blvd.

Las Vegas Wash- Lamb

A proposed storm drain system (Las Vegas Wash Lamb “LVLA”) was realigned along Alto Dr. to Lamb Blvd, where it eventually flows into the Las Vegas Wash Middle Branch. This area was identified as a hotspot by City of North Las Vegas. This facility will mitigate flooding on Alto Dr.

Iron Mountain

The alignment of the proposed storm drain system along Iron Mountain Road (IRMO 0000 & 0010) was extended downstream past Decatur Blvd to discharge flow into the Las Vegas Wash.

Aviary and Horse System

A regional facility (AVHR 0040) has been proposed to connect the two existing storm drain systems along Aviary Way and Horse Drive "AVHR" which drains into the Park Highlands West Detention Basin.

Las Vegas – Brooks

A regional facility (LVBR 0114) has been proposed along Mayflower Avenue, north on Commerce Street, and east on Brooks Avenue which flows into Las Vegas I-15 Freeway channel. This area was identified as a hotspot by the City of North Las Vegas. This facility will mitigate flooding on Brooks Drive.

In addition to the above information, **Table 5-2** summarizes the analysis of all the existing and proposed detention basins within the Lower Northern Las Vegas Wash Watershed.

Table 5-2 - Lower Northern Las Vegas Wash Watershed Detention Basin Summary Table

Name of Detention Basin	ID MILE	Status*	100-Year Peak Inflow (cfs)	Existing Storage @ Spillway (ac-ft)	Expansion Required (ac-ft)	Total Storage Volume @ Spillway (ac-ft)	Spillway Elevation (ft)	100-Year Clear Water Peak Elevation (ft)	Freeboard (ft)	Time to Peak (hrs)
Park Highlands West	GTEA 0169	PROP	1524	--	--	137	2308.50	2307.85	0.65	5.83
Cheyenne Peaking Basin	LVMD 1645/1646	EXP	13442	456	134	590	1889.75	1888.8	0.95	5.67
Lower Las Vegas Wash	LVMD 2050	EX	6591	700	--	700	2115.50	2103.53	11.97	5.58
North Las Vegas	LVUP 0405/0406	EXP	11256	1435	963	2398**	2136.00	2128.60	7.4	7.33

*EX = Existing Detention Basin, EXP = Existing Detention Basin with Proposed Expansion, PROP = Proposed Detention Basin

** Total Storage Volume accounts for Sediment Load

5.6. Facility Cost Estimates

Cost estimates for all facilities have been derived using the Cost Estimation Tool described in **Section 2.6**. Construction cost estimates for proposed facilities have been divided into Category A and Category B. The total estimated current value of existing facilities and total estimated construction cost of proposed Category A and B facilities in the Lower Northern Las Vegas Wash Watershed are as follows:

A detailed breakdown of current estimated values of existing facilities and construction cost estimates for proposed Category A and B facilities is included in **Appendix E**.

CHAPTER 6

Gowan Watershed

6.1. Introduction

This chapter presents the information developed for the 2023 MPU for the Gowan Watershed, which is located in the northwest portion of the Las Vegas Valley. This watershed is primarily within the City of Las Vegas jurisdiction; however, it includes portions of the City of North Las Vegas and unincorporated Clark County. The City of Las Vegas is responsible for programming flood control funds for Gowan Watershed. The Gowan Watershed is a major tributary to the Western Tributary of the Las Vegas Wash. This watershed is bounded on the west by the Spring Mountains, on the north by the 215 Beltway, on the northeast by the Western Tributary, and on the south by Charleston Boulevard and Cheyenne Avenue.

There has been rapid growth in the southwest portion of this watershed north of Charleston Boulevard and west of the 215 Beltway. Although the rate of development has slowed recently, it is anticipated that the growth is likely to continue in this area and in the northwest portion of the watershed in the vicinity of the 215 Beltway. The mountainous areas in the western portion of the watershed are within the Red Rock Canyon National Conservation Area (RRCNCA) and are expected to remain undeveloped. The majority of the remaining portion of this watershed, east of the 215 Beltway, is developed.

The total area of the Gowan Watershed is approximately 84 square miles. Drainage facilities within the watershed consist primarily of detention basins connected by conveyance facilities.

6.2. Drainage Characteristics

Drainage patterns in the Gowan Watershed are generally from west to east. The watershed is characterized by numerous small, steep mountain drainages on the west perimeter of the Valley that discharge to a broad alluvial fan extending from Kyle Canyon on the north to Red Rock

Wash on the south. Many small braided washes traverse the alluvial fan, but very few are incised enough to be perpetuated in the ultimate condition as natural unlined washes or floodways. The steep fan slopes have generated significant channel erosion in local areas, but the majority of runoff occurs in the form of sheet flow.

6.3. Master Plan Progress

Significant progress has been made on the implementation of the Master Plan since the 2018 MPU through the construction of flood control facilities. Construction of approximately 12 miles of conveyance facilities and 1 debris basin has been completed since the 2018 MPU. Major flood control facilities constructed or adopted into the plan since the 2018 MPU include the following:

- BLM 270 Centennial Parkway Infrastructure project constructed the Gowan Beltway West facilities (GOBW 0311 - 0320) along Centennial Parkway from Pole Line Rd to N Shaumber Road.
- Gowan North EL Capitan Branch Ann Road to Centennial Parkway project constructed the Gowan North – El Capitan Branch facilities (GOEC 0100 - 0176) along El Capitan Way from Centennial Parkway to Ann Road.
- Projects in Summerlin West Village 22, Kettle Ridge Drive, Kindle Rise Way and Kettle Bend Road constructed Angel Park Beltway Branch (APBE 0154 – 0275) along Kettle Ridge Drive from Lake Mead Boulevard to Kindle Rise Way and along Kettle Bend Road from Kindle Rise Way to Summerlin Parkway.
- Summerlin West Village 21 Carriage Hill Drive projects constructed Angel Park – Carriage Hill Branch facilities (APCH 0003 – 0031) along Carriage Hill Road from Sky Vista Drive to Far Hills Ave.
- Summerlin Village 26 – Reverence Offsite Improvements project constructed the Gowan Lone Mountain System – Branch 3 facility (GOL3 0109) connected to Village 26 Detention Basin
- Summerlin West Village 25 Grand Park Detention Basin and Grand Park Detention Basin Inlet Pipe projects constructed Grand Park Detention Basin (APDF 0125) and collection facilities (APDF 0128 – 0185 & APDF 0126 – 0127). Summerlin West Village 21 – Desert Foothills Drive projects constructed (APDF 0000-0026) along Desert Foothills Drive from Far Hills Avenue to Sky Vista Drive and Summerlin West Village 25 – Sky Vista Drive Improvements project constructed Sky Vista Drive (APDF 0037 – 0123) from Desert Foothills Drive to Fox Hill Drive.
- Gowan Outfall Alexander Road Project – Decatur Boulevard to Simmons Street constructed Gowan Outfall Facilities (GOOF 0275 – 0425 and GOAL 0000) along Alexander between Simmons Street and Decatur Boulevard.

- Grass channel facilities (APP2 0091 – 0181 and APP3 0000 – 0101) from Apple Drive to S Hualapai Way have been adopted to the MPU as existing facilities so that they are eligible for maintenance funding.
- Summerlin Village 29 – Park Drift Trail Improvements project and Summerlin West Village 29 Phase 1 infrastructures project constructed Angel Park – Park Drift Branch facilities (APPD 0004 – 0047) along Park Drift Trail between Sandstone Rise and the natural wash APM5.

In total, the following facilities have been constructed to date in the Gowan Watershed[6].

6.4. Hydrologic Analysis

The hydrologic analysis and models completed with the 2018 MPU served as the basis for the 2023 MPU hydrologic analysis and modeling effort. The delineations for a large portion of this watershed were based on the 2018 MPU subbasin delineations and remain unchanged with the following exceptions:

- Subbasins within the Summerlin Master Drainage Study Area were revised based on several detailed studies in the area.
- Sheep Mountain Parkway revised subbasins for the updated road alignment.
- Subbasins were revised within Gowan Outfall study drainage area along Alexandar Road based on the detailed design.

The Gowan Watershed boundary was revised at three different locations since the 2018 MPU. The first revision to the watershed boundary is between the Tropicana/Flamingo Watershed and Gowan Watershed. The delineation of subbasins west of Alta Drive and Sky Vista Drive were modified based on Master Conceptual Drainage Study V28/32 to reflect the latest flow patterns this area. Secondly, the watershed boundary between Gowan Watershed and Central Watershed was revised at two locations which resulted in re-delineation of subbasins south of

[6] Total length for facilities does not include floodways, natural washes, or existing facilities that are planned to be replaced.

Alexandar Road from Decatur Drive to Simmons Street to reflect the flow patterns from the Gowan Outfall Study. Minor changes were made to subbasin 2-GOLF-C based on the Via Olivero Study. Lastly, the Gowan Watershed and Lower Northern Watershed were changed at Alexander Road and Simmons Street to reflect the flow patterns from the Gowan Outfall Study.

The 2018 MPU hydrologic parameters used in the models were reviewed and updated to incorporate the changes in criteria and methodology described in **Section 2.3**, which primarily include changes in soils data, percent impervious and distribution of open space, as well as changes in land use density. The hydrologic parameters were revised to incorporate all new data collected and/or developed for the 2023 MPU. The major drainage reports, technical drainage studies, and Master Plan Amendments reviewed and incorporated into the hydrologic analysis are tabulated in **Table 6-1**.

Table 6-1 - Gowan Watershed Major Hydrologic Studies

#	NAME OF STUDY
1	SUMMERLIN WEST GRAND PARK DETENTION BASIN INLET PIPE (VTN, 2020)
2	MASTER PLAN AMENDMENT FOR SUMMERLIN WEST TRIBUTARY AREA TO REVERENCE VILLAGE 26 (ATKINS, 2021)
3	CONCEPTUAL DRAINAGE STUDY FOR SHEEP MOUNTAIN PARKWAY SHAUMBER ROAD TO GRAND TETON DRIVE (HORROCKS,2020)
4	SUMMERLIN VILLAGE 29 PARK DRIFT TRAIL (SANDSTONE RISE DRIVE TO COS-4) (GCW, 2021)
5	FINAL HYDROLOGIC/HYDRAULIC TECHNICAL MEMORANDUM GOWAN OUTFALL ALEXANDER RD – DECATUR BLVD TO SIMMONS STREET (JACOBS, 2020)
6	DESIGN REPORT FOR SUMMERLIN WEST VILLAGE 22 SUNSET RUN DRIVE (KETTLE RIDGE TO CALICO BEND (VTN, 2020)

Series A and Series B storm centerings were used for the majority of facilities in the Gowan Watershed (see **Section 2.3.11**). One Series C storm centering was developed to analyze a special circumstance at the Gowan South Detention Basin. The following hydrologic models were developed for analysis of Gowan Watershed:

- GOW_A (Series A): Series A models were developed to represent storm centerings over the entire Gowan Watershed. These Series A models are named GOW3A, GOW4A, and GOW5A. The number used in the model names represents SDN 3, 4, and 5, respectively.
- GOW_B (Series B): Series B models were developed to represent storm centerings for the portion of Gowan Watershed downstream of Summerlin 5, Ann Road, Lone Mountain, Village 22, Village 26, Box Canyon, Lone Mountain-Beltway, Angel Park, Gowan South, and Gowan North Detention Basins. Discharge from these detention basins was diverted out of the models to prevent it from combining with areas downstream of the detention basins. These Series B models are named GOW3B, GOW4B, and GOW5B. The number used in the model names represents SDN 3, 4, and 5, respectively.
- GOW4C (Series C): This Series C model uses a SDN4 storm centering for the Gowan South Detention Basin. This model is similar to GOW4B model except that the discharge associated with subbasin GDB was diverted out of the model to produce a smaller storm centering.

6.5. Flood Control Facility Plan

The final flood control facility plan is generally the same as the 2018 MPU. A list of studies collected along with maps are provided in **Appendix F** for referring to studies mentioned in this section. Problem areas and major revisions to the plan since the 2018 MPU are described below.

Summerlin West Facilities

The area west of the 215 Beltway in the Summerlin West development has had substantial revision due to a variety of drainage studies for the area and the Summerlin West Conceptual Master Drainage Study. Changes to the master plan are listed below:

- An extension of Angel Park – Park Drift facilities (APPD 0050 – 0053) north along Park drift and west along a future road. The facility running in the future road (APPD 0053) splits flow evenly when it reaches Park Drift Trail to the North (APDF 0158) and the south (APPD 0050).
- The alignment and descriptions of the Angle Park Branches which are planned in the southeastern portions of the Summerlin West development have changed based on updated conceptual plans.
    - Angel Park – Middle 5 Branch (APM5 0057 – 0155) is the furthest alignment north in the Summerlin West area it connects to a diversion berm on the east and drains to Detention Basin #5.
    - Angel Park – Middle 6 Branch (APM6 0008 – 0116) used to be included in the AMP5 facilities but was broken out and realigned to drain through Waters of the US (WOTUS) 3 to Detention Basin #5.
    - Angel Park – Middle 7 Branch (APM7 0008) is the furthest alignment south in the Summerlin West area. It will follow a future common space area planned in the area.

Gowan North Facilities

The Gowan North Facilities (GOL3 0304 – 0419) north of W Lake Mead Boulevard were revised based on the proposed Master Drainage Study Plan Amendment for Summerlin West Tributary Area to Reverence Village 26. The revisions include significant modifications to the conveyance facilities including the addition of one detention basin (GOL3 0464) and two debris basins (GOL3 0355 and GOL3 0219).

Gowan Ann Road Detention Basin Facilities

The alignment for Gowan Ann Road Detention Basin outfall facilities (GOAN 0000 & 0010) were revised to follow the future Sheep Mountain parkway alignment and connect to Gowan Beltway West RCB (GOWB 0183) near La Mancha Avenue.

Gowan – Craig Road

A MPU alignment (GCR1 0000) was extended on Craig Road west of Decatur Boulevard based on entity meetings, review of area, and the relatively high flow rate impacting this area.

Angel Park North

The existing Angel Park North Culvert (APNO 0015) at Summerlin Parkway had the incorrect dimensions in 2018 MPU and was updated to a 14' X 14' RCBC. The facility does not have enough capacity to convey the entire 100-yr storm without significant headwater and some flow being conveyed through the pedestrian tunnel under Summerlin Parkway. An additional 14' X 14' RCBC (APNO 0016) has been proposed for planning purposes so that the City of Las Vegas can review this area in more detail in the future. More design and analysis would be needed to determine if an additional culvert would be beneficial and/or substantially reduce the flow through the pedestrian tunnel.

In addition to the above information, **Table 6-2** summarizes the analysis of all the existing and proposed detention basins within the Gowan Watershed.

Table 6-2 - Gowan Watershed Detention Basin Summary Table

Name of Detention Basin	ID MILE	Status*	100-Year Peak Inflow (cfs)	Existing Storage @ Spillway (ac-ft)	Expansion Required (ac-ft)	Total Storage Volume @ Spillway (ac-ft)	Spillway Elevation (ft)	100-Year Clear Water Peak Elevation (ft)	Freeboard (ft)	Time to Peak (hrs)
Grand Park	APDF 0125	PROP	1424	121	--	121	3532.00	3528.99	3.01	5.42
Detention Basin #5	APM5 0000	EX	6745	487	--	487	3563.00	3558.61	4.39	5.25
Angel Park	APNO 0001	EX	8373	1654	--	1654	2620.80	2619.64	1.16	9.25
Ann Road	GOAN 0061/0062	EXP	5539	364	75	439**	3000.00	2998.81	1.19	5.67
Lone Mountain-Beltway	GOBW 0052	EX	4991	589	--	589	2738.27	2731.16	7.11	6.17
Box Canyon	GOBX 0118	PROP	3934	430	--	430**	22.25	18.73	3.52	6.5
Village 26	GOL3 0128	EX	4031	305	--	305	3022.00	3020.85	1.15	6.25
Village 31	GOL3 464	PROP	2029	101		101	4264.00	4261.7	2.3	4.42
Lone Mountain	GOLM 0146	EX	6336	888	--	888	2652.57	2645.08	7.49	6.25
Gowan North	GONO 0008	EX	2601	921	--	921	2328.00	2317.42	10.58	6.25
Gowan South	GOSO 0051/0052	EXP	6255	624	62	686	2351.20	2350.55	0.65	6.42

*EX = Existing Detention Basin, EXP = Existing Detention Basin with Proposed Expansion, PROP = Proposed Detention Basin

** Total Storage Volume accounts for Sediment Load

6.6. Facility Cost Estimates

Cost estimates for all facilities have been derived using the Cost Estimation Tool described in **Section 2.6.** Construction cost estimates for proposed facilities have been divided into Category A and Category B. The total estimated current value of existing facilities and total estimated construction cost of proposed Category A and B facilities in the Gowan Watershed are as follows:

A detailed breakdown of current estimated values of existing facilities and construction cost estimates for proposed Category A and B facilities is included in **Appendix E**.

CHAPTER 7

Central Watershed

7.1. Introduction

This chapter presents the information developed for the 2023 MPU for the Central Watershed, which is located in the middle of the Las Vegas Valley. This watershed is completely developed. It is primarily located within the City of Las Vegas jurisdiction; however, it includes portions of the City of North Las Vegas and unincorporated Clark County. The City of Las Vegas is responsible for programming flood control funds for Central Watershed. This watershed has three main discharge locations: 1) the Freeway Channel that drains north into the Lower Northern Las Vegas Wash Watershed, 2) the Las Vegas Wash, and 3) the Boulder Highway Facility that drains south into Flamingo Wash. The Central Watershed is bounded by Gowan Road to the north, Buffalo Drive to the west, Flamingo Road to the south, and the Las Vegas Wash to the east. The Central Watershed can be divided into three sub-watersheds corresponding to the three discharge points: 1) the area tributary to the Freeway Channel is bounded by Gowan Road to the north, I-15 to the east, Washington Avenue to the south, and by the Gowan South Facilities to the west, 2) the area tributary to Las Vegas Wash is bounded by Lake Mead Boulevard to the north, the Las Vegas Wash to the east, Flamingo Road to the south, and the Buffalo Drive to the west, and 3) area tributary to the Flamingo Wash is bounded by Stewart Avenue to the north, Boulder Highway to the east, Karen Avenue to the south, and I-15 to the west.

The total area of the Central Watershed is approximately 56 square miles. Drainage facilities within the watershed consist primarily of detention basins inter-connected by conveyance facilities.

7.2. Drainage Characteristics

The drainage patterns in the Central Watershed generally flow from west to east. The three main sub-watershed and discharge drainage patterns are described herein.

Freeway Channel

The Freeway Channel sub-watershed collects the flow from the northwest into the drainage system along the west side of I-15 which flows north and ultimately combines with the Las Vegas Wash in the Lower Northern Las Vegas Wash Watershed.

Las Vegas Wash

The Las Vegas Wash sub-watershed collects the flow from the southwest and the east portion of the Central Watershed and discharges the flow into the Las Vegas Wash via the Cedar Avenue Channel and the conveyance systems in Owens Avenue, Washington Avenue, Stewart Avenue, Charleston Boulevard, and Colorado Avenue. The Las Vegas Wash through the Central Watershed also includes tributary area from the Gowan Watershed, Upper Northern Las Vegas Wash Watershed and the Lower Northern Las Vegas Wash Watershed.

Flamingo Wash

The Flamingo Wash sub-watershed collects the flow from the south portion of the watershed into the conveyance systems in Sahara Avenue and Boulder Highway. This flow will ultimately combine with the Flamingo Wash in the Flamingo/ Tropicana Watershed.

7.3. Master Plan Progress

Some progress has been made on the implementation of the Master Plan since the 2018 MPU through the construction and design of various flood control facilities. There is approximately 5 miles of conveyance facilities that have been implemented since the 2018 MPU. Major flood control facilities constructed or adopted into the plan since the 2018 MPU include the following:

- Charleston/Maryland Storm Drain project constructed storm drain along Charleston Boulevard from Maryland Parkway to Freemont Street (FLBN 0170 – 0280) continuing upstream in 13th Street and Maryland Parkway up to Stewart Avenue (FLMP 0000 - 0068).
- Boulder Highway Storm Drain project constructed storm drain along Fremont Street from Charleston Boulevard to Sahara Avenue (FLBN 0038 – FLBN 0167).
- Meadows-Charleston Storm Drain project constructed storm drain along Charleston Boulevard from Lindell Road to Essex Drive (MECN 0000 - 0099).

In total, the following facilities have been constructed to date in the Central Watershed[7].

7.4. Hydrologic Analysis

The hydrologic analysis and models completed with the 2018 MPU served as the basis for the 2023 MPU hydrologic analysis and modeling effort. The 2023 MPU subbasin delineations for a large portion of this watershed were based on the 2018 MPU subbasin delineations and remain unchanged with the following exceptions:

- Subbasins were revised along US 95 west of Eastern Avenue based on entity meetings and hotspot information and contour data.
- Subbasins were revised north of Carey Avenue and west of Martin Luther King (MLK) Boulevard to refine drainage patterns tributary to MLK Boulevard. This addressed a hotspot identified by the CLV in the area.
- Subbasins were revised west of Sahara Ave and Rainbow Boulevard based on Via Olivero Project Changes (Meadows – Charleston) Storm Drain report.
- Subbasins were revised along Stewart Avenue between Pecos Road and Las Vegas Wash by referencing the Las Vegas Wash – Stewart, Las Vegas Wash to Lamb Storm Drain Final Report.
- Subbasins were revised along Charleston Boulevard between Jones Boulevard and Valley View Boulevard by referencing the Meadows-Charleston Storm Drain Essex Drive to Lindell Road Final Report.
- Subbasins were revised along Vegas Drive between Torrey Pines Drive and Shadow Mountain Place by referencing the 70% Design Report for Vegas Drive Storm Drain.

[7] Total length for facilities does not include floodways, natural washes, or existing facilities that are planned to be replaced.

- Subbasins were revised along Martin Luther King Boulevard between Clayton St and Martin Luther King Boulevard based on entity meetings and contour data.
- Subbasins were revised along Gowan Watershed Boundary along Vista Del Sol and Gowan Road based on flow patterns changing and resulted in re-delineation for subbasins within the Gowan Watershed.

The 2018 MPU hydrologic parameters used in the models were reviewed and updated to incorporate the changes in criteria and methodology described in **Section 4.3**, which primarily include changes in soils data, percent impervious and distribution of open space, as well as changes in land use density. The hydrologic parameters were revised to incorporate all new data collected and/or developed for the 2023 MPU. The major drainage reports and technical drainage studies reviewed and incorporated into the hydrologic analysis are tabulated in **Table 7-1**.

Table 7-1 - Central Watershed Major Hydrologic Studies

#	NAME OF STUDY
1	LAS VEGAS WASH TO LAMB STORM DRAIN 70% DESIGN REPORT (ATKINS, MAY 2022)
2	CHARLESTON/MARYLAND STORM DRAIN 90% DESIGN REPORT (ATKINS, DEC 2019)
3	VEGAS DRIVE STORM DRAIN FINAL DESIGN REPORT (WSP, OCT 2022)
4	MEADOWS-CHARLESTON STORM SRAIN 90% DESIGN REPORT (GCW, JAN 2022)
5	SPRINGS PREESERVE CIENEGA MODIFICATIONS PHASE II FINAL DESIGN REPORT (WESTWOOD, MAY 2023)
6	LUNNING DRIVE MEADOWS CHARLESTON ESSSEX DRIVE (APRIL 2018)

Series A, Series B and Series C storm centerings were used for the Central Watershed (see **Section 2.3.11**). The following hydrologic models were developed for analysis of the Central Watershed:

- NW (Series A): These Series A models were developed to analyze the northwestern portion of Central Watershed tributary to the Lower Northern Las Vegas Wash Watershed. In addition, a portion of Gowan Watershed was included in the models. These Series A models are named NW3, NW4 and NW5. The number used in the model names represents storm distributions SDN 3, 4, and 5, respectively.
- SW (Series A): These Series A models were developed to analyze the southwestern, southeastern, and northeastern portion of Central Watershed tributary to Las Vegas Wash and to the Flamingo/Tropicana Watershed. These Series A models are named SW3, SW4, and SW5. The number used in the model names represents storm distributions SDN 3, 4, and 5, respectively.
- NWSC (Series B): These Series B models were developed to analyze the northwestern portion of Central Watershed tributary to the Lower Northern Las Vegas Wash Watershed. In addition, a portion of Gowan Watershed was included in the models. Discharge from Carey-Lake Mead Detention Basin was diverted out of the models to prevent it from

combining with areas downstream of the detention basin. These Series B models are named NW3SC, NW4SC, and NW5SC. The number used in the model names represents storm distributions SDN 3, 4, and 5, respectively.

- SWSC (Series B): These Series B models were developed to analyze the southwestern, southeastern, and northeastern portion of Central Watershed tributary to the Las Vegas Wash and to the Flamingo/Tropicana Watershed. Discharge from the Oakey, Meadows, and Rainbow Detention Basins is diverted out of the models to prevent it from combining with areas downstream of the detention basins. These Series B models are named SW3SC, SW4SC, and SW5SC. The number used in the model names represent storm distributions SDN 3, 4, and 5, respectively.
- MEADOWS (Series C): These Series C models are similar to SWSC Series B models except that the discharge from Meadows and Rainbow Detention Basin was not diverted out of the model. These Series C models are named MEADOWS4 and MEADOWS5. The number used in the model names represent storm distributions SDN 4 and 5, respectively.
- CLVWASH5 (Series C): This Series C SDN 5 model represents a storm centering over the areas downstream of Kyle Canyon Detention Basin, ULVWDB, North Las Vegas Detention Basin, Gowan North Detention Basin, and Carey-Lake Mead Detention Basin. This model was used to compute the discharge in Las Vegas Wash through the Central Watershed.
- BOULDER4 (Series C): This Series C model uses a storm distribution SDN4 storm centering for the Flamingo-Boulder Highway North facilities between Sahara Avenue and the Flamingo Wash. This model is similar to the SW4 model except the discharge associated with subbasins FW01, FW02, FW03 and FW5 was diverted out of the model to produce a smaller storm centering.

7.5. Flood Control Facility Plan

The final flood control facility plan is generally the same as the 2018 MPU. A list of studies collected along with maps are provided in **Appendix F** for referring to studies mentioned in this section. Problem areas and major revisions to the plan since the 2018 MPU are described below.

Meadows Detention Basin

The 2023 MPU hydrology was updated to incorporate information for Meadows Detention Basin from Springs Preserve Cienega Modifications Phase II prepared by Westwood (May 2023). The previously proposed detention basin expansion has been removed and new labyrinth spillway and 17'W 4'D concrete channel (LCME 0023) was added to the plan to increase conveyance through the basin and eliminate the need for additional storage volume (peaking basin concept).

Las Vegas Wash - Smoke Ranch System

Storm drain shown as existing in 2018 MPU in Carey Avenue between Simmons Street and Martin Luther King Boulevard were incorrect and was updated based on Carey Avenue Storm

Drain construction plans. The existing facilities were still undersized (LVSR 0149 – 0208). The proposed replacement storm drains were updated to start and end as the existing storm drains (LVSR 0148 – 0209).

Second – Smoke Ranch System

Second – Smoke Ranch System was proposed on Martin Luther King Boulevard upstream from Carey Avenue to June Avenue (SSR10000) based on review of area, flow rates, and facility capacity.

Owens Avenue System

The Owens Avenue System was truncated to Torrey Pines Avenue by removing LVOW 0513. Storm drains between Shadow Mountain Place and Crest Haven Avenue (LVOW 0360 & 0380) were modified based on the 70% Design Report and Plans for the Vegas Drive Storm Drain Project dated October 2022.

The Owens Avenue System was found to be undersized downstream of Shadow Mountain Place (LVOW 0351 – 0355). The facilities are recommended to be removed and replaced. The flow is also recommended to be directed north (LMDE 0000) on Decatur Boulevard instead on continuing on Vegas Drive in the ultimate condition.

Flamingo – Boulder Highway North

Modifications were made to Flamingo Boulder Highway North Charleston Main to Maryland (FLBN 0281 – 0340) per 90% Design plans for Charleston Main to Maryland dated March 2022.

Las Vegas Wash – Stewart

The Las Vegas Wash – Stewart Storm Drain System was extended to Eastern Avenue (LVST0259) based on entity meetings, review of area, flow rates, and facility capacity.

Palmyra Sirius Drain - Decatur Lateral

Decatur Lateral Storm Drain was extended along Eldora Avenue (PSDE0047) based on entity meetings, review of area, and relatively high flow rate impacting the area.

In addition to the above information, **Table 7-2** summarizes the analysis of all the existing and proposed detention basins within the Central Watershed.

Table 7-2 - Central Watershed Detention Basin Summary Table

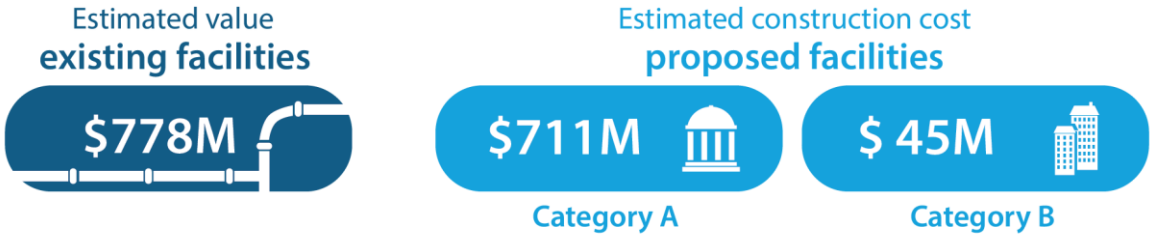
Name of Detention Basin	ID MILE	Status*	100-Year Peak Inflow (cfs)	Existing Storage @ Spillway (ac-ft)	Expansion Required (ac-ft)	Total Storage Volume @ Spillway (ac-ft)	Spillway Elevation (ft)	100-Year Clear Water Peak Elevation (ft)	Freeboard (ft)	Time to Peak (hrs)
Oakey DB	MECH 0324	EX	1932	201	--	201	2348.5	2346.06	2.44	6.33
Meadows DB	LCME 0020	EX	4836	238.5	--	238.5	2112	2111.31	0.69	4.75
Rainbow DB	LCCH 0513	EX	1003	102	--	102	2391.5	2382.4	9.1	5.42
Carey/Lake Mead DB	LVLM 0228	MOD	5600	607	--	607	2118.5	2118.17	0.33	6.17

*EX = Existing Detention Basin, EXP = Existing Detention Basin with Proposed Expansion, PROP = Proposed Detention Basin, MOD = Modify Outlet

** Total Storage Volume accounts for Sediment Load

7.6. Facility Cost Estimates

Cost estimates for all facilities have been derived using the Cost Estimation Tool described in **Section 2.6**. Construction cost estimates for proposed facilities have been divided into Category A and Category B. The total estimated current value of existing facilities and total estimated construction cost of proposed Category A and B facilities in the Central Watershed are summarized as follows:



A detailed breakdown of current estimated values of existing facilities and construction cost estimates for proposed Category A and B facilities is included in **Appendix E**.

CHAPTER 8

Flamingo/Tropicana Watershed

8.1. Introduction

This chapter presents information developed for the 2023 MPU for the Flamingo/Tropicana Watershed, which is located in the southwest and central portions of Las Vegas Valley. The majority of this watershed lies within unincorporated Clark County with small portions in the City of Las Vegas. Clark County maintains jurisdiction of the Flamingo/Tropicana Watershed and is responsible for programming flood control funds. The Flamingo/Tropicana Watershed extends from the Spring Mountain Range on the western rim of the Las Vegas Valley to the confluence of the Flamingo Wash and the Lower Las Vegas Wash.

Development has been steadily increasing over the past few years, and it is expected to continue in the western and southwestern portions of the Flamingo/Tropicana Watershed west of I-15. The mountainous areas in the far western limits of the watershed are within the RRCNCA and are expected to remain undeveloped. The majority of the watershed east of I-15 is developed.

The total area of the Flamingo/Tropicana Watershed is approximately 220 square miles. Drainage facilities within the watershed consist primarily of detention basins connected by conveyance facilities. The USACE, in partnership with the RFCD and Clark County Public Works Department (CCPW), analyzed, designed, and constructed main line facilities to detain and convey flow from the westernmost 174 square miles of the Flamingo/Tropicana Watershed. This portion of the watershed upstream of and including Tropicana Detention Basin is referred to as the USACE Watershed (see **Section 8.4**) and a boundary line (USACE Boundary) is shown in the W-Maps in **Appendix B**.

8.2. Drainage Characteristics

Drainage patterns in the Flamingo/Tropicana Watershed are generally from west to east. The Red Rock, Flamingo, Tropicana, and Blue Diamond washes begin in the mountainous region west of the Valley. The mountain ravines open to broad, steep alluvial aprons from which storm flows are intercepted by regional detention basins and open channels. These flood control facilities consolidate runoff and convey it along two wash alignments, Flamingo Wash and Tropicana Wash.

Slopes in the eastern portion of the Flamingo/Tropicana Watershed are comparatively mild. Storm flows in this area are collected by streets and storm drain systems and discharge into the major washes – Flamingo Wash and Tropicana Wash. Downstream of the confluence of these two washes, Flamingo Wash continues east where it discharges into Lower Las Vegas Wash between Sahara Avenue and Vegas Valley Drive.

8.3. Master Plan Progress

Progress on the implementation of the Master Plan since the 2018 MPU includes the construction of several flood control facilities. Construction of approximately 3 miles of conveyance facilities and 1 detention basin have been completed since the 2018 MPU. Major flood control facilities constructed or adopted into the plan since the 2018 MPU include the following:

- Naples Outfall Storm Drain project constructed Tropicana Wash - Swenson conveyance facilities along University Center Drive (TRSW 0000, 0003 and 0074)
- Tropicana and University Center Drainage Improvements Phase 1 and Phase 2 projects constructed Van Buskirk – Tompkins storm drain in Tropicana Avenue between Brussels Street and University Center that goes through Bock Street and connects to Paradise Detention Basin through Swenson (VBTM 0164 – 0216) and also constructed Paradise Detention Basin (VBTM 0217).
- Flamingo Wash Maryland Parkway to Palos Verdes Street Improvement project modified Tropicana Wash facility (TRWA 0013) near Flamingo Road and University Center Drive with a lid on the existing channel and constructed Flamingo Wash facilities (FLWA 0621 – 0642 and FLWA 0673 – 0694).
- Karen Avenue Maryland Parkway to Flamingo Wash Improvement project constructed Vegas Valley Drive conveyance facilities (VAVD 0000 and 0017).
- Wagon Trail Channel – Sunset Road to Teco Avenue improvement plans constructed Wagon Trail Channel facilities (WGTR 0111 – 0130) along Procyon Street from Sunset Road to Teco Avenue.
- Wagon Trail Channel facilities (WGTR 0247 & 0273) were adopted to the MPU so they are now considered regional facilities and are eligible for maintenance funding.

In total, the following facilities have been constructed to date in the Flamingo/Tropicana Watershed[8].

8.4. Hydrologic Analysis

The hydrologic analysis and models completed with the 2018 MPU served as the basis for the 2023 MPU hydrologic analysis and modeling effort. The 2023 MPU subbasin delineations for a large portion of the Flamingo/Tropicana Watershed remain unchanged, however, major modifications were made to subbasins in the following areas:

- Wagon Trail Channel (Sunset Road to Teco Avenue) area to represent the drainage pattern from the detailed design.
- MPA Harry Reid Airport Peaking Basin Outfall and Buskirk System to represent the drainage pattern from the detailed design.
- Flamingo Wash - Cimarron Branch (Russell Road to Patrick Lane) to represent the drainage pattern from the detailed design.
- Maryland Parkway – Rochelle Avenue to Flamingo Road to represent the drainage pattern from the detailed design.
- Outlying Areas Master Plan Update (OA MPU) to update Flamingo Tropicana Watershed boundary and the bordering subbasins in it to remove minor overlaps with Blue Diamond Watershed in OA MPU.
- Summerlin West Conceptual Plan area to represent designed drainage patterns.

The 2018 MPU hydrologic parameters used in the models were reviewed and updated to incorporate changes in criteria and methodology described in **Section 2.3**, which primarily included changes in soils data, percent impervious, right-of-way, and land use density. In addition, the hydrologic parameters were revised to incorporate all new data collected and/or

[8] Total length for facilities does not include floodways, natural washes, or existing facilities that are planned to be replaced.

developed for the 2023 MPU. The major drainage reports and technical drainage studies reviewed and incorporated into the hydrologic analysis are tabulated in **Table 8-1.**

Table 8-1 - Flamingo/Tropicana Watershed Major Hydrologic Studies

#	NAME OF STUDY
1	WAGON TRAIL CHANNEL – SUNSET ROAD TO TECO AVENUE (WESTWOOD, SEPT 2021)
2	MASTER PLAN AMENDMENT FOR HARRY REID AIRPORT PEAKING BASIN AND OUTFALL AND VAN BUSKIRK SYSTEM (ATKINS-JACOBS, FEB 2022)
3	FLAMINGO WASH, CIMARRON BRANCH – RUSSELL ROAD TO PATRICK LANE FINAL DRAINAGE REPORT (ATKINS, JULY 2023)
4	DRAFT FINAL DRAINAGE REPORT MARYLAND PARKWAY RUSSELL ROAD TO SAHARA AVENUE (WSP, MAR 2023)

The USACE watershed boundary developed in the 2008 MPU basically remains unchanged except for some minor modifications due to the subbasin delineation improvements. These changes were made to represent current drainage patterns. Within the USACE watershed boundary, the SCS Unit Hydrograph method is used for MPU hydrologic modeling, similar to the 2008 MPU. However, design flow rates published in the Facility Inventory Tables (of Volume 2) for main line and lateral facilities identified in the USACE's Tropicana and Flamingo Washes Project were determined by the USACE and are not supported by the hydrologic models developed for the 2023 MPU. USACE facilities were analyzed based on USACE-developed flowrates and not based on MPU flowrates. This was accomplished in the MPU models through the use of diversion cards.

USACE facility follow USACE prescribed analysis methods, which differs from methodology used in this MPU. USACE flow rates cannot exceed those developed by the USACE and published in the MPU document. Furthermore, USACE approval is required before a facility may drain into one of the Tropicana and Flamingo Wash Project facilities within the USACE Watershed, regardless of whether that facility is shown as a proposed facility in the MPU (e.g., FLCM 0003). Based on the different hydrologic methodologies, local or regional modeling performed for areas within the USACE Watershed boundary shall not refer to MPU model results.

To model the Flamingo/Tropicana Watershed downstream of Tropicana Detention Basin (downstream limit of the USACE watershed), all flow was diverted out of the model upstream of the basin. The USACE inflow hydrograph was then routed through Tropicana Detention Basin to mimic the USACE's design performance. The 2023 MPU hydrologic criteria and methodology were applied to the remainder of the watershed downstream of Tropicana Detention Basin.

The Flamingo/Tropicana Watershed boundary was revised at 3 different locations:

- The boundary between Flamingo/Tropicana Watershed and Duck Creek/ Blue Diamond Watershed was updated. Subbasins near the I-215/I-15 connectors and Harry Reid Airport runway were revised as part of the Duck Creek/ Blue Diamond Watershed and Flamingo/Tropicana Watershed.

- The western boundary of the Flamingo/Tropicana Watershed has been slightly modified along the Spring Mountains to match the Outlying Areas MPU for the Blue Diamond area.
- The boundary between the Flamingo/Tropicana Watershed and Central Watershed has been updated. Subbasins along Sahara Avenue, from Rainbow Boulevard to Durango Drive have boundary revisions.

Series A and Series B storm centerings were used for the majority of facilities in the Flamingo/Tropicana Watershed (see **Section 2.3.11**). One Series C storm centering was used to model an SDN4 storm pattern over the confluence of the Tropicana and Flamingo Washes. The following hydrologic models were developed for analysis of the Flamingo/Tropicana Watershed:

- FLAM_A (Series A): Series A models were developed to represent storm centerings over the entire Flamingo/Tropicana Watershed. These Series A models are named FLAM3A, FLAM4A, and FLAM5A. The number used in the model names represents SDN 3, 4, and 5, respectively.
- FLAM_B (Series B): Series B models were developed to represent storm centerings for the portion of Flamingo/Tropicana Watershed downstream of Red Rock, R4, Upper Flamingo, Upper Blue Diamond, Tropicana, Tropicana North, Tropicana-McCarran, Lakes, Desert Inn, and Lower Flamingo Detention Basins, F3 Detention Basin, Wagon Trail Detention Basin, KB Detention Basin, Harry Reid Airport Peaking Basin, Paradise Detention Basin, and F1, F2, and F4 Debris Basins. Discharge from these detention/debris basins was diverted out of the model to prevent it from combining with areas downstream of the detention/debris basins. These Series B models are named FLAM3B, FLAM4B, and FLAM5B. The number used in the model names represents SDN 3, 4, and 5, respectively.
- FLAM4C1 (Series C): This Series C model was developed to represent an SDN4 storm centering for the Flamingo/Tropicana Wash Confluence. This Series C model is similar to the FLAM4B models except that the discharge associated with subbasins TW1, FW1, and FW2 were diverted out of the model to produce a smaller storm centering. These models were used to compute the discharge in the Flamingo Wash downstream of the confluence to Algonquin Drive.

8.5. Flood Control Facility Plan

The final flood control facility plan is generally the same as for the 2018 MPU. A list of studies collected along with maps are provided in **Appendix F** for referring to studies mentioned in this section. Problem areas and major revisions to the plan since the 2018 MPU are described below.

Flamingo – Cimarron Branch

The proposed concrete channel and concrete box facilities (FLCM 0003 – 0052) have been planned to convey flow from Patrick Lane to an existing facility (FLCM 0000).

Brownstone Diversion Berm in Summerlin

A proposed lined WOTUS Berm (APM8 0000) has been designed in the Summerlin area to replace the current gabion baskets and assist in redirecting flow in the area to the Red Rock Detention Basin.

Tropicana Wash – North Branch

At the request of Clark County, and after a review of the current capacity of existing facilities in the flood zone north of the intersection of Hacienda Avenue and Decatur Boulevard, existing facilities (TRNB 0198 – 2819) were adopted to the MPU so they are now considered regional facilities and are eligible for maintenance funding. Existing facilities (TRNB 0412 – 1391) with inadequate capacity will be replaced with proposed facilities (TRNB 0413 – 1392) to better convey the flow towards the Tropicana North Branch Detention Basin.

MPA - Monson Channel - Jimmy Durante to Boulder Highway

To increase capacity, this MPA proposes to replace Las Vegas Monson Branch facilities east of Boulder Highway (LV02 0126 – 0293), which do not meet the required capacity or accommodate current MPU design flows, with the proposed facilities that do meet capacity (LV020127 – 0293).

Maryland Parkway Russell Road to Sahara Avenue

A proposed facility FLMR 0000 is removed from regional facility plan because the flow estimated is lower than the threshold of 500 cfs set for regional facilities.

Van Buskirk – Twain

The Van Buskirk – Twain facilities (VBTW 0000 & 0001) were shortened to US-95 and Boulder Highway. The portion of the facilities that were removed did not carry significant flow to be included in the regional plan.

Tropicana Wash – MPA Harry Reid Airport

Major Modifications were made based on the Airport Channel and Peaking Basin - Naples Draft Final Design Report (Atkins, April 2022), including:

The proposed 170 ac-ft Tropicana Wash - McCarran Airport Peaking Basin in the 2018 MPU is replaced with the 223.5 ac-ft Tropicana Wash - Harry Reid Airport Peaking Basin (TRMC 0033).

Facility TRMC 0030 will be removed and replaced with new proposed storm drain facilities (TRMC 0013 and 0031). A proposed facility (TRMC 0014) will return the flow from the peaking basin back to Naples Channel just upstream of Harmon Avenue. Additionally, a proposed Tropicana Wash - Swenson facility (TRSW 0080) will convey outflow from the Peaking Basin to the constructed Tropicana Wash - Swenson facilities (TRSW 0000 – 0074).

In addition to the above information, **Table 8-2** summarizes the analysis of all the existing and proposed detention basins within the Flamingo/Tropicana Watershed.

Table 8-2 - Flamingo/Tropicana Watershed Detention Basin Summary Table

Name of Detention Basin	ID MILE	Status*	100-Year Peak Inflow (cfs)	Existing Storage @ Spillway (ac-ft)	Expansion Required (ac-ft)	Total Storage Volume @ Spillway (ac-ft)	Spillway Elevation (ft)	100-Year Clear Water Peak Elevation (ft)	Freeboard (ft)	Time to Peak (hrs)
KB	F401 0003	EX	248	9.5	--	9.5	2764.50	2761.18	3.32	4.00
F3	FLF3 0185	EX	833	53	--	53	2745.40	2740.22	5.18	5.08
Desert Inn	FLLA 0308/ 0309	EXP	785	62	8	70	2373.00	2372.21	0.79	6.00
Lakes	FLSM 0087/ 0088	EXP	1996	143	37	180	2596.00	2595.60	0.4	6.17
Lower Flamingo	FLWA 1050	EX	3221	222	--	222	2254.00	2252.69	1.31	5.83
Flamingo	FLWA 1443	EX/ USACE	11800	1340	--	1340**	2470.50	2470.50	0.00	--
R4	RRR4 0160	EX/ USACE	3400	362	--	362**	3074.77	3074.77	0.00	--
Red Rock	RRWA 0716	EX/ USACE	12800	2007	--	2007**	3212.50	3212.50	0.00	--
Upper Blue Diamond	TRBD 0930	EX/ USACE	13800	2270	--	2270**	2965.00	2965.00	0.00	--
Harry Reid Airport Peaking Basin	TRMC 0033	PROP	1733	223.5	--	223.5	2069.5	2064.71	4.79	5.67
Tropicana North Branch	TRNB 0094	EX	1158	64	--	64	2222.90	2215.59	7.31	4.33
Tropicana	TRWA 0454	EX/ USACE	6700	825	--	825**	2290.00	2290.00	0.00	--
Wagon Trail	WGTR 0224	PROP	334	59	--	59	2327.00	2322.91	4.09	5.58
Paradise Detention Basin	VBTM 0217	EX	632	52	--	52	2057.5	2056.97	0.53	6.00

*EX = Existing Detention Basin, EXP = Existing Detention Basin with Proposed Expansion, PROP = Proposed Detention Basin, EX/USACE = Existing USACE Detention Basin

** Total Storage Volume accounts for Sediment Load

8.6. Facility Cost Estimates

Cost estimates for all facilities have been derived using the Cost Estimation Tool described in **Section 2.6**. Construction cost estimates for proposed facilities have been divided into Category A and Category B. The total estimated current value of existing facilities and total estimated construction cost of proposed Category A and B facilities in the Flamingo/Tropicana Watershed are as follows:

A detailed breakdown of current estimated values of existing facilities and construction cost estimates for proposed Category A and B facilities is included in **Appendix E**.

CHAPTER 9

Duck Creek/Blue Diamond Watershed

9.1. Introduction

This chapter presents information developed for the 2023 MPU for the Duck Creek/Blue Diamond Watershed, which is located in the southwest portion of the Las Vegas Valley. This watershed lies within portions of unincorporated Clark County and the City of Henderson. Clark County maintains jurisdiction of Duck Creek/Blue Diamond Watershed and is responsible for programming flood control funds. The watershed extends from the Bird Spring Range on the west side of the Las Vegas Valley to where Duck Creek Wash crosses under Boulder Highway. This watershed discharges into the Lower Duck Creek Wash which is a major tributary to the Las Vegas Wash.

The Duck Creek/Blue Diamond Watershed has experienced rapid growth. Growth is expected to continue in the Blue Diamond West development areas. These areas are located west of I-15 and south of Blue Diamond Road. Development is also continuing west of I-15 and north of Blue Diamond Road, and the remaining undeveloped areas east of I-15.

Duck Creek/Blue Diamond Watershed is bordered by Flamingo/Tropicana Watershed to the north, Pittman Watershed to the southeast, and drains to Lower Las Vegas Watershed to the east.

Pittman Watershed drains to Duck Creek/Blue Diamond Watershed at Bermuda Road/St. Rose Parkway. Outfall from Pittman North Detention Basin is diverted north to Duck Creek/Blue Diamond watershed via proposed regional facility along Bermuda Road. This outfall will eventually drain to Lower Duck Creek Detention Basin. Although the outfalls of Pittman North

Detention Basin drain to Duck Creek/Blue Diamond watershed, the tributary area of this detention basin lies within Pittman Watershed and belong to the City of Henderson jurisdiction.

The total area of the Duck Creek/Blue Diamond Watershed is approximately 165 square miles. Drainage facilities within the watershed consist primarily of detention basins connected by conveyance facilities.

9.2. Drainage Characteristics

Drainage patterns in the Duck Creek/Blue Diamond Watershed are generally from southwest to northeast. The watershed is characterized by steep mountain washes on the southwest perimeter of the Valley that discharge onto broad alluvial fans. Many small braided washes traverse the alluvial fans, but few washes are incised enough to be perpetuated in the ultimate condition as natural, unlined washes or floodways. The steep fan slopes have generated significant channel erosion in local areas, but the majority of runoff occurs in the form of sheet flow.

East of I-15, the watershed is more developed and the slopes in these areas are comparatively mild. Storm runoff in these areas is collected by streets and storm drain systems and discharged to the major washes.

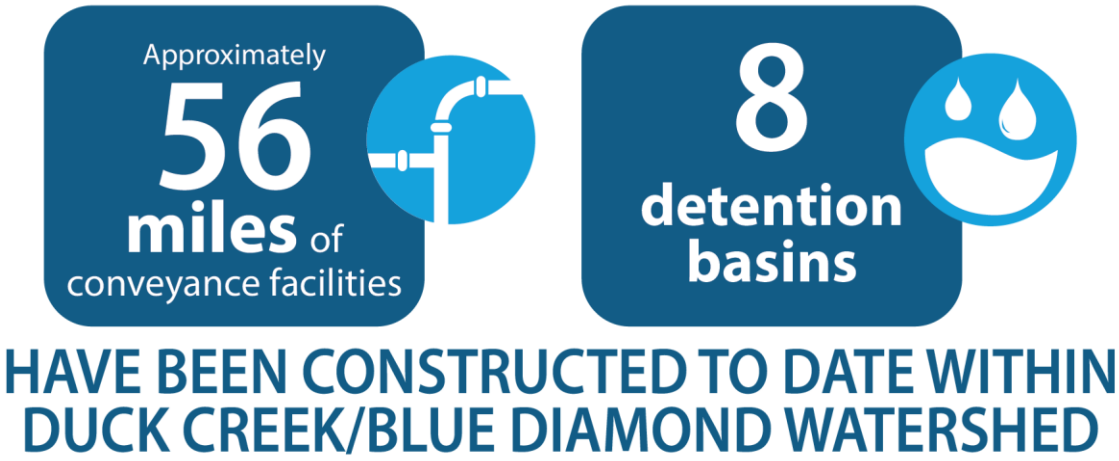
9.3. Master Plan Progress

Significant progress has been made on the implementation of the Master Plan since the 2018 MPU through the construction of flood control facilities. Construction of approximately 9 miles of conveyance facilities and 1 detention basin have been completed since the 2018 MPU. Major flood control facilities constructed or adopted into the plan since the 2018 MPU include the following:

- The Silverado Ranch Detention Basin & Outfall Facilities project constructed Silverado Ranch Inlet, Outfall, and Detention Basin facilities from Silverado Ranch Detention Basin to West of I-15 (BD02 0125 – 0310, BD02 0350 – 0404, and DCW4 0001).
- The Blue Diamon Wash from Arville Street to I-15 project constructed portions of Blue Diamond Wash facilities along Robindale Road between Arville St and I-15 (BDWA 0267 – 0367).
- The Duck Creek Haven Street Storm Drain project constructed a section of Duck Creek Haven Street along Haven Street between Cactus Avenue and Silverado Ranch Park (DCHV 0026 – 0057).
- The Jones Boulevard Phase II from Erie Avenue to Pyle Avenue project constructed Duck Creek Jones Boulevard, and Duck Creek Frias facilities (DCJB 0000 – 0043 & DCFR 0000) along Jones Boulevard between Pyle Avenue and Erie Avenue.

- The Cactus and El Capitan – Phase I project constructed Duck Creek Wash – Tributary 4 facility (DCW4 0713) along Great Creek Trail between El Capitan Way and Cactus Avenue.
- Duck Creek Wash – Tributary 6 facilities (DCW6 0000 – 0035) consisting of existing 72" RCPs along Fort Apache Road, Mountains Edge Parkway, and El Capitan Way were adopted to the MPU so they are now considered regional facilities and are eligible for maintenance funding.
- Duck Creek Gomer and Duck Creek Le Baron facilities (DCGO 0071 & 0082 and DCLB 0004 – 0022 & 0172) east of Buffalo Drive and north of Mountains Edge Parkway were adopted to the MPU so they are now considered regional facilities and are eligible for maintenance funding.
- Duck Creek Bermuda Pebble facilities (DCBP 0000 & 0006) along Pebble Road draining to Duck Creek Wash (DCWA) were adopted to the MPU so they are now considered regional facilities and are eligible for maintenance funding.
- The Duck Creek Cutoff East Interceptor Channel project constructed Duck Creek Railroad facility (DCRR0000) along Union Pacific Railroad and Joshua Peak Avenue.

In total, the following facilities have been constructed to date in the Duck Creek/Blue Diamond Watershed[9].



9.4. Hydrologic Analysis

The hydrologic analysis and models completed with the 2018 MPU served as the basis for the 2023 MPU hydrologic analysis and modeling effort. The 2018 MPU subbasin delineations for a large portion of the Duck Creek/Blue Diamond watershed remain unchanged with the following exceptions:

[9] Total length for facilities does not include floodways, natural washes, or existing facilities that are planned to be replaced.

- I-15 / I-215 Watershed Boundary changes along with Flamingo/Tropicana due to Harry Reid Airport Peaking Basin and Outfall MPA project.
- Subbasins along Chartan Avenue between Las Vegas Boulevard and Placid St based on Duck Creek Haven Street Storm Drain Final Design Report.
- Flow Split added at Fort Apache and Mountains Edge per drainage issues and discussions with Clark County.
- Subbasin around Sunset Park based on preliminary design of Sunset Park – Duck Creek Facilities.
- Russel/Stephanie area per Nixon-EGLI Equipment Campus for the Duck Creek Blue Diamond Watershed dated December 2021 and review of contours and drainage patterns.
- North of Pebble Road between Las Vegas Boulevard and Duck Creek Wash based on drainage issues and discussions with Clark County.
- Subbasin north of Blue Diamond Road between Buffalo Drive and Rainbow Boulevard per Copper Ranch Drainage Study.
- Subbasins north of Blue Diamond Road between I-15 and UPRR per Blue Diamond Wash – Arville Street to I-15 Final Design Report.
- Subbasin west of Decatur Boulevard between Silverado Ranch Boulevard and Meranto Avenue based on input from CC and the RFCD.

The 2018 MPU hydrologic parameters used in the models were reviewed and updated to incorporate changes in criteria and methodology described in **Section 2.3**, which primarily include changes in soils data, percent impervious and distribution of open space as well as changes in land use density. In addition, hydrologic parameters were revised to incorporate all new data collected and/or developed for the 2023 MPU. The major drainage reports and technical drainage studies reviewed and incorporated into the hydrologic analysis are tabulated in **Table 9-1**.

Table 9-1 - Duck Creek/Blue Diamond Watershed Major Hydrologic Studies

#	NAME OF STUDY
1	SILVERADO RACH DETENTION BASIN AND OUTFALL FACILITIES (WESTWOOD, FEB 2021)
2	BLUE DIAMOND WASH FINAL DESIGN REPORT (WESTWOOD, DEC 2021)
3	DUCK CREEK HAVEN STREET (ATKINS, JUNE 2020)
4	JONES BOULEVARD PHASE II (WSP, 2020)
5	CACTUS AND EL CAPITAN (TANEY ENGINEERING, JULY 2020)
6	DUCK CREEK CUTOFF – EAST INTERCEPTOR CHANNEL (WESTWOOD, FEB 2020)

Series A and Series B storm centerings were used for the majority of facilities in the Duck Creek/Blue Diamond watershed (see **Section 2.3.11**). Two Series C storm centerings were also developed to analyze special circumstances at the Blue Diamond Road confluence with Duck

Creek Wash and a larger storm over both Duck Creek Railroad and Silverado Ranch Detention Basins.

2023 MPU HEC-1 models were updated to incorporate 100% Design HEC-1 models of Silverado Ranch Detention Basin. Based on these designs, Silverado Ranch Detention peaks at 16.33 hours.

It should be noted that areas tributary to Pittman North Detention Basin is modeled in Duck Creek/Blue Diamond Watershed HEC-1 models. Facilities in this area are sized using flows from Duck Creek/Blue Diamond Watershed HEC-1 models. However, this area belongs to Pittman Watershed and are explained in Pittman Watershed (**Section 10**) of this report.

The following hydrologic models were developed for the analysis of Duck Creek/Blue Diamond Watershed:

- DUCK_A (Series A): Series A models were developed to represent storm centerings over the entire Duck Creek/Blue Diamond Watershed. These Series A models are named DUCK3A, DUCK4A, and DUCK5A. The number used in the model names represents SDN 3, 4, and 5, respectively.
- DUCK_B (Series B): These Series B models were developed to represent storm centering for the portion of the Duck Creek/Blue Diamond Watershed downstream of Birdspring, Upper Duck Creek, Duck Creek Railroad, Silverado Ranch, Central Duck Creek, Bruner, Duck Creek Larson, Southeast Pittman, Southwest Pittman, Pittman North, Lower Duck Creek, Lower Blue Diamond, and McCarran – East Branch 2 detention basins. Discharge from the detention basins was diverted out of the models to prevent it from combining with areas downstream of the detention basins. These Series B models are named DUCK3B, DUCK4B, and DUCK5B. The number used in the model names represents SDN 3, 4, and 5, respectively.
- DUCK4C (Series C): This Series C model uses a SDN4 storm centering for the Duck Creek//Blue Diamond Road Confluence. This model is similar to DUCK4B model except that the discharge associated with subbasins DCC080, DCC090, and DCC100 was diverted out of the model to produce a smaller storm centering. This model was used to compute the discharge for the portion of Duck Creek Wash downstream of the confluence.
- DUCK5C1 (Series C): This Series C model uses an SDN5 storm centering over Duck Creek Railroad and Silverado Ranch Detention Basin watersheds. Discharge from Duck Creek Railroad and Silverado Ranch Detention Basins was not diverted out of the model.
- DUCK5A_2(norain) (Series A): This model was developed to capture the peak stage and volume in Silverado Ranch Detention Basin. This model is a continuation of DUCK5A. The initial volume at detention basins is equal to the final volume at 41st hour from DUCK5A model. It assumes there is no more precipitation. This model stops downstream of Silverado Ranch Detention Basin.

9.5. Flood Control Facility Plan

The final flood control facility plan is generally the same as the 2018 MPU. A list of studies collected along with maps are provided in **Appendix F** for referring to studies mentioned in this section. Problem areas and major revisions to the plan since the 2018 MPU are described below.

Duck Creek – Tributary 4

The 2018 MPU Duck Creek Wash – Tributary 4 alignment along Cactus Avenue from Fort Apache Road to Buffalo Drive was shifted from Cactus Avenue to the natural wash south of the road. The 2023 MPU ID mile is DCW4 0606.

Duck Creek Durango Drive

The downstream connection point of Duck Creek Durango Drive (DCDU 0000) was shifted south with the changes in alignment for Duck Creek Tributary 4 which this system is tributary to. The system was also extended west to Quaterhorse Drive along the future Levi Avenue alignment (DCDU 0075).

Duck Creek - Gomer and Le Baron

New facilities are proposed west of Duck Creek Railroad Detention Basin (DCW4 0393) to Buffalo Drive. The existing culvert at Buffalo and Gomer is the upstream facility for the Duck Creek Gomer alignment (DCGO 0061 – 0082). This connects to the Duck Creek Le Baron alignment (DCLB 0004 – 0172) which conveys flow to Duck Creek Railroad Detention Basin. The added facilities are a mix of existing and proposed infrastructure to provide future protection to this undeveloped area.

Blue Diamond Railroad

The alignment and facility sizes have been updated for Blue Dimond Railroad system (BDW5 0026 – 0106) per Blue Diamond Wash Railroad Channel Plans.

Duck Creek – Frias

Proposed facilities (DCFR 0010 – 0044) were added along Frias Avenue and Mann St per Jones Boulevard Phase II Final Design Report.

Blue Diamond Channel 2

The sizes of Blue Diamond Channel 2 (BD02 0315 – 0334) were updated based on the MPC, the alignment was also extended along Decatur Boulevard to Serene Avenue (BD02 0449) to cut of flow going east and direct it south.

Blue Diamond Channel 3

The Blue Diamond Channel 3 alignment was extended Decatur Boulevard along Agate Avenue (BD03 0093) based on evaluation of the area for possible flooding to be resolved.

Duck Creek Wash – Tributary 5

The Duck Creek Wash – Tributary 5 lateral (DCW5 0077) at Pyle Avenue and I-15 was removed from the MPU due to changes in the drainage area.

Sloan Area 1

The natural wash east of Arville Street was replaced with a proposed RCB (SLO1 0040) to provide protection for future development in the area.

Duck Creek- Gilespie Channel

The proposed facility alignment for Duck Creek Gillespie Channel (DCGL 0200) was revised to run along La Cienega St instead of Placid St per Duck Creek – Gillespie System Mater Plan Amendment.

Duck Creek – Ford

A proposed RCB was added along Ford Avenue near the Silverton Casino. The facility along Ford Boulevard (DCFA 0000) will be connected to proposed facility (DC12 0000).

Duck Creek – Blue Diamond

The Duck Creek – Blue Diamond (DCBD 0075 – 0168) alignment was shifted from the natural wash between Windmill land and Shelbourne Avenue to Windmill Lane per Duck Creek – Blue Diamond Wash Bermuda Road to Las Vegas Boulevard Report dated April 2022. The existing culvert facilities (DCBD 0081 & 0176) along the old alignment were also removed from the MPU.

Blue Diamond Wash Pebble

The facilities at the upstream end of the Blue Diamond Wash Pebble system (BDW4 0160 – 0174) at Pebble Road and Rainbow Boulevard were removed due to change in the drainage area.

Duck Creek – Sunset Park

The Duck Creek -Sunset Park (DCSP 0000 – 0115) alignment was shifted from Sunset Road to along Maule Avenue. A small portion of the old alignment on Sunset Road and Duck Creek Wash remains in the MPU and was renamed to Duck Creek – Sunset Road (DCSR 0000)..

In addition to the above information, **Table 9-2** summarizes the analysis of all the existing and proposed detention basins within the Duck Creek/Blue Dimond Watershed.

Table 9-2 - Duck Creek/Blue Diamond Watershed Detention Basin Summary Table

Name of Detention Basin	ID MILE	Status*	100-Year Peak Inflow (cfs)	Existing Storage @ Spillway (ac-ft)	Expansion Required (ac-ft)	Total Storage Volume @ Spillway (ac-ft)	Spillway Elevation (ft)	100-Year Clear Water Peak Elevation (ft)	Freeboard (ft)	Time to Peak (hrs)
Silverado Ranch	BD02 0277	PROP	2117	293.8	--	293.8	2358.50	2352.93	2.57	42.41
Lower Blue Diamond	BDWA 0470	EX	3837	472.3	--	472.3	2397	2390.84	6.16	6.25
Birdsprings	DCBS 0323	PROP	11107	1700	--	1700**	3379	3375.5	3.5	7.17
Bruner	DCW1 0251	EX	1490	113	--	113**	2417	2414.25	2.75	5.5
Duck Creek Railroad	DCW4 0393/0394	EXP	7533	867	135	1002**	2528.5	2526.92	1.58	6.58
Upper Duck Creek	DCW4 0942	EX	12471	2644	--	2644**	2988	2984.74	3.26	7.42
Lower Duck Creek	DCWA 1217	EX	6176	1110	--	1110	2204	2196.8	7.2	5.92
Central Duck Creek	DCWA 1658/1659	EXP	6781	1046	334	1380**	2492	2488.34	3.66	15.33
McCarran East Branch 2	MCE2 0056/0057	EXP	1236	100	50	150	8	7.81	0.19	6.67
Duck Creek Larson	DCLA 0019	PROP	10221	10269	--	10269	2,634	2526.92	1.58	6.58

*EX = Existing Detention Basin, EXP = Existing Detention Basin with Proposed Expansion, PROP = Proposed Detention Basin, MOD = Modify Outlet

** Total Storage Volume accounts for Sediment Load

9.6. Facility Cost Estimates

Cost estimates for all facilities have been derived using the Cost Estimation Tool described in **Section 2.6**. Construction cost estimates for proposed facilities have been divided into Category A and Category B. The total estimated current value of existing facilities and total estimated construction cost of proposed Category A and B facilities in the Duck Creek/Blue Diamond Watershed are as follows:

A detailed breakdown of current estimated values of existing facilities and construction cost estimates for proposed Category A and B facilities is included in **Appendix E**.

CHAPTER 10

Pittman Watershed

10.1. Introduction

This chapter presents information developed for the 2023 MPU for Pittman Watershed, which is located in the south portion of the Las Vegas Valley. The watershed is within portions of City of Henderson and unincorporated Clark County; however, the City of Henderson is responsible for programming flood control funds for the Pittman Watershed. The Pittman Watershed is a major tributary to the Pittman and Duck Creek Washes. The overall watershed extends from the McCullough Range on the southwest to where several regional systems cross Boulder Highway to the northeast towards the Las Vegas Wash.

As expected in the 2018 MPU, extensive development occurred in the area southwest of St. Rose Parkway and Raiders Way with commercial development and continued construction of the Inspirada Master Planned community. Continued construction also occurred northeast of Lake Mead Parkway (SR 564) and Boulder Highway with the Cadence Master Planned community. While a majority of the remaining area within the Pittman Watershed is developed, development and redevelopment are still expected in the coming years.

Drainage facilities within the watershed consist primarily of detention basins connected by conveyance facilities. The total drainage area of Pittman Watershed in the 2023 MPU is approximately 122 square miles, which is a reduction of approximately 1 square mile from the 2018 MPU. The decrease is a result of 0.2 square mile draining to Duck Creek/Blue Diamond Watershed by way of existing and proposed conveyance facilities near US-95 and Russell Road along with 0.4 square miles identified by the Black Mountain Ranch development that contributes to the C-1 Watershed and not the Pittman Watershed.

10.2. Drainage Characteristics

Drainage patterns in the Pittman Watershed are generally from southwest to northeast. Numerous small, steep mountain washes begin in the mountainous region along the southern perimeter of the watershed. Development in the Pittman Watershed consists of master planned residential communities, large areas of commercial and industrial development, and single-family residential custom lots. Discharge from majority of the Pittman Watershed is collected by streets and storm drain facilities and ultimately conveyed into Pittman Wash. Pittman Wash discharges to Duck Creek Wash prior to the confluence with Las Vegas Wash. A smaller portion of the Pittman Watershed is a direct tributary to Lower Las Vegas Wash via storm drain facilities.

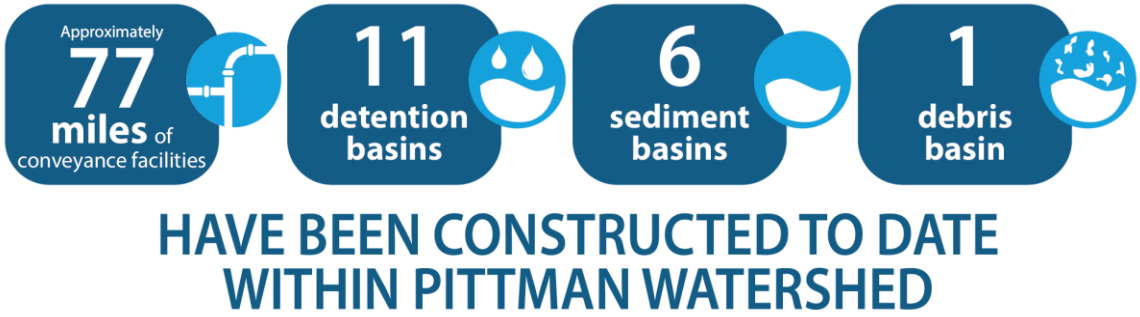
10.3. Master Plan Progress

Significant progress has been made on the implementation of the Master Plan since the 2018 MPU through the construction of flood control facilities. Construction of approximately 8 miles of conveyance facilities and 1 detention basin have been completed since 2018 MPU. Major flood control facilities constructed or adopted into the plan since the 2018 MPU include:

- The Via Nobila – Via Inspirada to Las Vegas Boulvard project constructed Pittman Via Nobila storm drain along Via Nobila, west of Via Inspirada east of Bermuda Road (PTVN 0000), Pittman Gillespie Street storm drain (PTGS 0000), and Pittman Wash – South storm drain (PTDS 0125) crossing Via Noila at Gillespie Street.
- The West Henderson MPU Facility PTSD0071 project constructed Pittman Wash – South storm drain southwest of Bermuda Road and Larson Lane (PTSD 0071)
- The Inspirada Village 6 Infrastructure project constructed Pittman Natural Wash 7 storm drain (PTN7 0000 and 0004), Pittman Democracy Middle storm drain (PTDM 0017), and Pittman Democracy Drive (PTDD 0023 and 0024) crossing Democracy Drive
- The Dundee Jones Park project constructed Pittman Anthem Parkway storm drain between Horizon Ridge Parkway and Siena Heights Drive (PTAP 0018 and 0040)
- The Gibson Road and Kelso Dunes Avenue project constructed Pittman Wash – Gibson storm drain just north of Kelso Dunes Avenue (PTGB 0211).
- The Wiesner Channel at Cadence Village A project constructed Pittman Wash – Burns storm drain from Wiesner Way to the Las Vegas Wash (PTBR 0020 – 0067)
- The Airparc Heights Arch Storm Drain and Z parcel – Unit 5 by Lennar Homes projects constructed Pittman Wash – Eastern storm drain facilities south of Sunridge Heights Parkway (PTEA 0230, 0240, and 0245)
- The Stephine Commerce Center project constructed Pittman Stephanie facilities between Wigwam Parkway and Pittman Railroad East (PTST 0000 and 0006)

- The Whitney Ranch Channel Replacement project constructed Whitney Wash – Duck Creek storm drain facility improvements between Whitney Mesa Park and the Pittman Wash – Duck Creek channel (WWDC 0001 – 0070)
- Pittman Pabco storm drain improvements from Boulder Highway to Galleria Drive (PTPA 0079 – 0286), Pabco South Peaking Basin (PTPA 0163) with a capacity of 57 ac-ft, Pittman Cadence storm drain facility (PTCA 0000) between Cadence Crest Avenue and Grand Cadence Drive, Pittman Galleria storm drain improvements between Cadence Vista Drive and Grand Cadence Drive (PTGA 0002 – 0040) were constructed with various Cadence projects.
- The Las Palmas Entrada Ministorage project constructed Pittman Las Palmas storm drain (PTLP 0020, 0027, 0029, 0032), while PTLP 0000 and 0023 are planned facilities.
- The Poncho Via and Horizon ridge project constructed Pittman Railroad East storm drain through a private parcel located north of Horizon Ridge Parkway and west of Gibson Road. (PTRE 0246 and 0255)
- The West Henderson Hospital Phase 1, Project Berry, South 15 Airport Buildings F, G, and H, and Fed Ex Parking Expansion projects constructed Pittman Amigo storm drain from Bruner Avenue to St Rose Parkway (PTAG 0000 – 0071)
- The Imperial Industrial Center project Pittman Sunset storm drain improvements crossing and along Warm Springs Road, east of Eastgate Road (PTSU 0136 and 0141).

In total, the following facilities have been constructed to date in the Pittman Watershed[10].



10.4. Hydrologic Analysis

The hydrologic analysis and models from the 2018 MPU served as the basis for the 2023 MPU hydrologic analysis and modeling effort. The 2023 MPU subbasin delineation for large portion of this watershed were based on the 2018 MPU subbasin delineation and remain unchanged with the following exceptions:

[10] Total length for facilities does not include floodways, natural washes, or existing facilities that are planned to be replaced.

- Subbasins and facilities within the Henderson West area south of St Rose Parkway and along Raiders Way were revised in accordance with the FedEx Parking Expansion, Valley Health Systems, South 15 Airport Buildings F, G, and H, Project Berry, and Project Hope studies.
- Subbasins and facilities within the West Henderson area west of Bermuda Road and south of Larson Lane were revised per coordination with RFCD and City of Henderson with supporting technical design analyses form the West Henderson Conceptual and CCRFCD MPU Facility PTSD 0071 design report and the Via Nobila - From Via Inspirada to Las Vegas Boulevard project.
- Subbasins and facilities within Inspirada were revised in accordance with the Inspirada Village 6 Infrastructure, Inspirada POD 6-5, Village 7 Infrastructure - Via Venetia and Via Inspirada, and Via Inspirada to Las Vegas Boulevard Access Road studies.
- Subbasins within the Inspirada Master Planned Community south of Via Inspirada were revised in accordance with the Inspirada POD 5-3 Unit 3, Inspirada POD 5-4, and Inspirada Town Center Studies. These studies revised the Pittman-Duck Model Boundary.
- Subbasins and facilities within the Cadence Master Planned Community were revised per the Cadence Village A Infrastructure, Cadence Northwest Master Infrastructure, Cadence Neighborhood 7 Phase 2 Infrastructure, and Cadence North Peaking Basin and Sports Park Outfall studies. In addition, the location and performance parameters of the two peaking basins with the Cadence area were updated to reflect the technical design documents.
- Subbasins tributary to the Whitney Ranch Channel were revised per the Whitney Ranch Channel Replacement study, to better represent the existing development and topography in the area.
- Subbasins near the boundary line between the C-1 and Pittman Watersheds were revised per the Founders Unit 1 and Mass Grading study. It was determined that the existing developments to the west and southwest of the proposed residential project drains differently than outlined in the 2018 MPU which modified the boundary line between the C-1 and Pittman watersheds. Any area changes were reflected in the Pittman and C-1 Watershed Hydrologic Analysis (See **Section 10.4**).
- Substantial subbasin adjustments in the area of the 2018 MPU Southeast Pittman Detection Basin. At the request of City of Henderson, the Southeast Pittman Detection Basin was shifted north in the 2023 MPU; as such, the subbasins in the area were adjusted to accommodate the relocated detention basin and inflow system adjustments.

The 2023 MPU hydrologic parameters used in the models were reviewed and updated to incorporate the changes in criteria and methodology described in **Section 2.3**, which primarily include changes in soils data, percent impervious and land use categories. The hydrologic parameters were revised to incorporate all new data collected and/or developed for the 2023

MPU. The major drainage reports, technical drainage studies, and Master Plan Amendments reviewed and incorporated into the hydrologic analysis are tabulated in **Table 10-1**.

Table 10-1 - Pittman Watershed Major Hydrologic Studies

#	NAME OF STUDY
1	WHITNEY RANCH CHANNEL REPLACEMENT (JACOBS, 2021)
2	TECHNICAL DRAINAGE STUDY FOR FOUNDERS UNIT 1 AND MASS GRADING (ADVANTAGE CIVIL DESIGN GROUP, 2021)
3	CADENCE VILLAGE A INFRASTRUCTURE STUDY & UPDATES (ATKINS, 2022)
4	CADENCE NORTHWEST MASTER INFRASTRUCTURE STUDY (ATKINS, 2021)
5	PROJECT HOPE (KIMLEY HORN, 2018)
6	CADENCE NEIGHBORHOOD 7 PHASE 2 INFRASTRUCTURE (WESTWOOD, 2021)
7	CADENCE NORTH PEAKING BASIN AND SPORTS PARK OUTFALL (ATKINS, 2022)
8	FEDEX PARKING EXPANSION (KIMLEY HORN, 2021)
9	INSPIRADA POD 5-3 UNIT 3 (SHG, 2018)
10	INSPIRADA POD 5-4 (WESTWOOD, 2021)
11	INSPIRADA TOWN CENTER (SHG, 2018)
12	INSPIRADA POD 6-5 UNIT 2 & UNIT 3 (WESTWOOD, 2021)
13	VILLAGE 7 INFRASTRUCTURE VIA VENETIA AND VIA INSPIRADA (VTN, 2017)
14	VIA INSPIRADA TO LAS VEGAS BOULEVARD ACCESS ROAD (VTN, 2017)
15	INSPIRADA VILLAGE 6 INFRASTRUCTURE (VTN, 2020)
16	BERMUDA WELPMAN MULTI-FAMILY (LOCHSA, 2021)
17	HENDERSON WEST PHASES I & II (KIMLEY HORN, 2021)
18	WEST HENDERSON CONCEPT & RFCD MPU PTSD 0071 (WESTWOOD, 2021)
19	UPDATE TO WEST HENDERSON CONCEPT & RFCD MPU PTSD 0071 (WESTWOOD, 2022)
20	VIA NOBILA (GCW, 2021)

Series A, B, and C storm centerings were used for the Pittman Watershed (**see Section 2.3.11**).

The following hydrologic models were developed for analysis of Pittman Watershed:

- PIT_ (Series A): Series A models were developed to represent storm centering over the entire Pittman Watershed. These Series A models are named PIT3, PIT4, and PIT5. The number used in the model names represents SDN 3, 4, and 5, storm patterns, respectively.
- PIT_B (Series B): Series B models were developed to represent storm centering for the portion of the Pittman Watershed downstream of the Pittman Railroad East Sediment Basin, Cactus, Headworks, Pittman East, Pittman Anthem, McCullough Hills Park, Desert Willows Golf Course, Horizon Ridge, Pioneer, Pabco South, and Pabco North Detention Basins. Discharge from these detention basins and from the Pittman Railroad East Sediment Basin was diverted out of the models to prevent it from combining with areas downstream of the basins. These Series B models are named PIT3B, PIT4B, and PIT5B. The number used in the model names represents SDN 3, 4, and 5, storm patterns, respectively.
- PIT_C (Series C): Series C models were developed to represent storm centering for the portion of the Pittman Watershed downstream of Cactus, Headworks, Pittman East, Pittman

Anthem, McCullough Hills Park, Desert Willows Golf Course, Horizon Ridge, Pioneer, Pabco South, and Pabco North Detention Basins. Discharge from these detention basins was diverted out of the models to prevent it from combining with areas downstream of the basins. Discharge from the Pittman Railroad East Sediment Basin was not diverted out in this model. These Series C models are named PIT3C, PIT4C, and PIT5C. The number used in the model names represents SDN 3, 4, and 5, storm patterns, respectively.

10.5. Flood Control Facility Plan

The final flood control facility plan has been adjusted from the 2018 MPU to reflect the constructed and planned developments. Flowrate reductions and/or increases across the watershed are due to a combination of updated percent impervious, land use categories, and development resulting in lower and/or higher curve numbers. A list of studies collected along with maps are provided in **Appendix F** for referring to studies mentioned in this section. Major revisions to the plan since the 2018 MPU are described below:

Pittman Wash - South

The Pittman Wash – South system alignments were shifted per technical design analyses from the West Henderson Conceptual and CCRFCD MPU Facility PTSD 0071 design report and the Via Nobila - From Via Inspirada to Las Vegas Boulevard project (PTSD 0070 and 0071). Incidental alignment changes were made through coordination with RFCD and the City of Henderson based on available technical data of the area (PTSD 0000, 0017, and 0040).

Pittman Gillespie

The 2018 MPU Pittman Gilespie alignment was shifted from Gilespie Street to Larson Lane to avoid existing utilities in Gilespie Street. The Pittman Gilespie system in the 2018 MPU discharge into the Pittman North Detention Basin directly. With the 2023 MPU, the system only consists of PTGL 0000 and 0001 north of Volunteer Boulevard.

Pittman Larson Lane

With the shift of the planned Gilespie system to Larson Lane and a disconnect from the existing Pittman Gilespie facility, a new alignment name was warranted. The 2023 MPU has a RCB in Larson Lane that contributes to the Pittman Wash – South system (PTLL 0000).

Pittman – Larson Bermuda

Accompanying the changes to the Pittman Wash – South system alignment is the addition of the Pittman – Larson Bermuda system. This new system (PTLB 0000 and 0018) connects the Pittman Natural Wash 8 system to the Pittman Wash – South system.

Pittman South Edge – West

The upstream limit of the Pittman South Edge – West was anticipated to be concrete lined channels in the 2018 MPU. With the support of design documents for the area, the system was modified to be existing and reflective of a natural wash (PTSO 0043, 0070, and 0085).

Pittman Democracy Drive

One segment of the Pittman Democracy Drive was anticipated to be concrete lined in the 2018 MPU. With the support of design documents for the area, the system was modified to be existing and reflective of a natural wash (PTDD 0000).

Pittman Democracy Middle

One segment of the Pittman Democracy Drive was anticipated to be concrete lined in the 2018 MPU. With the support of design documents for the area, the system was modified to be existing and reflective of a natural wash (PTDM 0000)

Pittman Sunset

Facilities PTSU 0000 – 0069 were adjusted per the Pittman Sunset Storm Drain Improvement Phase II project. An extension to the Pittman Sunset RCB facility was added from the intersection of Sunset Road and Merlayne Drive towards Warm Springs Road; the system continues easterly and terminates just west of Boulder Highway. The facility is identified as the Pittman Sunset System (PTSU 0088).

Pittman Las Palmas

A new facility alignment, Pittman Las Palmas, was determined as a necessary addition to the 2023 MPU. The upstream facility limit is located near the intersection of Las Palmas Entrada Avenue and Tyler Ridge Avenue and terminates at the Pittman Pioneer Detention system near the US-95 corridor crossing. The system is a combination of proposed and existing facilities. The system is identified as Pittman Las Palmas (PTLP 0000 – 0032).

Pittman East Detention Basin

Through discussion with the City of Henderson, an opportunity was identified to make an outlet adjustment to the Pittman East Detention Basin for the benefit of the Pittman Wash – Eastern system; specifically, PTEA 0291 would be downsized. The modification opportunity stems from the completion of the Headworks Detention Basin (PTEA 0773) reducing the flow volume into the Pittman East Detention Basin. With the identified existing excess volume, there is now a recommended outlet modification (PTEA 0440) that utilizes the excess detention basin volume and reduces the discharge to the downstream facility.

Pittman Railroad

Associated with the shift in watershed boundary between the Pittman and C-1 watersheds, the flow rate contributing to existing facility PTRR 0135 is not as high as previously anticipated. As such, the 2018 MPU recommendation for a replacement facility via PTRR 0136 is no longer necessary and has been removed from the 2023 MPU.

Pittman Pecos

Through discussion with the City of Henderson, concerns of facility performance and maintenance was identified for the segments of the Pittman Pecos system through the existing Legacy Golf Course. The Stabilization Study for Pittman Wash & Pittman Pecos Wash was

utilized to establish a remove and replace of the existing regional facilities (PTPE 0001 and 0052 replaces 0000 and 0051, respectively).

Pittman Wash - Interstate

The Master Plan Amendment for Pittman Wash Interstate Channel proposed the replacement of PTIS 0068 – 0102 with a continuous concrete lined rectangular channel system to accommodate capacity deficiencies (PTIS 0110 and 0115).

In addition to the above information, **Table 10-2** summarizes the analysis of all the existing and proposed detention basins within the Pittman Watershed.

Table 10-2 - Pittman Watershed Detention Basin Summary Table

Name of Detention Basin	ID MILE	Status*	100-Year Peak Inflow (cfs)	Existing Storage @ Spillway (ac-ft)	Expansion Required (ac-ft)	Total Storage Volume @ Spillway (ac-ft)	Spillway Elevation (ft)	100-Year Clear Water Peak Elevation (ft)	Freeboard (ft)	Time to Peak (hrs)
Headworks Detention Basin	PTEA 0773	EX	5,854	1,004	--	1,004**	2,778	2,775.61	2.39	5.92
Pabco South Peaking Basin	PTPA 0163	EX	1,523	57	--	57**	1,693	1,691.06	1.94	4.33
Pioneer Detention Basin	PTVW 0185	EX	4,170	377	--	377**	1,810	1,803.54	6.46	5.75
Pabco North Peaking Basin	PTPA 0032	PROP	2,295	83.8	--	83.8**	1577	1,574.33	2.67	4.42
Pittman Anthem Detention Basin	PTAN 0280	EX	1,370	175.2	--	175.2**	3,075	3,070.42	4.58	6.00
Pittman East Detention Basin	PTEA 0439	EX	6,441	1,718	--	1,718**	2,502	2,492.18	9.82	8.92
McCullough Detention Basin	PTPW 0309	EX	3,297	355	--	355**	2,532	2,525.67	6.33	6.33
Pittman Park Peaking Basin	PTWA 0050	EX	700	75	--	75	1,831.5	1,829.34	2.16	5.67
Desert Willow Golf Course Detention Basin	PTDW 0085	EX	997	38	--	38**	2,250	2,246.78	3.22	4.00
Horizon Ridge Detention Basin	PTHR 0205	EX	887	69	--	69**	2,269	2,263.57	5.43	5.50
Pittman North Detention Basin	PTNO 0182	EX	6,155	1,533	--	1,533**	2,439	2,423.49	15.51	6.33
Cactus Detention Basin	PTWA 0740	EX	3,335	840	--	840**	2,264	2,247.29	16.71	6.33
Southwest Pittman Detention Basin	PTSD 0234	PROP	2,411	--	--	452**	2,784	2782.59	1.41	7.25
Southeast Pittman Detention Basin	PTBE 0064	PROP	6,079	--	--	550**	2,550	2,548.35	1.65	6.92

*EX = Existing Detention Basin, EXP = Existing Detention Basin with Proposed Expansion, PROP = Proposed Detention Basin

** Total Storage Volume accounts for Sediment Load

10.6. Facility Cost Estimates

Cost estimates for all facilities have been derived using the Cost Estimation Tool described in **Section 2.6**. Construction cost estimates for proposed facilities have been divided into Category A and Category B. The total estimated current value of existing facilities and total estimated construction cost of proposed Category A and B facilities in the Pittman Watershed are as follows:

A detailed breakdown of current estimated values of existing facilities and construction cost estimates for proposed Category A and B facilities is included in **Appendix E**.

CHAPTER 11

C-1 Watershed

11.1. Introduction

This chapter presents information developed for the 2023 MPU for the C-1 Watershed, which is located in the southeast portion of the Las Vegas Valley. The watershed is primarily within the City of Henderson jurisdiction; however, it includes portions of unincorporated Clark County. The City of Henderson is responsible for programming flood control funds for the C-1 Watershed. The C-1 Watershed is the most downstream major tributary to the Las Vegas Wash in the Las Vegas Valley. The west watershed limit meanders along Horizon Ridge Parkway, Greenway Road, Boulder Highway and Lake Mead Drive. The watershed is bound to the north, east and south by the Las Vegas Wash, the River Mountains, and the McCullough Range, respectively.

This watershed has experienced steady growth, mainly in the central portion of the watershed south of Lake Mead Parkway (SR 564) and north of US-95. Continued development is expected to occur in the southern portion of the watershed south of US-95 with the Nevada State College planning and expanded City of Henderson limit via annexation, and in the northeastern portion of the watershed with the Lakemoor Master Planned community located south of Lake Mead Parkway. The mountainous areas in the eastern portion of the watershed are federally owned and are outside the ultimate development boundary. The majority of the west portion, with the exception of the mountainous areas in the southwest corner of the C-1 Watershed has been developed.

The total area of the C-1 Watershed increased to approximately 51 square miles in the 2023 MPU. The approximate 1 square mile increase is attributed to the Lakemoor area and planned regional facilities as well as the area identified by the Black Mountain Ranch development that contributes to the C-1 Watershed and not the Pittman Watershed. Drainage facilities within the watershed consist primarily of detention basins connected by conveyance facilities.

11.2. Drainage Characteristics

Drainage patterns in the C-1 Watershed are generally from south to north and the C-1 Channel is the main conveyance facility for the majority of the watershed. The watershed is characterized by steep, mountainous terrain along the southern and eastern perimeter, and steep, urbanized alluvial fans and alluvial plains at the base of the mountains. Seven regional basins are located within the southern and eastern portions of the watershed intercept runoff from the McCullough Range and River Mountains; two of which are peaking basins and five are traditional detention basins. In addition to conveying outflow from the detention basins, the C-1 Channel intercepts flow directly from several tributaries before ultimately discharging into the Las Vegas Wash.

11.3. Master Plan Progress

A majority of the C-1 watershed facilities were constructed before the 2018 MPU. One major flood control facility (< 1 mi) has been constructed since the 2018 MPU and is described as follows:

- The Cadence C1 Channel project constructed channel improvements parallel to Lake Mead Parkway west of Olsen Street (C1CH 0173)

In total, the following facilities have been constructed to date in the C-1 Watershed[11].

11.4. Hydrologic Analysis

The hydrologic analysis and models completed with the 2018 MPU served as the basis for the 2023 MPU hydrologic analysis and modeling effort. The 2018 MPU subbasin delineations for a large portion of the C1 watershed remain unchanged with the following exceptions:

- The Conceptual Drainage Study for Lakemoor, as well as the Nevada State Campus Master Plan, significantly revised the subbasins within their respective areas, while still

[11] Total length for facilities does not include floodways, natural washes, or existing facilities that are planned to be replaced.

generally maintaining the overall drainage pattern as the 2018 MPU. These subbasin changes were incorporated into the 2023 MPU.

- After reviewing the Technical Drainage Study for the Founders Unit 1 and Mass Grading, it was determined that the existing developments to the west and southwest of the proposed residential project drains differently than outlined in the 2018 MPU which modified the boundary line between the C-1 and Pittman Watersheds. Any area changes were reflected in the Pittman and C-1 Watershed Hydrologic Analysis (See **Section 10.4**).
- The extreme eastern boundary of the C-1 Watershed was verified and adjusted to match the 2022 Boulder City MPU subbasin and watershed boundaries.

The hydrologic analysis and models from the 2018 MPU served as the basis for the 2023 MPU hydrologic analysis and modeling effort. The 2023 MPU hydrologic parameters used in the models were reviewed and updated to incorporate the changes in criteria and methodology described in **Section 2.3**, which primarily include changes in soils data, percent impervious and land use categories. The hydrologic parameters were revised to incorporate all new data collected and/or developed for the 2023 MPU. The major drainage reports, technical drainage studies, and Master Plan Amendments reviewed and incorporated into the hydrologic analysis are tabulated in **Table 11-1**.

Table 11-1 - C-1 Watershed Major Hydrologic Studies

#	NAME OF STUDY
1	CONCEPTUAL DRAINAGE STUDY & UPDATE FOR LAKEMOOR (WESTWOOD, 2022)
2	NEVADA STATE CAMPUS MASTER PLAN UPDATE (TSK ARCHITECTS, 2022)
3	TECHNICAL DRAINAGE STUDY FOR FOUNDERS UNIT 1 AND MASS GRADING (ADVANTAGE CIVIL DESIGN GROUP, 2021)

Series A and Series B storm centerings were used for the C-1 Watershed (see **Section 2.3.11**). No Series C storm centerings were necessary for this watershed. The following hydrologic models were developed for the analysis of C-1 Watershed:

- C1SDN_ (Series A): Series A models were developed to represent storm centering over the entire C-1 Watershed. These Series A models are named C1SDN3, C1SDN4, and C1SDN5. The number used in the model names represents SDN 3, 4, and 5, storm patterns, respectively.
- C1SDN_B (Series B): Series B models were developed to represent storm centering for the portion of the C-1 Watershed downstream of Black Mountain, Mission Hills, Equestrian, SNWA, East C-1, and Northeast C-1 detention basins. Discharge from these detention basins was diverted out of the model to prevent it from combining with areas downstream of the detention basins. These Series B models are named C1SDN3B, C1SDN4B, and C1SDN5B. The number used in the model names represents SDN 3, 4, and 5, storm patterns, respectively.

11.5. Flood Control Facility Plan

The final flood control facility plan for C-1 Watershed is generally the same as the 2018 MPU, with the addition of facilities for the Lakemoor community, Nevada State College, and in Mission Hills area. A list of studies collected along with maps are provided in **Appendix F** for referring to studies mentioned in this section. Major revisions to the plan since the 2018 MPU are described below:

C-1 – Nevada State

The updated Master Plan for the Nevada State College site introduced a new concrete channel on the west side of the development intended to protect the planned development. The facilities are identified as the C-1 Nevada State system (C1NS 0000 and 0053).

C-1 – Paradise Hills

Due to the proposed improvements by the Nevada State College detailed above, a concrete channel on the east side of the site was added to the C-1 Channel to protect the Nevada State College. The added facility is identified as C-1 Paradise Hills (C1PH 0114). As part of the assessment of the area, regional facility CHCH 0882 was renamed to C1PH 0000.

C-1 Channel

It was identified that there was a gap in the regional facilities along the C-1 Channel system contributing to the Black Mountain Detention Basin consisting of a natural wash. The added facility to provide connectivity is identified as C1CH 1130.

C-1 - College

At the request of the City of Henderson in association with the expanded UDB, the C-1 Channel – College alignment has been incorporated. The facilities are identified as the C-1 Channel - College system (C1CO 0000 and 0027).

C-1 Channel – Julie

At the request of the City of Henderson in association with the expanded UDB, the C-1 Channel – Julie alignment has been incorporated. The system conveys just under 500 cfs and is located near the Foxhall Road and Julie Road intersection. The added facility is identified as the C-1 Channel - Julie system (C1JL 0000).

C-1 Channel – Havre

It was identified that there was a gap in the regional facilities along the C-1 Channel – Havre alignment consisting of a natural wash. The added facility to provide connectivity is identified as C1HV 0366.

Lakemoor East

The Lakemoor East channel system (LKES) lies towards the eastern edge of the C-1 Watershed boundary. The upstream portions of the system contribute to the Lakemoor East Detention

Basin, and the downstream portion serves as the detention basin outlet, which ultimately contributes to the Lakemoor Park system.

Lakemoor East Detention Basin

The proposed detention basin is located near the eastern boundary of the C-1 Watershed and is intended to attenuate flows from subbasin C1-92. It is designed to have a peak storage of 65 ac-ft. The Lakemoor East Facility LKES 0045 flows into the basin, and facility LKES 0040 serves as the basin spillway.

Lakemoor Park

The Lakemoor Park system (LKPK) lies near the center of the Lakemoor Master Planned community. It is split by the Lake Park Detention Basin and consists of concrete channels and RCBs. This system is notable as it does not contribute to the Las Vegas Wash upstream of Lake Las Vegas, and it terminates at an energy dissipator near Lake Mead Parkway.

Lakemoor Park Detention Basin

The Lakemoor Park Detention Basin is located on a parcel planned by the Master Development to be a community park, and it is intended to attenuate flows from subbasin C1-88A. It is designed to have a peak storage of 16 ac-ft. Lakemoor Park Facility LKPK 0424 flows into the basin, and facility LKPK 0349 serves as the basin outlet.

Lake Las Vegas – Magic Way

The Lake Las Vegas – Magic Way (LLMW) system was included in the 2018 MPU as a proposed facility, however facility sizing and alignment has been adjusted due to the revised hydrology by the Lakemoor Conceptual Study.

Lake Las Vegas – Lakemoor West

A RCB system near the Lake Mead Parkway corridor is proposed by the Lakemoor study. This facility ultimately discharges to the Lake Las Vegas – Magic Way system. The facilities are identified as the Lake Las Vegas – Lakemoor West (LLMR 0000 – 0053).

In addition to the above information, **Table 11-2** summarizes the analysis of all the existing and proposed detention basins within the C-1 Watershed.

Table 11-2 - C-1 Watershed Detention Basin Summary Table

Name of Detention Basin	ID MILE	Status*	100-Year Peak Inflow (cfs)	Existing Storage @ Spillway (ac-ft)	Expansion Required (ac-ft)	Total Storage Volume @ Spillway (ac-ft)	Spillway Elevation (ft)	100-Year Clear Water Peak Elevation (ft)	Freeboard (ft)	Time to Peak (hrs)
Equestrian Detention Basin	C1EQ 0160	EX	4,616	448.2	--	448.2**	2,068.86	2,066.98	1.88	6.08
Black Mountain Detention Basin	C1CH 1095	EX	2,415	366	--	366**	2,593	2,582.39	10.61	6.33
Mission Hills Detention Basin	C1CH 0854	EX	4,310	480	--	480**	2,350	2,345.51	4.49	6.25
East C-1 Detention Basin	C1DC 0303	EX	2,843	880	--	880**	2,500	2,487.13	12.87	7.33
Northeast C-1 Detention Basin	C1HV 0140	EX	1,998	408.4	--	408.4**	1,986	1,981.62	4.38	6.92
Lakemoor Park Detention Basin	LKPK 0350	PROP	652	16	--	16**	1,851	1,849.51	1.49	3.75
Lakemoor East Detention Basin	LKES 0041	PROP	1049	65	--	65**	1,937	1,934.31	2.69	4.42

*EX = Existing Detention Basin, EXP = Existing Detention Basin with Proposed Expansion, PROP = Proposed Detention Basin

** Total Storage Volume accounts for Sediment Load

11.6. Facility Cost Estimates

Cost estimates for all facilities have been derived using the Cost Estimation Tool described in **Section 2.6**. Construction cost estimates for proposed facilities have been divided into Category A and Category B. The total estimated current value of existing facilities and total estimated construction cost of proposed Category A and B facilities in the C-1 Watershed are as follows:

A detailed breakdown of current estimated values of existing facilities and construction cost estimates for proposed Category A and B facilities is included in **Appendix E**.

CHAPTER 12

Lower Las Vegas Wash Watershed

12.1. Introduction

This chapter presents the information developed for the 2023 MPU for the Lower Las Vegas Wash Watershed, which is located in the southeast portion of the Las Vegas Valley. The watershed is within portions of the City of Henderson and unincorporated Clark County. City of North Las Vegas maintains jurisdiction of Lower Las Vegas Wash Watershed and is responsible for programming flood control funds. The Lower Las Vegas Wash Watershed consists of drainage basins tributary to the Las Vegas Wash downstream of the Flamingo Wash Confluence and upstream of Lake Las Vegas. The watershed is bounded on the west by Nellis Boulevard/Boulder Highway, on the south by the Duck Creek Wash/Las Vegas Wash, on the east by Lake Las Vegas and on the north by the Rainbow Gardens and Sunrise Mountains.

The majority of the watershed west of the Las Vegas Wash is currently developed. The area east and north of the Las Vegas Wash is currently open desert or designated wetlands. The majority of this land is owned by BLM, and the Clark County Wetlands Park is located along the Las Vegas Wash south of the Federally owned land. This area is also known as the Sunrise Management Area which is a partnership between BLM, National Park Services and Clark County to enhance recreational opportunities.

The total area of the Lower Las Vegas Wash Watershed is approximately 25 square miles. However, all the flow from the all the watersheds in the Las Vegas Valley other than Apex, Eldorado Valley and a small portion of C-1 Watershed drains into the reach of the Las Vegas Wash located within this watershed. Drainage facilities analyzed with this watershed consist of the Tropicana Channel downstream of Boulder Highway, the Duck Creek Wash downstream of the Pittman Wash and Duck Creek confluence, and the Las Vegas Wash downstream of the Flamingo Wash confluence. The portion of the Las Vegas Wash located within the Wetlands Park is managed in accordance with the SNWA Comprehensive Adaptive Management Plan

for the Las Vegas Wash. This area contains numerous existing erosion control and bank protection facilities planned and built through SNWA. Current SNWA information on these facilities has been acquired and incorporated into the 2023 MPU. All of these facilities are impacted by flow generated by the ten watersheds.

12.2. Drainage Characteristics

Approximately 1,568 square miles from the ten watersheds drain to the Las Vegas Wash. Major tributaries to the lower portion of the Las Vegas Wash are the upper portion of the Las Vegas Wash, the Flamingo Wash, the Sloan Channel, the Monson Channel, the Tropicana Channel, the Duck Creek Wash, and the C-1 Channel. Several other minor facilities drain to the Wash from the west and south. Numerous natural washes drain to the Lower Las Vegas Wash from the alluvial fan located directly to the north.

12.3. Master Plan Progress

A majority of the Lower Las Vegas Wash watershed facilities were constructed before the 2018 MPU. Construction of one facility (< 1 mile) has been completed since the 2018 MPU and is described as follows:

- The Desert Inn Road Project constructed a bridge at Desert Inn Road over the Lower Las Vegas Wash (LVMD0776).

In total, the following facilities have been constructed to date in the Lower Las Vegas Wash Watershed[12].

[12] Total length for facilities does not include floodways, natural washes, or existing facilities that are planned to be replaced.

12.4. Hydrologic Analysis

The hydrologic analysis and models completed with the 2018 MPU served as the basis for the 2023 MPU hydrologic analysis and modeling effort. The 2018 MPU hydrologic parameters used in the models were reviewed and updated to incorporate the changes in criteria and methodology described in **Section 2.3**, which primarily include changes in percent impervious and distribution of open space as well as changes in land use density.

Due to the comprehensive nature of the tributary area, special hydrologic models were developed for each of the three drainage systems located within the Lower Las Vegas Wash Watershed: 1) the Duck Creek Wash downstream of its confluence with the Pittman Wash, 2) the Tropicana Channel east of Boulder Highway, and 3) the Las Vegas Wash. Numerous detention basins impact storm flows from a majority of the watersheds tributary to the Las Vegas Wash.

The 2018 MPU storm centerings were used to estimate the ultimate developed flow in the Lower Las Vegas Wash for planning purposes. Each storm centering is approximately 200 square miles with an elliptical shape and 2:1 axis ratio. Five locations/orientations of storms (see **Figure 12-1**) were examined and the governing flow from the different storm orientations for each reach was used in the 2023 MPU. These type of storm centerings were necessary considering the flows in this reach of Las Vegas Wash are controlled by major storm events centered over the tributary area within the Las Vegas valley consisting of the ten watersheds. The flow rates from the five storm centerings vary significantly from 10,000 cfs to 23,000 cfs and should be considered only as an approximate range of potential flow rates for the Las Vegas Wash. Due to the large complex tributary area of the Las Vegas Wash and the large differences in peak flow rate from the five storm centerings, it is difficult to determine what flow rate actually constitutes a 100-year frequency flood event. Further hydrologic investigation is warranted for final design.

The following Series C hydrologic models were developed for analysis of the Lower Las Vegas Wash within this watershed:

- LVWSC1 (Series C): This SDN 5 model is a 200 square mile elliptical storm centering over portions of the Upper Northern, Lower Northern, Range, Central, Gowan, Flamingo/Tropicana and the Lower Las Vegas Wash Watersheds oriented from northwest to southeast.
- LVWSC2 (Series C): This SDN 5 model is a 200 square mile elliptical storm centering over portions of the Lower Northern, Range, Central, Gowan, Flamingo/Tropicana, Duck Creek/Blue Diamond and Lower Las Vegas Wash Watersheds oriented from northeast to southwest.
- LVWSC3 (Series C): This SDN 5 model is a 200 square mile elliptical storm centering over the downstream portions of all of the watersheds oriented from northwest to southeast.

- LVWSC5 (Series C): This SDN 5 model is a 200 square mile elliptical storm centering over portions of the Pittman, Duck Creek/Blue Diamond, Flamingo/Tropicana and Lower Las Vegas Wash Watersheds oriented from southwest to northeast.
- LVWSC6 (Series C): This SDN 5 model is a 200 square mile elliptical storm centering over portions of the Lower Northern, Range, Central, Flamingo/Tropicana, Duck Creek/Blue Diamond, Pittman and Lower Las Vegas Wash Watersheds oriented from north to south.
- The following Series C hydrologic models were developed for analysis of the Lower Duck Creek Wash and Tropicana Channel:
- DUCKPITT (Series C): This SDN 5 model was compiled from the Duck Creek Watershed Series B model and Pittman Watershed Series C models and includes a few directly tributary subbasins from Flamingo/Tropicana and Lower Las Vegas Wash Watershed.
- TROPCHNL (Series C): This SDN 3 model was compiled from pertinent portions of Flamingo/Tropicana Watershed model and includes a few directly tributary subbasins from Lower Las Vegas Wash Watershed.

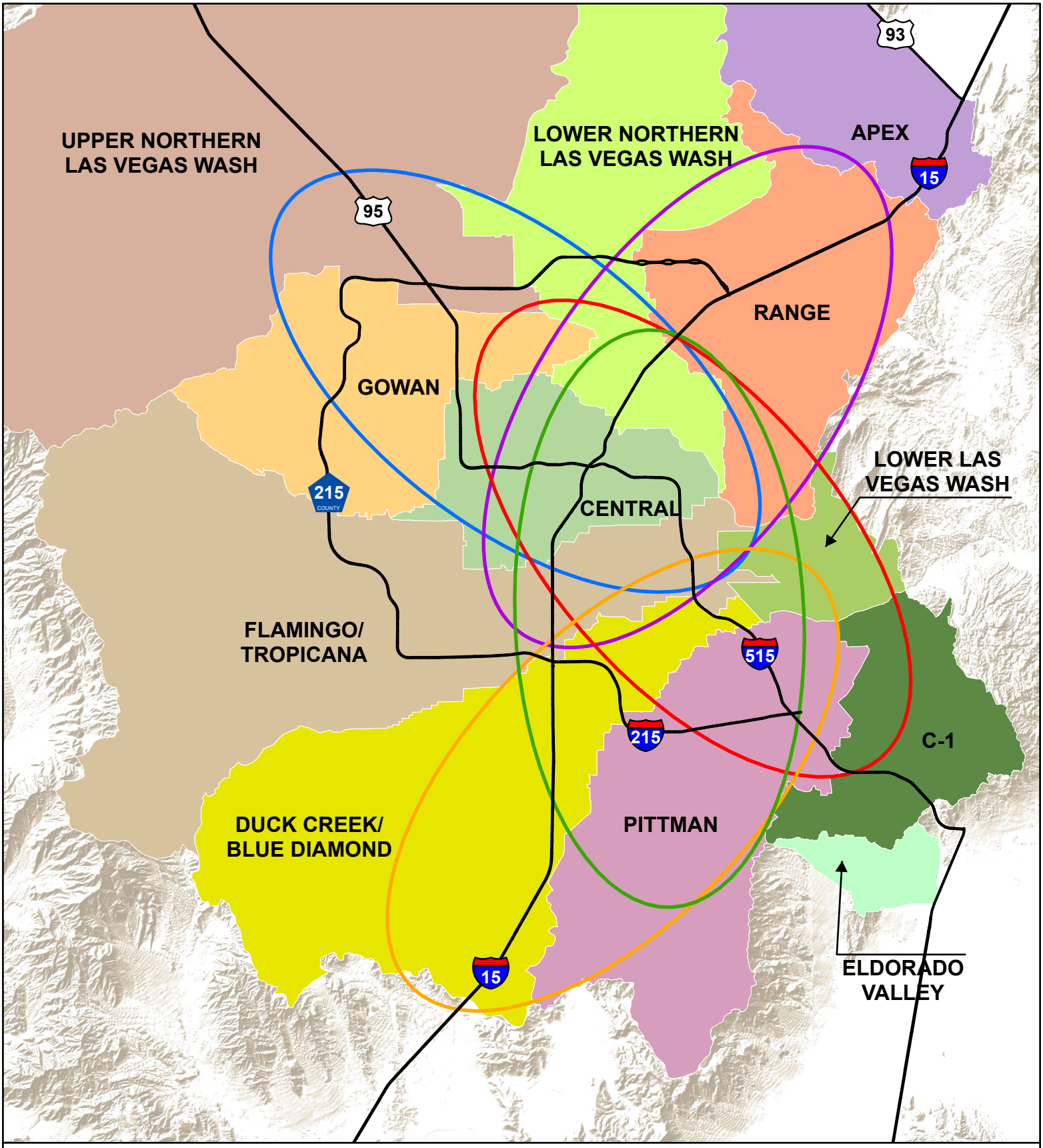
12.5. Flood Control Facility Plan

The final flood control facility plan is the same as the 2018 MPU. A list of studies collected along with maps are provided in **Appendix F** for referring to studies mentioned in this section. No revision to the plan have been made due to the plan being mostly complete in this area.

12.6. Facility Cost Estimates

Cost estimates for all facilities have been derived using the Cost Estimation Tool described in **Section 2.6**. Construction cost estimates for proposed facilities have been divided into Category A and Category B. The total estimated current value of existing facilities and total estimated construction cost of proposed Category A and B facilities in the Lower Las Vegas Wash Watershed are as follows:

A detailed breakdown of current estimated values of existing facilities and construction cost estimates for proposed Category A and B facilities is included in **Appendix E**.



N

0 1.25 2.5 5

Miles

1 in = 5 miles

2023 LAS VEGAS VALLEY FLOOD CONTROL MASTER PLAN UPDATE

FIGURE 12-1
LOWER LAS VEGAS WASH
STORM CENTERING ANALYSIS

HEC-1 MODEL NAME

- LVWSC1
- LVWSC2
- LVWSC3
- LVWSC5
- LVWSC6

REGIONAL FLOOD CONTROL DISTRICT

AtkinsRéalis

Westwood

CHAPTER 13

Eldorado Valley Watershed

13.1. Introduction

This chapter presents information developed for the 2023 MPU for the Eldorado Valley Watershed, which is located outside of the Las Vegas Valley. Unlike other watersheds in the 2023 MPU which drain to the Las Vegas Wash, the Eldorado Valley Watershed drains to the dry lakebed within Eldorado Valley located south of Boulder City. The Eldorado Valley Watershed is created as a result of the City of Henderson annexation of this area and resulting expansion to the UDB. The watershed is impacted at the eastern limit by the North Railroad and West Airport Watershed from the 2022 Boulder City MPU. The watershed is primarily within the City of Henderson jurisdiction; however, it also includes portions of unincorporated Clark County and Boulder City. The City of Henderson is responsible for programming flood control funds for the Eldorado Valley Watershed. The watershed is bounded on the north and west by the McCullough Range, on the east by the I-11 and US-95 corridors, and on the south by Spring Canyon Road.

This watershed is a new addition to the 2023 Las Vegas Valley MPU and is expected to experience significant development in the coming years, most likely beginning with industrial developments in the area adjacent to the US-95 corridor. The mountainous areas in the western portion of the watershed are within the UDB but are currently without planned development or zoning. The majority of the Eldorado Valley Watershed is undeveloped, with only a few existing solar and commercial developments.

The total area of the Eldorado Valley Watershed is approximately 13 square miles, with no current existing drainage facilities in the watershed. The approximate 13 square miles does not include drainage areas from the east that are part of the 2022 Boulder City MPU.

Being a new addition to the Las Vegas Valley MPU, subbasins have been delineated where proposed developments are expected by City of Henderson according to the most currently

available data. Proposed facilities have been added where development and flow concentrations are expected, mainly along the western edge of the planned development and the eastern boundary of the watershed along the I-11/US-95 corridor. These include large RCB storm drain and concrete channels. New 2023 HEC-1 models for the Eldorado Valley Watershed have been created.

13.2. Drainage Characteristics

Drainage patterns in the Eldorado Valley Watershed are characterized by two sub-watershed and discharge patterns; one generally flowing from the northwest to southeast and one from north to south. The watershed is characterized by steep, mountainous terrain along the northern perimeter and central part of the watershed, and steep, urbanized alluvial fans and alluvial plains elsewhere. No existing drainage facilities currently exist in the watershed; all runoff ultimately ends up in the dry lake bed south of Boulder City.

13.3. Master Plan Progress

As this is the first time the Eldorado Valley Watershed is being presented, no progress has been made on the proposed facilities. The facilities are in planning stages within Eldorado Valley Watershed.

13.4. Hydrologic Analysis

The hydrologic analysis and models are new as this is the introduction of the Eldorado Valley Watershed. The hydrologic parameters used in the models reflect the criteria and methodology changes described in **Section 2.3**. The major drainage reports, technical drainage studies, and Master Plan Amendments reviewed and incorporated into the hydrologic analysis are tabulated in **Table 13-1**.

Table 13-1 – Eldorado Valley Watershed Major Hydrologic Studies

#	NAME OF STUDY
1	ELDORADO VALLEY CONCEPTUAL DRAINAGE STUDY (WESTWOOD, 2022)
2	TOWNSITE SOLAR FACILITY (STANTEC, 2020)
3	COPPER MOUNTAIN SOLAR 3 (BURNS & MCDONNEL, 2013)
4	2022 BOULDER CITY FLOOD CONTROL MASTER PLAN (ATKINS, 2022)

The drainage studies were reviewed for overall drainage patterns to support and establish the planned ultimate drainage in the area along with the Boulder City MPU. However, the following should be noted:

- The 2022 Boulder City MPU subbasins were referenced, with adjustments made to drainage patterns per existing topography, I-11 plans identifying storm drain corridors, and coordination with City of Henderson.

- Subbasins were defined based on the existing topography in coordination with the on-going planned development with direction from the City of Henderson.

Series A and Series B storm centerings were used for the Eldorado Valley Watershed (see **Section 2.3.11**). No Series C storm centering were necessary for this watershed. The following hydrologic models were developed for the analysis of Eldorado Valley Watershed:

- ELV3 (Series A): Series A models were developed to represent storm centering over the entire Eldorado Valley Watershed. The Series A model is named ELV3. The number used in the model names represents the SDN 3 storm pattern.
- ELV3B (Series B): Series B models were developed to represent storm centering for the portion of the Eldorado Valley Watershed downstream of the proposed Eldorado Valley Detention Basin. Discharge from this detention basin was diverted out of the model to prevent it from combining with areas downstream of the detention basin. This Series B model is named ELV3B. The number used in the model name represents the SDN 3 storm pattern.

13.5. Flood Control Facility Plan

A list of studies collected along with maps are provided in **Appendix F** for referring to studies mentioned in this section. The flood control facility plan for the Eldorado Valley Watershed is described as follows:

Eldorado Valley Northwest

A concrete channel is proposed to intercept runoff from subbasin ELV4 and route it to the proposed Eldorado Valley Detention Basin. The new facility is identified as Eldorado Valley Northwest (EVNW 0000).

Eldorado Valley Southwest

A concrete channel is proposed to intercept runoff from subbasin ELV3 and route it north to the proposed Eldorado Valley Detention Basin. The new facility is identified as Eldorado Valley Southwest (EVSW 0000).

Eldorado Valley Detention Basin

The proposed detention basin (ELDV 0170) is located near the geographic center of the Eldorado Valley Watershed and is intended to attenuate flows from the undeveloped western portion of the watershed. It is designed to have a peak storage of 253 ac-ft. Facilities EVNW 0000 and EVSW 0000 flow into the basin, and facility ELDV 0118 serves as the basin outlet. The detention basin spillway is identified by facility ELDV 0171.

Eldorado Valley East

The proposed Eldorado Valley East system consists of large RCBs and conveys runoff to the east portion of the watershed as well as some subbasins referenced from the 2022 Boulder City

MPU. The facilities are identified as EVET 0000 through 0040 and contributes to the Eldorado Valley system.

Eldorado Valley Middle

A RCB storm drain is proposed to intercept runoff from subbasin ELV6. The new facility is identified as Eldorado Valley Middle (EVMD 0000) and contributes to the Eldorado Valley system.

Eldorado Valley System

The proposed Eldorado Valley Storm drain system serves as a basin outlet to the Eldorado Valley Detention Basin and combines with other subbasins and systems before it discharges in the southeast corner of the Eldorado Valley Watershed. The facilities are RCPs and RCBs with the exception of the dissipator structure at the terminus of the system. The new facilities are identified as ELDV 0000 through 0118.

Eldorado Valley Fan

One diversion berm is proposed to route runoff from the greater western portion of the Eldorado Valley Watershed. The system discharges south of the Eldorado Valley Watershed boundary. The new facility is identified as Eldorado Valley Fan (EVFN 0000).

In addition to the above information, **Table 13-2** summarizes the analysis of all the existing and proposed detention basins within the Eldorado Valley Watershed.

Table 13-2 - Eldorado Valley Watershed Detention Basin Summary Table

Name of Detention Basin	ID MILE	Status*	100-Year Peak Inflow (cfs)	Existing Storage @ Spillway (ac-ft)	Expansion Required (ac-ft)	Total Storage Volume @ Spillway (ac-ft)	Spillway Elevation (ft)	100-Year Clear Water Peak Elevation (ft)	Freeboard (ft)	Time to Peak (hrs)
Eldorado Valley Detention Basin	ELDV 0170	PROP	2,934	253.2	--	253.2**	1823	1820.65	2.35	5.92

*EX = Existing Detention Basin, EXP = Existing Detention Basin with Proposed Expansion, PROP = Proposed Detention Basin

** Total Storage Volume accounts for Sediment Load

13.6. Facility Cost Estimates

Cost estimates for all facilities have been derived using the Cost Estimation Tool described in **Section 2.6**. Construction cost estimates for proposed facilities have been divided into Category A and Category B. The total estimated construction cost of proposed Category A and B facilities in the Eldorado Valley Watershed are as follows:

A detailed breakdown of current estimated values of existing facilities and construction cost estimates for proposed Category A and B facilities is included in **Appendix E**.

CHAPTER 14

Apex Watershed

14.1. Introduction

This section presents the information developed for the 2023 MPU for the Apex Watershed, which is located to the northeast of the Las Vegas Valley. The watershed is roughly bounded by US 93 to the north and east, Sheep Mountain Wildlife Area and NAFB to the west and Nellis Dunes Recreation Area to the south. The western part of the watershed is mostly undeveloped and consists of steep slopes and alluvial fans. It is primarily within the City of North Las Vegas jurisdiction; however, it includes portions of unincorporated Clark County. The portion of the watershed within the City of North Las Vegas limits is anticipated to be developed as heavy industrial (land use category 11). City of North Las Vegas is responsible for programming flood control funds for Apex Watershed.

Construction of new facilities since the 2018 MPU has been very limited. However, recent communications with the City of North Las Vegas reveal significant implementation of local flood control facilities that eliminates the need of some of the planned regional conveyance and detention facilities from the watershed. Most of the master plan facilities in Apex Watershed are developer-built (Category B) except the facilities to collect runoff from the offsite alluvial fan to the west and its associated facilities. W-Map for Apex Watershed (W11 - Apex) serves as a useful reference for this section.

This watershed has three outlet locations along US 93: 1) CA-5, 2) CNAP04, and 3) CCAPX05. The total area of the Apex Watershed is approximately 71 square miles. Drainage facilities within the watershed consist of conveyance facilities that drain water from either the detention basins along the Sheep Mountain National Wildlife Area limits or runoff from southern boundary, across the US93.

14.2. Drainage Characteristics

Drainage patterns in the Apex Watershed are generally from west to east. The western part of the watershed is generally undeveloped and consists of alluvial fans and steep slopes. The developed part of the watershed drains north towards US 93.

14.3. Master Plan Progress

Some progress has been made on the implementation of the Master Plan since 2018 MPU through the construction of flood control facilities. Construction of less than 1 mile of conveyance facilities has been completed since the 2018 MPU. Major flood control facilities constructed or adopted into the plan since the 2018 MPU include the following:

- The Garnet Interchange and US 93 Capacity Improvement project constructed Apex – US 93 culverts along the southwest side of US Highway 93 and Frontage Road (AP93 0008, 0036, and 0063) and Apex – East culvert along the southwest side of US Highway 93 and Frontage Road (APXE 0013)

In total, the following facilities have been constructed to date in the Apex Watershed[13].

14.4. Hydrologic Analysis

The hydrologic analysis and models completed with 2018 MPU served as the basis for the 2023 MPU hydrologic analysis and modeling effort. The area tributary to US 93 is divided into four major drainage systems: North Apex 1 (Offsite), North Apex 2, Mountain View Industrial, and Apex. These four systems are proposed to cross US 93 at three locations. The delineations on the Apex watershed were based on the 2018 MPU subbasin delineations, with changes made to the following:

[13] Total length for facilities does not include floodways, natural washes, or existing facilities that are planned to be replaced.

- Subbasins were revised along the Mountain View Industrial mainline and branching drainage systems west of US-93 according to the Vegas Industrial Park – North Channel Technical Drainage Study. The study also includes changes to subbasins along Apex Power Parkway near the solar panel fields.
- Subbasins were revised northeast of Nadine Peterson Boulevard and Wesley D Adams Ave intersection based on the Apex – North Las Vegas Logistics Center Building 1 Drainage Study. This area is tributary to Apex – Las Vegas Blvd Branch 2.
- Subbasin changes were made to the Apex and Range Watershed boundary near Las Vegas Blvd based on the Miners Mesa study.

The major drainage reports, technical drainage studies reviewed and incorporated into the hydrologic analysis are tabulated in **Table 14-1**.

Table 14-1 - Apex Watershed Major Hydrologic Studies

#	NAME OF STUDY
1	APEX – NORTH LAS VEGAS LOGISTICS CENTER BUILDING 1 (GCW, JAN 2022)
2	TECHNICAL DRAINAGE STUDY FOR MINERS MESA ACCESS ROAD (WESTWOOD, JAN 2020)
3	VEGAS INDUSTRIAL PARK – NORTH CHANNEL (WESTWOOD, JUNE 2022, SUPP OCT 2022)

The storm centerings used for the 2018 MPU have been classified into two general categories: Series A and Series B. These two storm centering series are generally defined as follows:

- APEX_A (Series A). Storm centering for the entire watershed with SDN 3, 4, and 5 hydrologic models. These Series A models are named APEX3A, APEX4A and APEX5A. This series of storm centerings will control many areas of the watershed, especially in the upper portions of the watershed upstream of detention basins.
- APEX_B (Series B). Storm centering for the entire watershed with SDN 3, 4, and 5 hydrologic models, which is the same as Series A, except that the discharge from all detention basins is diverted out of the hydrologic models. This series of storm centerings will control most areas of the watershed downstream of detention basins. These Series B models are named APEX3B, APEX4B and APEX5B.

14.5. Flood Control Facility Plan

The final flood control facility plan footprint is significantly reduced since the 2018 MPU. A list of studies collected along with maps are provided in **Appendix F** for referring to studies mentioned in this section. Revisions to the plan since the 2018 MPU are based on comments received from City of North Las Vegas, Clark County, and the RFCD, and are described below:

City of North Las Vegas – Proposed MPU Facility Changes

Per discussion with City of North Las Vegas, Clark County and the RFCD several MPU facility alignment were removed from the 2023 MPU. These removals were largely contained within

the City of North Las Vegas jurisdiction. Removal of the proposed facility consist of the following systems (ID miles listed are from 2018 MPU and are no longer on the 2023 MPU):

- Mountain View Industrial South Branch 2 (MVS2 0000 – 0141) this alignment was south of MVI1 running west to east draining to US 93
- Mountain View Industrial South Branch 3 (MVS3 0000) west of Grand Valley Parkway draining south to MVI2
- Apex – Las Vegas Blvd Branch 4 (LVB4 0000) this alignment was south of MVI2 running west draining to US 93
- Apex – Las Vegas Blvd Branch 3 (LVB3 0103) Upstream of Las Vegas Boulevard Branch 3 (LVB3 0050)
- Mountain View Industrial Branch 5 (MVI5 0000 – 0051) east of US 93 draining southwest to MVI1
- Apex – Foothills (AXFH 0000 – 0332) along Wesley D Adams Avenue draining to APLV. This included the removal of 311 Ac-Ft Apex Foothills Detention Basin (AXFH 0127)
- Apex – Foothills Branch 2 (FH02 0000 – 0075) along Wesley D Adams Avenue draining to AXFH
- Apex – Foothills Branch 4 (FH04 0000 and 0042) running west of N Donald Lee Adams Way draining to AXFH
- The upstream portion of Apex – Las Vegas Blvd (APLV 0437 – 0494) along Las Vegas Boulevard N
- Apex – Las Vegas Blvd Branch 5 (LVB5 0000 and 0056) draining to APLV
- The upstream portion of Apex – Vegas Vista (APVV 0056 – 0086) along Apex Road. This included the removal of 212 Ac-Ft Apex Vegas Vista Detention Basins (APVV 0074)
- The upstream 145 Ac-Ft Apex Black Mountain Detention Basin and outfall for Apex – Black Mountain (APBM 0129 – 0133)
- The upstream portion of Apex – Industrial Railroad (APIR 0143 – 0145) This included the removal of 19.5 Ac-Ft Apex industrial Railroad Detention Basin (APIR 0145)

Vegas Industrial Park – North Channel Area

Systems downstream of Mountain View Industrial Branch 2 and System 1 Detention basins have been realigned and upsized based on the Vegas Industrial Park – North Channel Study. The Mountain Industrial System 1 conveyance facilities (MVI1 0097 – 0216) have been shifted north closer to the 4th Street alignment. The system then turns south (MVI1 0267 – 0300) further upstream of the previous plan and follows the old alignment to the detention basin. The Mountain View Industrial Branch 2 facilities (MVI2 0000 and 0100) alignment has been shortened and altered, with the downstream end connecting to “MVI1”. The Mountain View

Industrial South System 1 facilities (MVSI 0000 – 0199) have been realigned to the west running along the solar panel field connecting to MVI1 directly north.

Apex Las Vegas Boulevard Confluence Area

Previously designated as the 1,094 ac-ft Apex Las Vegas Blvd Detention Basin (APLV 0010) in the 2018 MPU, the basin has been repurposed into the Apex Las Vegas Blvd Confluence (renamed to APLV 0012) structure and its footprint reduced following a review of the design assumptions associated with downstream development and coordination with SNWA regarding their proposed Northern Flats Lift Station which is planned in the same area as the previous detention facility. The newly designated confluence facility is expected to receive flows from the same tributary drainage systems as the previous detention facility. It should be noted that this footprint and facility description is conceptual and any development in the area needs to account for the potential flooding from all of these tributary sources and the limited capacity of the US-95 culverts.

North Apex System 2

The alignment of North Apex System (NAP2 0061 – 0101) east of the Apex Power Pkwy has been changed to better align with the slope of the existing topography.

Apex Conveyance Facilities

Many of the proposed Apex conveyance facilities draining northward along Las Vegas Blvd have been upsized and existing culverts crossing under Las Vegas Blvd, I-15, and US-93 were proposed to be replaced due to the removal of upstream detention basins increasing flows downstream.

Apex – Solar Sites

The drainage point of the Apex watershed previously ended at the northern edge of US 93. This has been extended with the Apex – Solar Site System (APSS 0000 – 0170) to drain into the dry lake bed to the north.

In addition to the above information, **Table 14-2** summarizes the analysis of all the existing and proposed detention basins within the Apex Watershed.

Table 14-2 - Apex Watershed Detention Basin Summary Table

Name of Detention Basin	ID MILE	Status*	100-Year Peak Inflow (cfs)	Existing Storage @ Spillway (ac-ft)	Expansion Required (ac-ft)	Total Storage Volume @ Spillway (ac-ft)	Spillway Elevation (ft)	100-Year Clear Water Peak Elevation (ft)	Freeboard (ft)	Time to Peak (hrs)
Mountain View Industrial System 1	MVI1 0334	PROP	3155	--	--	540**	2510.50	2506.96	3.54	6.42
Mountain View Industrial Branch 2	MVI2 0145	PROP	2782	--	--	253**	2445.00	2440.91	4.09	5.67
North Apex System 1	NAP1 0154	PROP	7218	--	--	2050**	3015.00	3013.28	1.72	8.42

*EX = Existing Detention Basin, EXP = Existing Detention Basin with Proposed Expansion, PROP = Proposed Detention Basin

** Total Storage Volume accounts for Sediment Load

14.6. Facility Cost Estimates

Cost estimates for all facilities have been derived using the Cost Estimation Tool described in **Section 2.6**. Construction cost estimates for proposed facilities have been divided into Category A and Category B. The total estimated current value of existing facilities and total estimated construction cost of proposed Category A and B facilities in the Apex Watershed are as follows:

A detailed breakdown of current estimated values of existing facilities and construction cost estimates for proposed Category A and B facilities is included in **Appendix E**.

CHAPTER 15

Environmental Management

15.1. General

The RFCD and its member agencies are required to follow all federal, state, and local environmental compliance regulations relating to construction and maintenance of flood control facilities in the Las Vegas Valley.

This chapter is not intended to serve as an environmental analysis, but rather to provide a general overview of existing sensitive resources and the agencies (federal, state, and/or local) responsible for the management of those resources. The reader is encouraged to contact the various/appropriate resource and land management agencies early in the planning phases of any particular Master Plan facility to identify current policies and/or resources that might be present and adversely impacted, as well as mitigation measures that might be required.

15.2. Chapter 8 Project-Specific Analysis

A Project-Specific Analysis is required for all new RFCD flood control facilities. The Record of Decision for the *Final Supplemental Programmatic Environmental Impact Statement, Clark County Regional Flood Control District, 2002 Master Plan Update* (SEIS) (September 2004) requires the preparation of an environmental analysis using the methods described in Chapter 8, Project-Specific Procedures, of the SEIS for all new RFCD facilities. The facility-specific process is designed to allow for an explicit screening of facilities to determine the appropriate level of environmental documentation, i.e., categorical exclusion/memorandum to file, environmental assessment (EA), or facility-specific Environmental Impact Statement (EIS).

At the time a facility is being evaluated, an initial screening analysis must be performed to determine the need to perform an EA or EIS. Each screening evaluation requires preparation of a report documenting the decision or categorical exclusion. If the facility has the potential to

significantly impact the environment based on the initial review, a facility-specific EA or EIS then is required to be prepared following the facility-specific EA or EIS process in Chapter 8 of the SEIS.

15.3. Wetlands and Waters of the U.S.

Waters of the U.S. (WOTUS) and adjacent wetlands are regulated by the USACE (33 Code of Federal Regulations [CFR] 3 [328]). Wetlands primarily occur along the Las Vegas Wash, which has perennial flow primarily due to treated wastewater effluent and urban runoff. However, wetlands also can be found along the Flamingo Wash, the Duck Creek Wash, and any areas that provide a relatively permanent water supply.

Section 404 of the Clean Water Act

Section 404 of the Clean Water Act (CWA) (33 United States Code [USC] 1344 et seq.), and as revised by the 2023 Waters of the U.S. Rule and its amendments, requires that a permit be obtained from the USACE prior to beginning construction activities involving the placement of dredged or fill material in WOTUS including adjacent wetlands and tributaries. The term WOTUS refers to the jurisdictional limits of the USACE. The jurisdiction of the USACE extends to the ordinary high-water mark of Traditional Navigable Waters (TNWs), Relatively Permanent Waters (RPWs), and to wetlands adjacent to TNWs and RPWs., In August 2023 the USACE and USEPA amended the 2023 Waters of the US rule to bring the definition into line with the decision in *Sackett v. Environmental Protection Agency*. The amended rules removed streams that do not have relatively permanent flows from regulation under Section 404 of the Clean Water Act.

TNWs are all waters that are currently used, were previously used, or could potentially be used for interstate or foreign commerce, including all waters that are subject to the ebb and flow of the tide. RPWs are non-navigable and flow into a TNW either directly or indirectly through other tributaries. They either have flow year-round or at least have continuous flow seasonally.

The watersheds discussed in this MPU are tributaries of the Las Vegas Wash. The Las Vegas Wash is a tributary to the Colorado River system, which is an interstate TNW.

To comply with Section 404 of the CWA (33 USC 1344), field investigations would need to be conducted for each project utilizing methods outlined by the USACE. Wetland delineations must be performed according to the methods described in the Corps of Engineers Wetlands Delineation Manual (Environmental Laboratory 1987) and the Regional Supplement to the Corps of Engineers Wetlands Delineation Manual: Arid West Region, Version 2.0 (USACE 2006; 2008b). Under the new rule, only those tributaries to TNW that are relatively permanent, continuously flowing bodies of water (perennial and intermittent stream) are regulated. Tributaries that are not RPWs, e.g., ephemeral washes, no longer fall under USACE jurisdiction. Only those wetlands that exhibit a direct surface connection to a relatively permanent water are regulated under Section 404.

A jurisdictional determination (JD) request can be made to determine if a geographical area should be treated as subject to regulation by the USACE under Section 404 of the CWA. If it is decided that a JD request is necessary, either an approved or preliminary JD will be made (USACE 2016). An approved JD is a legally binding and official determination that is valid for five years, whereas a preliminary JD is an initial determination that is not legally binding but is more expeditious and can help guide the applicant as to whether the geographic area likely would be considered jurisdictional under an approved JD.

If a determination of jurisdictional waters is made, then a Section 404 Permit is required. Permit types include: Nationwide, Regional General, Letter of Permission, and Individual (USACE 2008a). A Nationwide Permit (NWP) is a form of general permit that authorizes a category of activities throughout the nation. These permits are valid only if the conditions applicable to the permits are met. If the conditions cannot be met, then one of the other permits would be required. Most NWPs require that the area of impact to WOTUS be less than 0.5 acre. NWP 43 covers the "construction and maintenance of stormwater management facilities, including detention and retention basins and other stormwater management facilities; the construction of stormwater control structures, outfall structures and emergency spillways; the construction of low impact development integrated management features such as bioretention facilities (e.g. rain gardens), vegetation filter strips, grassed swales, and infiltration trenches; and the construction of pollution reduction green infrastructure features designed to reduce inputs of sediments, nutrients, and other pollutants into waters, such as features needed to meet reduction targets established under Total Daily Maximum Loads set under the CWA (USACE 2021)." The requirements for NWPs were recently updated and released in 2021(USACE 2021).

Regional General Permits are issued by the USACE for a general category of activities when the activities are similar in nature and cause minimal environmental impact (both individually and cumulatively), and the regional permit reduces duplication of regulatory control by state and federal agencies. On January 5, 2024, the USACE proposed to reissue the Regional General Permit (RGP) 7 – Construction and Maintenance of Flood Control Facilities under the Clark County Regional Flood Control District Master Plan. A public notice for the reissuance of RGP 7 was published on December 29, 2023. RGP 7 would be valid for five years and authorize the permanent and/or temporary discharge of dredged and/or fill material into waters of the U.S., including wetlands, for construction and maintenance of flood control facilities under Section 404 of the Clean Water Act. Time period to act on the water quality certification request is 180 days (USACE 2024: SPK-2007-00300).

The USACE District Engineer may determine that more than minimal impacts may occur as a result of the proposed action, or the proposed action exceeds the maximum acreage of disturbance, and, therefore, does not qualify for coverage under a NWP or RGP7. In such cases, either a Letter of Permission (LOP) or an Individual Permit (IP) would be required.

A LOP may be required if it is determined that the impacts would be minor. The LOP is an expedited process for a standard permit, wherein a public notice is not issued. However, a notice

is issued to surrounding land owners and their comments are evaluated. The permit decision for the LOP is usually made within 45 days.

An IP is a type of standard permit in which public notice is issued and an evaluation of comments received is conducted. Decisions on these permits generally occur within 60 to 120 days unless additional time is needed to extend the comment period, to conduct a public hearing, to prepare environmental documents, or to comply with other federal laws.

Coordination with the RFCD and the USACE may be necessary to determine the appropriate Section 404 permit required for specific projects.

Section 401 of the Clean Water Act

According to Section 401 of the CWA (33 USC 1341), any applicant for a federal license or permit for any activity that may result in a discharge into WOTUS must obtain a certification from the state or agency having jurisdiction over the affected waters at the point of discharge. The discharge must comply with current applicable effluent limitations and water quality standards. Certification obtained for the construction of any facility also must pertain to the subsequent operation of the facility. Project proponents would be required to apply for a Section 401 Water Quality Certification with the Nevada Division of Environmental Protection (NDEP).

Temporary Permit for Working in Waterways (formerly Rolling Stock Permit)

A Working in Waterways Permit (formerly Rolling Stock Permit) would be required from the NDEP for any work performed in or along a water body or waterway, including ephemeral tributaries. An application, fee, site plan, map, description of the BMPs to be used, water quality analysis, and quantity of discharge that will be produced are required. This permit is issued for a maximum of 180 days (6 months) (NDEP 2008b; 2018b).

Temporary Discharge Permit

A Temporary Discharge Permit would be required from the NDEP for construction activities requiring the discharge of water for any purpose other than working in waterways. The discharge of water may be required due to various reasons, including, but not limited to, groundwater dewatering or hydrostatic testing. An application, fee, site plan, map, description of the BMPs to be used, water quality analysis, and quantity of discharge that will be released are required. This permit also is issued for a maximum of 180 days (6 months) (NDEP 2008b; 2018b).

Section 10 of the Rivers and Harbors Act

Section 10 of the Rivers and Harbors Act (33 USC 403), prohibits the unauthorized obstruction or alteration of any navigable WOTUS. The construction of any structure in or over any navigable WOTUS, the excavating from or depositing of material in such waters, or the accomplishment of any other work affecting the course, location, condition, or capacity of such waters is unlawful unless the work has been recommended by the Chief of Engineers and authorized by the Secretary of the Army. The Colorado River (including Lake Mead) is the only navigable WOTUS in reasonable proximity to the Las Vegas Valley (USACE 2008b; USFWS

2017); impacts to these waters are the only impacts that would require a permit under Section 10 of the Rivers and Harbors Act.

15.4. National Pollution Discharge Elimination System

As authorized by the U.S. Environmental Protection Agency (EPA) under the CWA as amended, (33U.S.C. 1251 et. seq.), the National Pollutant Discharge Elimination System (NPDES) permit program regulates water pollution from point sources that discharge pollutants into WOTUS.

Permit for Discharges from Municipal Separate Storm Sewer Systems

In accordance with the CWA and Chapter 445A of the NRS, the RFCD, is a co-permittee, to a NPDES stormwater discharge permit. The NDEP issued the permit to the RFCD, City of Las Vegas, City of Henderson, City of North Las Vegas, and Clark County (permittees). The permit authorizes both stormwater and non-stormwater discharges from the municipal separate storm sewer system (MS4) in the Las Vegas Valley to the Las Vegas Wash. In return, the permit outlines a schedule of monitoring requirements, BMPs, and conditions designed to promote the reduction of pollutants in both stormwater and authorized non-stormwater discharges to the "maximum extent practicable".

In cooperation with the permittees, the RFCD has implemented an educational program to inform the general public and engineering community of NPDES permit requirements, the proper disposal of household hazardous waste, and other measures necessary to protect water quality. The RFCD participates on the Stormwater Quality Management Committee (SQMC) which was formed to help manage program development and compliance activities under the NPEDES permit. For more information about the SQMC, please visit https://www.lvstormwater.com/about.

Since 1992, the RFCD has used automated monitoring stations to monitor stormwater quality at major stormwater outfalls in the Las Vegas Valley. Data collected are then reported to NDEP annually along with information necessary to address other NPDES permit requirements. The RFCD is in full compliance with the NPDES permit and promotes the construction of facilities that will help reduce the concentration of pollutants in stormwater runoff. Facilities such as detention basins help to extract pollutants through soil absorption of the "first flush" of runoff and the capture and removal of transported sediments from stormwater inflow. All flood control design and construction projects should be consistent with NPDES permit requirements and incorporate design strategies and construction techniques that will promote the reduction of stormwater pollutants.

Construction Stormwater General Permit

Stormwater runoff from construction activities can have a significant impact on water quality, contributing sediment and other pollutants exposed at construction sites. The State of Nevada Storm Water Program requires operators of both large and small construction sites to obtain authorization to discharge stormwater under an NPDES Construction Stormwater General Permit.

In compliance with the CWA (33 U.S.C. 1251) and NRS Chapter 445A, all construction sites over one acre in size and occurring within Nevada are required to comply with the Stormwater General Permit NVR100000 (40 CFR 122.26 [b] [14]). If the project is less than one acre in size but will be impacting receiving waters or its tributaries within a one-quarter mile radius of the project, the owner/operator of the project also will be required to obtain a Stormwater General Permit NVR100000. For all other projects less than one acre, the NDEP will determine whether compliance with the Construction Stormwater General Permit is required.

In order to be in compliance, contractors must complete a Stormwater Pollution Prevention Plan (SWPPP) and maintain it on the project site at all times. It must include the BMPs the contractor intends to use to keep sediment, turbidity, and other pollutants from impacting water quality. In addition, a Notice of Intent must be submitted to NDEP via NDEP's website before construction begins. The contractor must also have in place a Stormwater Compliance Monitor and keep records of site inspections for three years after the work is completed (NDEP 2018a).

15.5. Known Environmentally Sensitive Area

Land ownership and potential environmentally sensitive areas are presented in **Appendix A** on **Figure G-1** – Land Ownership map and on **Figure G-2** – Environmentally Sensitive Areas. **Figure G-2** shows land ownership throughout the study area, but also includes Wilderness Areas, National Wildlife Areas, recreation areas, and Conservation Areas. Sensitive areas on **Figure G-2** include BLM-designated areas, such as ACEC, Bighorn Sheep Crucial Habitat, Bighorn Sheep Winter Range, Horse and Burro Management Areas, and Crucial Quail Habitat. Sensitive areas also are shown on Figure G-2 for the Las Vegas bearpoppy (*Arctomecon californica*), Las Vegas buckwheat (*Eriogonum corymbosum* var. aureum), Mojave milkvetch (*Astragalus mohavensis* var. *mohavensis*), Blue Diamond cholla (*Opuntia whipplei* var. *multigeniculata*), white bearpoppy (*Arctomecon merriamii*), yellow two-tone beardtongue (*Penstemon bicolor* ssp. *bicolor*), and rosy two-tone beardtongue (*Penstemon bicolor* ssp. *roseus*).

Figure G-2 is intended for general reference only. The areas displayed on the map are meant to only show where there is a "potential" for sensitive resources to occur and are not meant to define exact locations. Due to the nature and pace at which development is occurring in the study area, environmentally sensitive areas presented on this figure are conservative and do not account for areas that are urbanized. Portions of the sensitive areas may currently contain developed areas but still have sections with the potential for sensitive resources to occur. Therefore, site-specific investigations and species-specific surveys may need to be conducted for each project to determine whether sensitive environmental resources occur in a specific project area. The sensitive species included on **Figure G-2** are discussed in further detail below along with other environmental resources that must be considered for proposed flood control projects.

Other sensitive species, such as the Mojave Desert tortoise (*Gopherus agassizii*), western chuckwalla (*Sauromalus ater*), banded Gila monster (*Heloderma suspectum* ssp. *cinctum*),

various species of bats, the Willow Flycatcher (*Empidonax traillii*), Yellow-billed Cuckoo (*Coccyzus americanus*), Black Rail (*Laterallus jamaicensis*) and cacti and yucca species (*Cactaceae* family and genus *Yucca*) also have some form of special status. Although these species are listed in the legend of **Figure G-2**, their distributions and potential habitat are unknown throughout the study area to effectively be presented geographically on the map.

Sensitive cultural resources could also potentially occur throughout the study area and, therefore, were not geographically represented on **Figure G-2**. In addition, to protect cultural sites from destruction and vandalism, state and federal laws prohibit the release of specific information on cultural sites and their locations to the general public.

15.6. Other Significant Regulatory Programs

The Clark County Multiple Species Habitat Conservation Plan (MSHCP) is discussed in Section 15.7.4, and the In-Valley EA is discussed in Sections 15.7.4 and 15.7.6.

15.7. Environmental Resources

The potential environmental issues related to the study area are presented in this section. Not all of the issues will apply to every facility due to variations in design and location.

Environmental resources that may be addressed for proposed projects include:

- Geology and Soils
- Groundwater Resources
- Surface Water Resources
- Terrestrial and Aquatic Biological Resources
- Paleontologic Resources
- Cultural Resources
- Visual Resources
- Air Quality
- Noise
- Hazardous Materials
- Socioeconomics
- Environmental Justice

15.7.1. Geology and Soils

The Las Vegas Valley lies in the southwestern part of the Great Basin within the Basin and Range physiographic province. Surrounding the low-lying, alluvium-filled valley are sharp,

rugged mountain ranges. Valley floor elevations range from 1,800 feet to 2,400 feet. The basin is bordered on the north by the Las Vegas Range with a crest elevation of approximately 7,000 feet, and on the east by the Frenchman, Sunrise, and River mountains with crest elevations ranging from 3,000 feet to 4,000 feet. The western boundary of the Valley is formed by the Spring Mountains, which reach a maximum elevation of 11,918 feet at Charleston Peak. The southeastern boundary is the McCullough Range with a 5,000-foot crest elevation. Low hills and the Bird Spring Range bound the basin on the southwest.

Extensive coalescing alluvial fans extend from the surrounding mountain ranges to the floor of the Las Vegas Valley. These fan surfaces have moderately steep slopes of about 1.5 percent to 3 percent. The Valley floor is relatively flat, with a slope of less than 1 percent to the southeast.

Soils in the Las Vegas Valley range from gravelly, cobble-filled soils at the edges of the basin to fine-grained silty to clayey loams toward the Valley's center. Steep slopes and shallow soils occur at the edges of the Valley, and rock outcrops are common in and near the mountains. Deep soils abut the mountains to the east and north of the Las Vegas Valley, whereas shallow soils are found over much of the western half of the basin. Soils on alluvial fans contain pebbles and cobbles derived from nearby mountains. Soils near the eastern, western, and northeastern edges of the Valley have abundant calcareous cobbles (caliche), whereas those in the southern part of the valley are mostly volcanic (Dames & Moore 1991).

The analysis of potential effects associated with geologic conditions would include an evaluation of the geologic hazards and constraints that may require special engineering design or construction practices. An analysis of potential impacts on geologic and soil resources that may result from the construction and operation of flood control facilities also may be required. A site-specific geotechnical investigation would be performed for each project prior to facility design.

15.7.2. Groundwater Resources

The study area is in the southeastern part of the Great Basin Regional Aquifer System (Great Basin) of the U.S., which includes most of Nevada and portions of adjacent states.

The hydrogeology of the Great Basin is controlled by the basin and range geologic structure and climate. The groundwater flow patterns in the region are generally complex. The carbonate rock province is that part of the Great Basin in which groundwater flow may be strongly influenced or dominated by carbonate rocks of Paleozoic age. Flow between hydrographic basins is often recognized (Mifflin 1988). Hydrogeologic units in the southern Great Basin include:

- Metamorphic, igneous, and sedimentary rocks of Precambrian and early Cambrian age;
- Carbonate and clastic sedimentary rocks of middle Cambrian to early Triassic age;
- Sedimentary and igneous rocks of middle Triassic to Quaternary age;
- Older basin-fill deposits of Miocene and Pliocene age; and
- Younger basin-fill deposits of Pliocene to Holocene age.

The two dominant aquifer systems recognized in the southern Great Basin consist of the carbonate and clastic sedimentary rocks of middle Cambrian to early Triassic age (carbonate-rock aquifers) and permeable basin-fill deposits (basin-fill aquifers). With some exceptions, the remaining units act as barriers or impediments to groundwater flow (Harrill and Prudic 1998).

The Paleozoic carbonate rocks either comprise or underlie most of the ranges and lie beneath the basin-fill of most basins. Because a single layer of carbonate rocks may underlie several basins, it can link groundwater flow systems over large areas. The basin fill deposits may or may not be hydraulically connected to equivalent aquifers in neighboring basins or to the underlying or adjacent Paleozoic carbonate rocks.

Carbonate-Rock Aquifer

Thick sequences of carbonate rocks underlie most of the alluvial basins within the Basin and Range area in eastern Nevada and southeastern California; these rocks also extend into western Utah, northwestern Arizona, and southeastern Idaho. The carbonate rocks have been faulted, deformed, and eroded through geologic time; original thicknesses of up to 40,000 feet have been reduced by one-half or more. Consequently, most of these rocks are in isolated blocks that form individual aquifers with areal dimensions of only a few square miles. In Nevada, however, the carbonate rocks form a north-south section of aquifer, or “central corridor,” that is generally laterally continuous for more than 250 miles.

The carbonate-rock aquifers within the Great Basin consist of consolidated limestones, dolomites, and lesser amounts of clastic rocks that either comprise or underlie most of the mountain ranges and many of the intervening basins. The carbonate rocks are commonly dense and brittle, and, where unbroken, exhibit very low values of hydraulic conductivity. In most areas, however, the carbonate rocks were fractured and brecciated as a result of intense deformation. Most noncarbonate sedimentary rocks will reconsolidate or yield ductility and not retain openings through which water can flow (Dettinger *et al*. 1995). In contrast, the carbonate rocks will retain their secondary permeability, in part because they are slightly soluble in water.

Basin-Fill Aquifer

Basin-fill deposits typically consist of an older unit of late Miocene to early Pliocene age and a younger unit of late Pliocene to Holocene age. The younger basin fill typically consists of unconsolidated to semi-consolidated deposits of sand, silt, gravel, and clay, which make up the uppermost part of the fill in most basins. The sand and gravel deposits usually are more conductive than the finer-grained deposits. The older basin fill often is more uniformly fine-grained, e.g., silts and clays, and has correspondingly lower conductivities. Recharge to basin-fill aquifers usually occurs through leakage of water from carbonate aquifers along the margins of the basins. The amount of recharge that occurs by direct infiltration of precipitation on the aquifer outcrop is limited because there is a very limited amount of precipitation that falls at basin elevations in the region. Otherwise, groundwater travels through the basin aquifers and is discharged in a manner similar to that of carbonate aquifers.

Groundwater information specific to each proposed facility would be acquired during site-specific geotechnical investigations prior to design.

Shallow Aquifer

The shallow aquifer is located in central, eastern and southeastern parts of the Las Vegas Valley and typically refers to water in the shallow groundwater system, which is water that lies within 30 - 50 ft of land surface. It is separated from the deeper aquifers by thick layers of clay and fine-grained sediments. The shallow zone is composed primarily of silts, clays and poorly sorted sands and gravels of low transmissivity. The general flow gradient of the shallow aquifer system is southeast towards Las Vegas Wash.

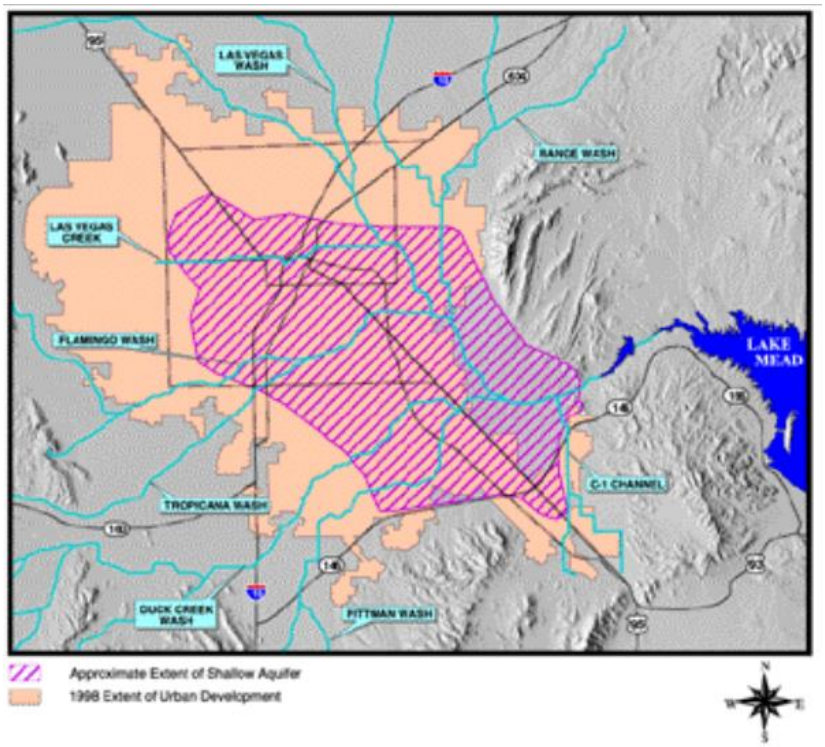


Figure showing the extent of the shallow ground water system in the Las Vegas Valley (LVWCC 2000).

The shallow aquifer is primarily created through water runoff by excess surface irrigation, although positive upward gradient from the deeper aquifers can aid recharge of the shallow aquifer. Recent groundwater modeling shows that more than 100,000 acre-feet of irrigation water may be accumulating in this shallow zone each year (LVVGMP 2024).

Water quality of the shallow aquifer tends to be poor as evidenced by total dissolved solids (TDS) concentration ranging from 1,500 milligrams per liter (mg/L) in the central part of the valley to greater than 7,000 mg/L in the southeast (LVWCC 2000). The high salinity levels in the shallow aquifer are attributed to two factors: 1) over-irrigation of landscapes and the associated evapotranspiration resulting in concentration of salts, and 2) the presence of gypsum deposits and the subsequent dissolution of the minerals by the shallow groundwater.

As the water source for the shallow aquifer is primarily surface water, past industrial activities in the southeast part of the valley and current human-related activities such as over-irrigation of landscapes, leaking underground storage tanks and improper surface disposal of contaminants makes the aquifer particularly vulnerable to contamination by pesticides and fertilizers. Contaminated groundwater that seeps into the Las Vegas Wash and eventually into Lake Mead has heightened concerns for the protection of such hydrologic features (LVWCC 2000).

As described, the shallow aquifer water quality is poor with total dissolved solids exceeding acceptable drinking water standards in most locations. As such, water from the shallow aquifer is not used for drinking water. It is possible to treat shallow groundwater for drinking, but costs are still relatively high.

Surfacing of shallow ground water in commercial and residential areas in the southeast part of the Valley has raised concerns ranging from geotechnical, health and safety, and aesthetic issues. It is believed that shallow ground water levels rise due to increased irrigation resulting from the growing Valley population.

Groundwater in the Las Vegas Valley comes from three major aquifer zones generally located from 300 to 1,500 feet below land surface (LVVGMP 2024). This drinking-water supply is protected from surface contamination detailed above in the shallow aquifer by a layer of clay and fine-grained sediments throughout most of the Valley. The Las Vegas Valley Water District (LVVWD) uses groundwater to augment its supply, and businesses and residents using community and domestic wells rely on groundwater 100 percent of the time. There are more than 6,000 wells within the Las Vegas Valley that provide groundwater year-round to residents and other users who aren't on a municipal water supply (LVVWD 2024).

The SNWA uses the Southern Nevada Groundwater Bank as a means to provide a stable, reliable water supply by diversifying the community's sources of water. This groundwater bank is a massive "natural" storage facility beneath the Las Vegas Valley. Beginning in 1987, the Las Vegas Valley Water District and City of North Las Vegas, as SNWA member agencies, began injecting treated Colorado River water from Lake Mead into the valley's primary aquifer in years when Nevada's Colorado River allocation exceeded demand. By doing this, the Water District and the City of North Las Vegas collectively have stored more than 360,000 acre-feet of water for the community's use in times of need. That equates to roughly 117 billion gallons of water (LVVWD 2024). Rather than withdrawing water from this groundwater bank during times of drought, these water reserves are stored for an emergency or as a bridge to future resources. The groundwater bank has also been used by the Las Vegas Valley Groundwater Management Program to permanently store Colorado River water for the benefit of the aquifer. By injecting water into portions of the Valley where the water table is susceptible to decline, the Water Authority is able to maintain stable water levels and reduce the likelihood of subsidence and well failures.

15.7.3. Surface Water Resources

Hydrology

The study area lies within the Las Vegas Wash watershed (U.S. Geological Survey [USGS] Hydrologic Unit Code (HUC) 8: 15010015 [EPA 2008a]). Average annual precipitation is low, measuring approximately 4 inches to 6 inches per year. The Las Vegas Valley is an externally draining basin. The general drainage pattern of the study area includes collection of precipitation runoff from tributaries located on alluvial fill from the Sheep Mountains, Spring Mountains, and alluvial fans north of the City of North Las Vegas to the Upper Las Vegas Wash. These flows then are conveyed to the southeast end of the Valley and eventually to the Las Vegas Wash and Lake Mead (Dames & Moore 1991).

The Las Vegas Wash drainage basin is divided into 10 smaller watersheds (Upper Northern Las Vegas Wash, Lower Northern Las Vegas Wash, Gowan, Central, Range, Flamingo/Tropicana, Duck Creek/Blue Diamond, Pittman, C-1, and Lower Las Vegas Wash) and are each addressed in this MPU.

Due to the presence of desert pavement and caliche, runoff either flows into the washes or evaporates quickly following rainfall events. Localized flash flooding may occur from brief intense thunderstorms.

15.7.4. Terrestrial and Aquatic Biological Resources

Field investigations for biological resources may be required for each proposed facility. The results of the investigations would be used to assess potential impacts to sensitive species[14] associated with the proposed facility. If federally-listed, state-listed, or candidate species occur within or immediately adjacent to the project site, the project sponsor would be required to consult with federal and/or state agencies, including the BLM, U.S. Fish and Wildlife Service (USFWS), Nevada Division of Forestry (NDF), and Nevada Department of Wildlife (NDOW). The investigation also may include additional species-specific surveys and formal resource agency determination of the project's potential to jeopardize the continued existence of a species population. If it is determined that project activities could potentially result in impacts to sensitive biological resources, the project may not be allowed to proceed as planned or may require redesign of the project to reduce or avoid impacts. Upon consultation with applicable regulatory agencies, mitigation for the potential impact of the project also may be required.

[14] A species is considered sensitive if it is federally-listed or state-listed as threatened, endangered, or proposed as such (USFWS 1992, 1993a; Krueger 2000; Nevada Natural Heritage Program [NNHP] 2008; NNHP 2018a). It also would be considered sensitive if it is a State of Nevada protected species covered under NRS 501, Nevada Administrative Code (NAC) 503, or NRS 527. In addition, the BLM may classify certain wildlife as “Nevada BLM Sensitive Species” (BLM 2011) and these species are managed following policy guidance outlined in *Manual 6840—Special Status Species Management* (BLM 2008b).

Conducting a project-specific analysis also would address species that are not federally or state listed, but which nonetheless require special consideration. For example, there are several bat species that are declining throughout their range but do not have state or federal protection.

By analyzing the above federal- and state-listed species and habitats, a determination can be made to establish the significance of potential impacts. After the impacts are determined, the appropriate mitigation measures can be developed. If mitigation measures do not reduce the potential impacts to less than significant, a project-specific EIS may need to be completed.

Federal Endangered Species Act

The USFWS perform most administrative and regulatory actions under the Endangered Species Act (ESA) of 1973 (16 USC 1531-1544), as amended. The ESA and its implementing regulations prohibit any action that would "take" a federally-listed threatened or endangered species or its critical habitat (on public or private lands) without a permit or other authorization. Under Section 3(18) of the ESA, the definition of take includes to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct toward any federally listed species. "Harm" is further defined to include significant habitat modification or degradation when it actually kills or injures wildlife. Such an act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering.

Each federal agency must ensure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of a listed species in the wild, or destroy or adversely modify its critical habitat. If a federal agency determines that a proposed action may adversely affect such a species, it must formally consult with the USFWS pursuant to Section 7 of the ESA. Further, proposed actions that may adversely affect a listed species but do not have a federal nexus may be permitted pursuant to Section 10 of the ESA.

BLM Policies

BLM Sensitive Species are those species found on public lands administered by the BLM whose survival is of concern due to limited distribution, low numbers of individuals or populations, and potential threats to habitat. The BLM uses the term "Sensitive Species" to include: (1) federally listed as endangered, threatened, proposed, and candidate species; (2) Nevada state protected species; and (3) Nevada BLM sensitive species (BLM 2011).

Nevada state protected species require the same level of protection and consideration as is provided for federal candidate species; that is, to "ensure that actions authorized, funded, or carried out do not contribute to the need to list any of these species as threatened or endangered" (BLM 2008).

The list of Nevada BLM sensitive species includes: (1) only those state-protected animals that have been determined to meet BLM's policy definition of "listing by a state in a category implying potential endangerment or extinction," and (2) all plant species designated by the state of Nevada as "critically endangered" (BLM 2011).

In May 1998, the BLM published the Proposed Las Vegas Resource Management Plan and Final Environmental Impact Statement (RMP/FEIS) (BLM 1998a). In 2008, BLM initiated a revision to the 1998 RMP. A draft was released October 2014 for public review (BLM 2014). This plan includes protocols for rights-of-way management for flood control facilities on public lands. The RMP/FEIS was revised again in 2019 (BLM 2019). The updated plan includes amendments to the vegetation and wilderness study areas. These amendments pertain to actions that result in the loss or degradation of tortoise habitat will require reclamation to pre-disturbed conditions and managing existing and future congressionally designated wilderness area to preserve the wilderness character of the area (BLM 2019).

State of Nevada Laws and Regulations

The NDOW has established a state list of threatened, endangered, or sensitive species due to population decline in all or portions of their natural range within the state of Nevada. NDOW protects such species per NAC 503 and NRS 501.100 to 501.110 and further provides administrative and regulatory actions involving state game and furbearer species, and wildlife species protected by the state of Nevada. A person cannot hunt or take any wildlife that is classified as protected, or possess any part thereof, (from public or private lands) without first obtaining the appropriate license, permit, or written authorization from NDOW.

The NDF performs administrative and regulatory actions involving state-protected plants. The NDF State Forester Firewarden has an established list of “fully protected” native plant species (NAC 527.010) that are critically endangered and threatened with the potential to become extinct within the State of Nevada. The purpose of NRS 527.260 through 527.300 is to provide programs for the conservation, protection, restoration, and propagation of critically endangered and threatened plant species, and the continuation of the habitats of such species (NRS 527.260). Fully protected native plant species require a special permit from the State Forester Firewarden for removal or destruction from both public and private lands (NRS 527.270).

Clark County

The Clark County Multiple Species Habitat Conservation Plan (MSHCP) (Clark County 2000) applies to development of private land within Clark County. This plan covers 78 species of mammals, birds, reptiles, plants, and invertebrates within Clark County. The MSHCP is intended under Section 10(a) of the ESA to support the issuance by the USFWS of a permit (Section 10(a) Permit) that allows the take of threatened or endangered species resulting from otherwise lawful activities on non-federal properties within the County, and also allows the take of threatened or endangered species that are currently unlisted but may become listed in the future (Clark County 2000).

The MSHCP and the resultant Section 10(a) Permit also reduces the likelihood of the listing of additional species located in Clark County as threatened or endangered and provides federal agencies and public land users with streamlined review under Section 7 of the ESA. It provides assurances that the take of ESA-listed migratory birds named on the incidental take permit will not be in violation of the Migratory Bird Treaty Act, provided the incidental take permit remains

in effect (Clark County 2000). The permit for this plan was issued by the USFWS on November 1, 2000 and will stay in effect for 30 years for a maximum of 145,000 acres disturbed.

Wildlife

The majority of bird species endemic to the United States (except House Sparrows [*Passer domesticus*], European Starlings [*Sturnus vulgaris*], and Rock Doves [*Columba livia*]) are protected by international treaty under the Migratory Bird Treaty Act (MBTA) of 1918 (16 USC 703-711), as amended. The USFWS administers this law, and it applies to both public and private lands. The NDOW performs administrative and regulatory actions involving state game and furbearer species that are protected by NAC 503 sections and NRS 501.100 to 501.110 within the jurisdiction defined by the state.

Potential habitat exists for the desert tortoise, western chuckwalla, banded Gila monster, desert bighorn sheep, Burrowing Owl, protected bat species, and desert kit fox on undeveloped land throughout the study area. Potential habitat for Gambel's Quail occurs in washes and wetland areas throughout the study area.

Sensitive wildlife species have the potential to be affected by construction of the proposed facilities. Avoidance of sensitive wildlife species habitat and/or implementation of other mitigation measures may preclude effects.

Mojave Desert Tortoise (*Gopherus agassizii*)

Because of significant population decline and habitat loss, the USFWS ultimately afforded the Mojave Desert population of the desert tortoise protection as a threatened species under the ESA. The desert tortoise has also been classified as threatened by the State of Nevada pursuant to NAC 503.080 and 503.090, and was identified in the Nevada Wildlife Action Plan (NWAP 2022) as a Species of Greatest Conservation Need (SGCN).

The Mojave Desert population of desert tortoise occurs in southern Nevada, southern California, southwestern Utah, and small portions of northwestern Arizona (USGS 2013). Desert tortoise habitat generally occurs at elevations less than 5,000 feet in arid regions and typically in association with the creosote bush scrub and wash scrub vegetation communities (Berry and Nicholson 1984). Common traits of these areas are scattered shrubs with abundant inter-space for growth of herbaceous plants (Stebbins 1985). The desert tortoise occurs most often in areas with flats and bajadas characterized by sandy to gravelly soils but it also can use habitat with slopes and rocky soils (Smith and Brodie 1982; Stebbins 1985).

To avoid high summer and low winter temperatures, tortoises spend most of the year underground in burrows. Tortoise burrows also are used by other species such as kit fox, small mammals, Burrowing Owls, snakes, lizards, and insects. Tortoises are most likely to be out of their burrows and active during spring; however, if weather conditions are favorable, they could be active at any time of year.

In April 1993, a Biological Opinion (BO) (1-5-93-F-67R) (USFWS 1993b) was issued by the BLM for the RFCD's Master Plan. It provides mitigation measures proposed by BLM to minimize

effects of the Master Plan implementation to desert tortoises. It also provides that 20 desert tortoises may be taken in the form of direct mortality, 525 desert tortoises may be taken in the form of harassment (through removal from project site), and a total of 5,120 acres of tortoise habitat may be destroyed during construction. In the 2004 Record of Decision, it was determined that the 1993 BO covered all new areas mentioned in the SEIS; therefore, no new BO would be required (BLM and USACE 2004a).

Areas within the Mojave Desert essential for desert tortoise recovery were designated as critical habitat and published in the Federal Register (FR) in February 1994 (59 FR 5820).

In 1995, an incidental take permit (PRT-801045) was issued to Clark County for the "incidental take" of desert tortoises within Clark County for a period of 30 years (USFWS 1995).

The desert tortoise is also included in the Clark County MSHCP (Clark County 2000), a plan that applies to development of non-federal land within Clark County. This plan was developed to allow the take of other protected species or their habitat, not just the desert tortoise. The ESA Section 10(a) take permit for this plan was issued by the USFWS on November 1, 2000. This plan replaces the 1995 Desert Conservation Plan Section 10(a) permit issued August 1, 1995 (Clark County 1995), and the incidental take permit (PRT-801045) specifically for the desert tortoise.

Proposed facilities have the potential to be covered under the existing USFWS Programmatic Biological Opinion (PBO) (File No. 84320-2010-F-0365.R0396, 6th Reinitiation) for impacts to currently undisturbed tortoise habitat in Clark County (USFWS 2013, USFWS 2018b). The updated PBO was issued by the USFWS on January 2, 2013, for "Programmatic Activities Proposed for Implementation" by the BLM's Southern Nevada District Office.

The June 21, 2018 Reinitiation of consultation with the USFWS is the fifth Reinitiation of the 2013 PBO and covers proposed modifications that would affect the Mojave desert tortoise on BLM lands. The October 17, 2018 Reinitiation of consultation with the USFWS is the sixth Reinitiation of the 2013 PBO and added 3,500 acres for disposal lands and a modification to the Crescent Peak race course to add ten miles to the course. Currently, the 2013 PBO is the most recent consultation that the BLM has completed with the USFWS that covers affects to species in the Las Vegas Valley. Previous PBO's were obtained by the BLM from the USFWS in 1997, 1998, 2004, and 2009. The 2013 PBO covers affects to 19 listed species and critical habitat. If a proposed action or project is anticipated to result in adverse effects to the desert tortoise and the effects exceed the acreage threshold (i.e. 5 acres critical habitat or 20 acres non-critical habitat affected (USFWS 2013)), then the project will require the BLM and USFWS to produce project-specific documentation that is appended to the PBO before the action occurs. The incidental take for proposed actions that fall below the acreage threshold for desert tortoise is exempted in this PBO. The PBO, together with the appended documentation, fulfills the consultation requirements for implementation of both program-level and project-level actions (USFWS 2013).

If a project is proposed on non-Federal lands that falls under purview of a section 10 incidental take permit (e.g., the MSHCP) involving a nexus to a BLM action with adverse effects to the desert tortoise, such projects may be covered or appended to this PBO. The project-level consultation would evaluate only the effects of the Federal component as effects to the non-Federal portion were analyzed prior to issuance of the Section 10 permit. For example, if a project involves effects to BLM land below 20 acres of desert tortoise habitat or 5 acres of desert tortoise critical habitat, the project may proceed as stated above; if the BLM acreage threshold is exceeded, the project would be appended to the 2013 PBO.

The 2013 BO also identifies specific maximum thresholds for the desert tortoise for programs of activities and sub-categories. The Rights-of-way Program includes a sub-category specifically identified as Site-Type ROWs and includes Flood-Control Structures. These programs are covered by the 2013 PBO if they fulfill the consultation requirements.

As identified in the 2013 BO, maximum thresholds for adverse effects for Site-type ROWs include 25 acres in critical habitat and 750 acres in non-critical habitat. Once these thresholds are surpassed, additional consultation and permitting will be required.

In accordance with the USFWS guidance, the project proponent would be required to pay a fee of $885 (adjusted annually for inflation) per acre to the BLM for disturbance to tortoise habitat on federal land. The cost will be adjusted each year for inflation and new fee costs will become effective each March 1st. Fees will be based on the Bureau of Labor Statistics Consumer Price Index for All Urban Consumers (CPI-U). The $885 per acre cost is based on the 2018 5th Reinitiation of the 2013 PBO (USFWS 2018b).

The 2013 PBO and “incidental take” permit for the desert tortoise also were issued to the BLM on January 2, 2013, by the USFWS for Programmatic Activities Proposed for Implementation by the Bureau of Land Management. The BLM also completed a Las Vegas In-Valley Area Multi-Action Environmental Assessment in 2016 (BLM 2016). Portions of the 2013 BO are within the areas covered by that EA. Under this permit, survey and removal of tortoises prior to construction may be required and payment of mitigation fees of $885 (USFWS 2018b) (adjusted annually for inflation) per acre of disturbance to undisturbed tortoise habitat would be required.

Chuckwalla *(Sauromalus ater)*

The chuckwalla is a BLM Nevada Sensitive Species, is a Nevada SOCP, is on the Nevada Natural Heritage Program (NNHP) watch list and is covered under the MSHCP (Clark County 2000). This reptile is found throughout the deserts of the southwestern U.S. and northern Mexico. Chuckwallas inhabit rocky outcrops where cover is available between boulders or in rock crevices, typically on slopes and open flats of elevations less than 6,100 feet (Stebbins 1985). They require shady, well-drained soils for nests. Warm rock surfaces are used for basking and as lookout positions for predators.

Typical habitat includes rocky hillsides and talus slopes, boulder piles, lava beds, or other clusters of rock, usually in association with desert scrub vegetation including Mojave Desert

scrub, blackbrush, salt desert scrub, and mesquite/catclaw (Smith and Brodie 1982). The chuckwalla is a widespread species, but is regionally limited by its requirement for rock outcrops.

Banded Gila Monster (*Heloderma suspectum cinctum*)

The banded Gila monster is a BLM Sensitive Species, and a Nevada State protected species (NAC 503.080 and NRS 501). This large venomous reptile generally is found in canyon bottoms or arroyos with permanent or intermittent streams where it digs burrows. It also seeks shelter in mammal burrows and under rocks (Stebbins 1985). Active at night and on cloudy days, Gila monsters can be found in arid and semi-arid regions of gravelly and sandy soils throughout the Mojave Desert. Habitat for this species is found to occur in the study area mostly on BLM lands (Clark County 2000) near permanent or intermittent water supplies.

Mojave Desert Sidewinder (Crotalus cerastes cerastes)

The Mojave Desert sidewinder is a BLM Sensitive Species. The Mojave Desert sidewinder is a nocturnal snake hiding in the day in animal burrows or coiled camouflaged in a shallow self-made pit at the base of a shrub. This species is most common where there are sand hummocks topped with creosote bushes, mesquite, or other desert plants but may also occur on flats, barren dunes, hardpan, and rocky hillsides.

Desert Bighorn Sheep (*Ovis canadensis nelsoni*)

The desert bighorn sheep is a Nevada State Game species (NAC 503.020). The desert bighorn sheep's main threats are unregulated or illegal hunting, introduced diseases, competition from livestock, and continual human encroachment on their habitat. Fragmentation of their population by highways, fences, and aqueducts has also contributed to some decline in their population. Over the past 12 years, desert bighorn sheep numbers have stabilized or increased slightly as a result of reintroduction to former habitat, water developments, and favorable land use decisions (BLM 1998b).

Phainopepla (Phainopepla nitens)

Phainopepla is protected under the MBTA of 1918, as amended (16 USC 703-712), is an NNHP At Risk Species, and is covered under the MSHCP. It is found primarily in acacia stands in desert washes that contain mistletoe within the project area. The berries from the mistletoe, juniper, elder, and buckthorn plants make up a large portion of the Phainopepla diet (NatureServe 2008a).

Yellow-billed Cuckoo (Coccyzus americanus)

Yellow-billed Cuckoos are relatively common in the Midwest and eastern US, but primarily due to the conversion of riparian habitat to agriculture and housing they have become rare in the west. The birds are thin with long tails, curved bills with a distinct yellow color, and a somewhat hunchbacked profile. The large, oval white spots that show on their long tails are distinctive. In the west they generally inhabit riparian areas dominated by cottonwoods (members of the genus *Populus*). The species is covered under the Clark County MSHCP and is protected under the MBTA.

Southwestern Willow Flycatcher (*Empidonax traillii extimus*)

This small sub-species of Flycatcher is an overall brown to gray color with a whitish throat, pale olive colored breast and a yellow belly. They are generally around 6 inches long, including the tail. They generally nest in dense riparian woods, a habitat type that has been dwindling. The species breeds in the U.S> in the summer, and winters in Central America. The species is covered under the Clark County MSHCP and is protected under the MBTA.

Burrowing Owl (*Athene cunicularia hypugea*)

Burrowing Owls are found throughout open landscapes of North and South America. The owls are approximately 10 inches tall and live in underground burrows in the desert where they are insulated from extreme temperatures and protected from predators. This ground-nesting owl prefers dry desert scrub areas and open conifer habitats at higher elevations. It often nests in colonies, is active year-round, and produces young from mid-March through August. It is an "evaluation species" for the Clark County MSHCP and is protected under the MBTA. Killing or possessing Burrowing Owls or destruction of their nests with eggs or young is prohibited (USFWS 2007).

Gambel's Quail (*Callipepla gambelii*)

Gambel's Quail is protected under NAC 503.045 as an upland game bird. In Nevada, habitat for Gambel's Quail generally is located on alluvial fans dissected by numerous washes at elevations between 2,000 feet and 4,500 feet. All springs, seeps, rivers, lakes, and water catchments are important-use areas for these birds (BLM 1998a).

Horse and Burro

On December 15, 1971, Congress enacted the Wild and Free-Roaming Horse and Burro Act authorizing the BLM to manage wild horses and burros on public lands. The Act mandated that wild and free-roaming horses and burros be protected from unauthorized capture, branding, harassment, or death (Public Law 92-195; BLM 1998a).

There are eight Herd Management Areas (HMAs) throughout the Las Vegas BLM District and six of those areas are included in the RMP/FEIS. The management area shown on the Environmental Constraints Map (**Figure G-2**) is the Red Rock HMA and is addressed in the RRCNCA General Management Plan (BLM 2001). An aerial survey conducted in December 2004 showed the estimated populations to be 191 wild burros and 35 wild horses (BLM 2006a). As of 2023, the estimated horse population at Red Rock HMA was 97 individuals, no estimated burro population was provided (BLM 2023). As of 2011, the estimated burro population was 65 individuals (BLM 2013).

The management objective for wild horses and burros is to maintain the population at a level that provides a thriving natural ecological balance consistent with multiple-use management objectives. This population level is referred to as the "Appropriate Management Level" (AML) and is derived from field studies that determine the amount of available forage and water, and combined monitoring of the effects of the animals on other resources. In 2004, HMAs within the

Las Vegas Field Office's jurisdiction were reviewed to determine the AML. It was determined that the Red Rock HMA had an AML of only 29 to 49 burros, and 16 to 27 wild horses. Excess wild burros were tentatively proposed for removal in 2007 (BLM 2006a). Appropriate Management Levels for the portions of the HMAs managed by the U.S. Forest Service Spring Mountain National Recreation Area were set in the Spring Mountain NRA General Management (USDA 1996).

In the Red Rock HMA, the Herd Use Areas (HUA) for the wild horses is from Bonnie Springs south to Bird Spring and Goodsprings. The wild burro's HUA is from Bonnie Springs north and east to White Rock and Red Springs. There is overlap in the use areas around State Route 160. The historic separation of the horses and burros has been due to existing old livestock fences across the HMA at Oliver Ranch, Bonnie Springs, and Spring Mountain Ranch.

Vegetation

The study area is in the eastern Mojave Desert. The plant communities represented in the study area include Mojave creosote bush scrub and Mojave wash scrub. Mojave creosote bush scrub occurs over most of the study area, and Mojave wash scrub occurs in the major washes.

Mojave Creosote Bush Scrub

Mojave creosote bush scrub is a widespread vegetation community type and the most common type found in the Mojave Desert at elevations less than 4,000 feet (Holland 1986; Rowlands *et al*. 1982; Vasek and Barbour 1977). The Mojave creosote bush scrub is characterized by widely spaced shrubs approximately 2 to 8 feet tall and is usually found on well-drained soils, often on bajadas and low hills (Holland 1986).

Creosote bush (*Larrea tridentata*) and white bursage (*Ambrosia dumosa*) often are co-dominant in this vegetation community type. Common species in this community, however, vary slightly with soil type and terrain but generally include a combination of the following species: Mormon tea (*Ephedra nevadensis*), Pima rhatany (*Krameria erecta*), chaff-bush (*Amphipappus fremontii*), turpentine broom (*Thamnosma montana*), snakeweed (*Gutierrezia microcephala*), silver cholla (*Opuntia echinocarpa*), beavertail cactus (*Opuntia basilaris*), and Mojave yucca (*Yucca schidigera*).

This community type is common throughout the Las Vegas Valley; however, much of it is fragmented and highly disturbed (BLM 2016) due to urban centers and mixed land ownership. Within this community, cactus and yucca often are dominant, but non-native species invasions have reduced the quality of this community type (BLM 2016).

Cacti and Yucca

Cacti and yucca species occur not only within the Mojave Creosote Bush Scrub vegetation community, but also among undeveloped land throughout the study area. Per NRS (Section 527.100), it is "unlawful to cut, destroy, mutilate, remove or possess any Christmas tree, cactus, yucca or branches thereof, or knowingly transport or sell any [of the same] from any of the lands owned by or under the jurisdiction of the State of Nevada or its counties, or on any reserved or

unreserved lands owned by the United States, or from any privately owned lands, without written permission from the legal owner, or his duly authorized agent, specifying locality by legal land description and number of plants to be removed or possessed." Permits allowing removal or destruction of cacti and yucca species may be obtained from the NDF. The BLM coordinates all plant salvages on BLM-administered lands with the State. The BLM is authorized to salvage vegetation on public lands under 43 CFR 5400 and BLM Manual 5000-1 (BLM 1991).

Mojave Wash Scrub

Mojave wash scrub occurs in the broad ephemeral washes that cross the study area. In general, Mojave wash scrub is a shrubby, open community with a scattered to locally dense overstory of microphyllous trees (Holland 1986). Common plants occurring in the washes of the study area include catclaw (*Acacia greggii*), snakeweed (*Gutierrezia microcephala*), indigo bush (*Psorothamnus fremontii*), big galleta grass (*Pleuraphis rigida*), cheesebush (*Hymenoclea salsola*), bush sunflower (*Encelia actoni*), bladder sage (*Salazaria mexicana*), paper daisy (*Psilostrophe cooperi*), desert marigold (*Baileya multiradiata* var. *multiradiata*), desert almond (*Prunus fasciculata*), and Mojave yucca (*Yucca schidigera*). Common plants of the adjacent creosote bush scrub community may also occur in the ephemeral washes.

Sensitive plant species have the potential to be affected by construction of flood control facilities and staging areas. However, avoidance of these plant species, and/or implementation of other measures may avoid any adverse effects. Such measures may include:

- Minimization of workspace used during construction
- Removal of topsoil in areas where sensitive plant species are known to occur and replacement of that topsoil after completion of construction
- Revegetation of the temporary construction use areas with plants salvaged from the disturbed project area

Ivory-spined Agave (*Agave utahensis var. eborispina*)

Ivory-spined agave is a BLM Sensitive Species (BLM 2023). This perennial succulent grows on calcareous outcrops with desert scrub (NatureServe 2017a). Ivory-spined agave occurs in California and Nevada.

Clark Mountain Agave (*Agave utahensis var. nevadensis*)

Clark Mountain agave is a BLM Sensitive Species (BLM 2023). This perennial grows in desert scrub to conifer woodlands on calcareous outcrops (NatureServe 2020a). The Clark Mountain agave is found in California and Nevada and is an endemic species to the Mojave Desert.

Las Vegas Bearpoppy (*Arctomecon californica*)

The Las Vegas bearpoppy is a State of Nevada critically endangered plant (NRS 527.260 through 527.300, and NAC 527.010), a BLM Sensitive Species, and is covered under the MSHCP. This perennial grows in areas such as barren, gravelly desert flats, hummocks, and slopes. Distribution is patchy, across low badland hills and sometimes on ridges and benches.

The Las Vegas bearpoppy is currently found only in scattered areas throughout Clark County and a few northern Arizona sites. Major populations occur in the Las Vegas Valley and typically are associated with the silty, gypsum-rich soils of the Colorado River drainage. Populations in this area are considered regionally significant because this is the only known area in the world where this plant grows. A potential impact to this species on federal land requires a permit from the NDF. Clark County maintains a permit for non-federal land from NDF.

Black Woollypod (*Astragalus funereus*)

Black woollypod is a BLM Sensitive Species and a NNHP At-Risk Species (BLM 2023, and NNHP 2021). This perennial grows in the desert transitional zones on gravelly clay ridges and ledges, and rocky areas (NatureServe 2022a). Black woollypod grows in California and Nevada at a wide range of elevation, 3,400 to 5,249 feet in California and 3,199 to 7,500 feet in Nevada.

Three Corner Milkvetch (*Astragalus geyeri* var. *triquetrus*)

Three corner milkvetch is a BLM Sensitive Species, a State of Nevada critically endangered plant (NAC 527.010), an NNHP At-Risk Species, and is covered by the MSHCP (NNHP 2008; 2018b). It is found in open, deep sandy soil or dunes and usually is found around other vegetation or in a gravel veneer (CCRFCD 2004).

Gilman's Milkvetch (*Astragalus gilmanii*)

Gilman's milkvetch is a BLM Sensitive Species and a NNHP At-Risk Species (BLM 2023, and NNHP 2021). This perennial grows in conifer woodlands, shrubland, and forest/woodland in gravelly or rocky areas (NatureServe 2015a). Gilman's milkvetch occurs in California and Nevada.

Straw Milkvetch (*Astragalus lentiginosus var. stramineus*)

Straw milkvetch is a BLM Sensitive Species and a NNHP At-Risk Species (BLM 2023, and NNHP 2021). Straw milkvetch grows in deep sand or sandy and gravelly flat dunes, flats, and washes between 1,600 and 4,000 feet of elevation (NatureServe 2019b). Straw milkvetch occurs in Arizona, California, and Nevada.

Half-ring Milkvetch (*Astragalus mohavensis var. hemigyrus*)

Half-ring Milkvetch is a BLM Sensitive Species and a NNHP At-Risk Species (BLM 2023, and NNHP 2021). Half-ring milkvetch grows on rocky ledges and arid gravelly hillsides on limestone (NatureServe 2015b). Half-ring milkvetch occurs in California and Nevada in the Mojave Desert scrub and Joshua tree woodland communities.

Mojave Milkvetch *(Astragalus mohavensis* var. *mohavensis)*

The Mojave milkvetch is on the NNHP watch list due to its rarity and restricted range. In Nevada, it is found only in Clark and Nye Counties (NNHP 2007a). There are 37 occurrences documented on NNHP's database and the last documented observation was in 1998 (NNHP 2008).

Nye Milkvetch (*Astragalus nyensis*)

Nye milkvetch is a BLM Sensitive Species and a NNHP At-Risk Species (BLM 2023, and NNHP 2021). Nye milkvetch grows in the foothills of desert mountains, gravelly flats, and sandy soil (NatureServe 1999). Nye milkvetch occurs in California, Nevada, and Utah.

Littlefield Milkvetch (*Astragalus preussii var. laxiflorus*)

Littlefield milkvetch is a BLM Sensitive Species and a NNHP At-Risk Species (BLM 2023, and NNHP 2021). This perennial grows in gravelly or sandy washes and clay flats in the southwest Mojave Desert (NatureServe 2008). Littlefield milkvetch occurs in Arizona, California, and Nevada at elevations 1,181 to 2460 feet.

Pahrump Silverscale (*Atriplex argentea var. longitrichoma*)

Pahrump silverscale is a BLM Sensitive Species and a NNHP At-Risk Species (BLM 2023, and NNHP 2021). Pahrump silverscale grows in saline soils of valley bottoms in the Mojave Desert scrub (NatureServe 2022b). Pahrump silverscale occurs in California and Nevada at elevations of 2,132 to 2,789 feet.

Tecopa Salty Bird's-Beak (*Chloropyron tecopense*)

Tecopa salty bird's-beak is a BLM Sensitive Species (BLM 2023). This annual grows in the Mojave Desert scrub, alkali flats and meadows (NatureServe 2015c). Tecopa salty bird's-beak occurs in California and Nevada at elevations below 2,500 feet.

Pintwater Rabbitbrush (*Chrysothamnus eremobius*)

Pintwater rabbitbrush is a BLM Sensitive Species and a NNHP At-Risk Species (BLM 2023, and NNHP 2021). This perennial grows on limestone cliff crevices of desert mountains (NatureServe 2017b). Pintwater rabbitbrush occurs in the state of Nevada.

Cane Spring Suncup (*Chylismia megalantha*)

Cane spring suncup is a BLM Sensitive Species and a NNHP At-Risk Species (BLM 2023, and NNHP 2021). Cane spring suncup grows in light-colored volcanic soils and salt desert shrub communities (NatureServe 1988). Cane spring suncup occurs in the state of Nevada.

Mojave Thistle (*Cirsium mohavense*)

Mojave thistle is a BLM Sensitive Species (BLM 2023). Mojave thistle grows in very limited wetland habitats and damp soil in the desert such as canyons, streams, hanging gardens, wet soil, springs, and alkaline desert meadows (NatureServe 2022c). It is usually associated with saltbush. Mohave thistle occurs in Arizona, California, Nevada, and Utah.

Blue Diamond Cholla *(Opuntia whipplei* var. *multigeniculata)*

Blue Diamond cholla is a State of Nevada critically endangered plant (NAC 527.010), a BLM Sensitive Species, and is covered by the MSHCP (NAC 527.010). The Blue Diamond cholla was formerly a candidate for listing but USFWS determined the species did not warrant a listing

under ESA. This cactus is found on rocky and sandy soils of desert slopes and is endemic to the Blue Diamond Hills of Clark County, Nevada (NatureServe 2008b).

Sanicle Biscuitroot (*Cympoterus ripleyi*)

Sanicle biscuitroot is a BLM Sensitive Species and a NNHP At-Risk Species (BLM 2023, and NNHP 2021). Sanicle biscuitroot grows in Joshua tree woodlands, Mojave Desert scrub, and in sandy carbonate soils (NatureServe 2002). It occurs in California and Nevada at elevations ranging from 3,280 to 5,446 feet.

White Bearpoppy (*Arctomecon merriamii*)

White bearpoppy is a BLM Sensitive Species, on the NNHP At-Risk Species list, and is covered by the MSHCP. It is found on dry basic soils, including alkaline clay and sand, gypsum, calcareous gravels, and carbonate rock outcrops (CCRFCD 2004).

Planoconvex Cordmoss (*Entosthodon planoconvexus*)

Planoconvex cordmoss is a BLM Sensitive Species and a NNHP At-Risk Species (BLM 2023, and NNHP 2021). This perennial grows in sandy soils, in canyons and along desert washes (NatureServe 2021a). Planoconvex cordmoss occurs in Arizona, California, New Mexico, Nevada and Utah at moderate to high elevations.

Las Vegas Buckwheat (*Eriogonum corymbosum* var. *nilesii*)

The Las Vegas buckwheat is a BLM designated Nevada Sensitive Species (BLM 2023), and is covered under the MSHCP. Las Vegas buckwheat was a candidate for listing as endangered or threatened under the ESA, but after a 12-month review the USFWS concluded that the listing was not warranted (USFWS, 2014). This species is a long-lived shrub with numerous, small yellow flowers that grow in clusters on the end of the stalks. The Las Vegas buckwheat occurs on and near gypsum soils, often forming low mounds or outcrops in washes and drainages, or in areas of generally low relief. It often grows with Las Vegas bearpoppy and other gypsum-tolerant species.

Bullfrog Hills Sweetpea (*Lathyrus hitchcockianus*)

Bullfrog hills sweetpea is a BLM Sensitive Species and a NNHP At-Risk Species (BLM 2023, and NNHP 2021). This perennial grows in washes and canyon in rocky volcanic, gravelly or sandy soils in desert scrub (NatureServe 2021b). It often grows entangled with nearby shrub. Bullfrog hills sweetpea occurs in California and Nevada at elevation ranging from 4,495 to 5200 feet.

Mojave Monardella (Monardella mojavensis)

Mojave monardella is a BLM Sensitive Species (BLM 2023). This perennial grows in mixed desert scrub, pinyon-juniper woodland, and desert riparian scrub habitats. It grows along granite boulders, flats, washes and cliffs (NatureServe 2022d). Mojave monardella occurs in California and Nevada at elevation ranging from 2625 to 4921 feet.

Yellow Two-tone Beardtongue (*Penstemon bicolor* spp. *bicolor*)

The yellow two-tone beardtongue is a BLM designated Nevada Sensitive Species (BLM 2023), is an NNHP At-Risk Species, and is covered under the MSHCP. This perennial grows in shallow, gravelly washes and on roadsides at elevations ranging from 1,970 feet to 5,480 feet (Mozingo and Williams 1980). It typically is associated with creosote bush habitats and its known distribution is Clark County, Nevada, and portions of Arizona.

Las Vegas Catseye (*Cryptantha insolita*)

Las Vegas catseye is a BLM Sensitive Species and a NNHP At-Risk Species (BLM 2023, and NNHP 2021). This perennial grows in light-colored alkaline clay flats and rolling hillsides with creosote bush scrub (NatureServe 2020b). Las Vegas catseye only occurs in southern Nevada.

White-margined Beardtongue (*Penstemon albomarginatus*)

White-margined beardtongue is a BLM Sensitive Species and a NNHP At-Risk Species (BLM 2023, and NNHP 2021). The white-margined beardtongue grows on desert dunes, sandy Mojave Desert scrub, at the base of hills and mountains, and loose sand washes (NatureServe 1989). White-margined beardtongue occurs in Arizona, California, and Nevada.

Rosy Two-Tone Beardtongue (*Penstemon bicolor* spp. *roseus*)

The rosy two-tone beardtongue is a BLM designated Nevada Sensitive Species and an NNHP At-Risk Species (NNHP 2021). This perennial grows on rocky calcareous, granitic, or volcanic soils in washes, roadsides, scree at outcrop bases, rock crevices, or similar places receiving enhanced runoff. It has been recorded at elevations from 1,800 feet to 4,839 feet. It typically is associated with creosote-bursage, blackbrush, and mixed-shrub zones. Its known distribution is Clark County, Nevada, and Arizona (NNHP 2001).

Mojave Fishhook Cactus (*Sclerocactus polyancistrus*)

Mojave fishhook cactus is a BLM Sensitive Species and a NNHP At-Risk Species (BLM 2023, and NNHP 2021). This annual grows in rocky soils of basalt rock hillsides, limestone hillsides, and desert pavement (NatureServe 2015d). They usually grow on south to southwest facing slopes. Mojave fishhook cactus occurs in the Mojave Desert in California and Nevada.

Mesquite (*Prosopis* spp.) and Catclaw Acacia (*Acacia greggii*)

Mesquite trees are native to the study area and currently do not have a formal status. However, because habitat for this species in the Las Vegas Valley is declining due to development, the BLM now requires mitigation for this species. Mesquite and Acacia woodlands provide critical habitat for many other sensitive species, including 11 species covered by the MSHCP; namely, the Phainopepla, whose diet consists primarily of mistletoe berries. Mistletoe is a parasite to mesquite and acacia trees and is dependent on them for its own growth (BLM 2006b). Small, scattered stands of mesquite occur in ephemeral drainages and on sand dunes throughout the study area. Mitigation for this species may include revegetation with native mesquites and in-lieu fee programs. These species can potentially occur throughout the study area.

Noxious Weeds

"Noxious weed" means any species of plant that is, or is likely to be, detrimental or destructive and difficult to control or eradicate (NAC 555 and NRS 555.005). Noxious weeds have become a growing concern in the U.S. and in southern Nevada because they can increase in cover relative to surrounding vegetation and exclude native plants from an area. The spread of noxious weeds has resulted in substantial economic impacts to some sectors of the state. Noxious weeds with the potential to occur in the study area are listed in Table **15-1.**

Table 15-1 - Southern Nevada Noxious Weed List

Common Name	Scientific Name	Other Name(s)
African rue	*Peganum harmala*	
Camelthorn	*Alhagi camelorum*	
Canada thistle	*Cirsium arvense*	
Crimson fountain grass	*Pennisetum setaceum*	
Diffuse knapweed	*Centaurea diffusa*	
Eurasian water-milfoil	*Myriophyllum spicatum*	
Giant reed	*Arundo donax*	Green fountain grass
Giant salvinia	*Salvinia molesta*	
Hoary cress	*Cardaria draba*	
Horsenettle	*Solanum carolinense*	Carolina horse-nettle
Hydrilla	*Hydrilla verticillate*	
Johnson grass	*Sorghum halepense*	Perennial sorghum
Malta starthistle	*Centaurea melitensis*	
Mediterranean sage	*Salvia aethiopis*	
Musk thistle	*Carduus nutans*	
Perennial pepperweed	*Lepidium latifolium*	Tall whitetop
Puncturevine	*Tribulus terrestris*	
Purple loosestrife	*Lythrum salicaria*	
Russian knapweed	*Centaurea repens*	
Saltcedar	*Tamarix spp.*	
Sahara mustard	*Brassica tournefortii*	African mustard
Salt cedar	*Tamarix ramosissima*	Tamarisk
Scotch thistle	*Onapordum acanthium*	
Spotted knapweed	*Centaurea maculosa*	
Toadflax, Dalmatian	*Linaria dalmatica*	
White Horse Nettle	*Solanum elaeagnifolium*	Sliver leaf nightshade
Whitetop	*Cardaria draba*	Hoary cress
Yellow starthistle	*Centaurea solstiltialis*	

Source: Nevada Administrative Code (September 2018; NAC 555.010)

The Las Vegas In-Valley EA (BLM 2016) reported a high density of saltcedar (*Tamarix ramosissima*) in the Las Vegas Valley, which were present throughout the Las Vegas Wash and tributaries. Crimson fountaingrass (*Pennisetum setaceum*) and Sahara mustard (*Brassica tournefortii*) also were very common throughout the Las Vegas Valley. Both species form large mono-culture stands and quickly out-compete native vegetation. The Sahara mustard seeds are toxic to the USFWS ESA threatened Mojave Desert tortoise.

Land that has been graded and cleared is vulnerable to noxious weed invasion because it no longer has native vegetation for competition. Seeds then can be easily introduced into these areas via construction vehicles that have been in other areas where noxious weeds are present. Seeds or plant material may become lodged between tire treads, in the coils of a winch, behind the license plate, or in cracks and crevices on the underside of the vehicle.

Impacts from the spread of noxious weeds can include:

- Decrease in biological diversity of native ecosystems
- Reduction in water quality and availability for native wildlife species
- Decrease in the quality of habitats for native wildlife
- Reduction in habitats needed by threatened and endangered species
- Increased direct and indirect competition with native species
- Health hazards (some species are poisonous to humans, wildlife, and livestock)

With implementation of mitigation measures, impacts associated with noxious weeds can be avoided or greatly reduced.

15.7.5. Paleontological Resources

Paleontological resources (fossils) are remains or traces of plants and animals that existed during the 600-million-year geological history of southern Nevada. Fossils are unique, non-renewable resources that provide clues to the history of life on Earth and, as such, have scientific value (BLM 1998a). These resources are protected on federal lands by federal legislation. While fossils are not expressly mentioned, they have been interpreted by federal agencies to be covered by the reference to “scientific” or “historic” values.

This legislation includes the following acts:

- *Antiquities Act of 1906* (16 USC 431-433). This act forbids the disturbance of any object of antiquity on federal lands without a federal permit, and also establishes sanctions for unauthorized appropriation of antiquities.
- *National Environmental Policy Act of 1969* (42 USC 4321-4347). This act requires that important natural aspects of the national heritage be considered in assessing the environmental consequences of a proposed project.

- *Archaeological and Historic Preservation Act of 1974* (16 USC 469-469c). This act provides for the preservation of historical and archaeological data that may be lost as a result of federal projects or federal actions. It specifically requires survey for, and protection or recovery of, objects or data of scientific significance that are threatened by construction activities.
- *Federal Land Policy and Management Act of 1976* (43 USC sec. 1701, 1761-1771). This act requires that scientific values be addressed in the management of public lands and resources.
- *2022 Nevada Revised Statute 383.121.* Requires that all departments, commissions, boards, and other agencies of the state and its political subdivisions cooperate with the State Historic Preservation Office (SHPO) to salvage or preserve historic, prehistoric or paleo-environmental evidence located on property owned or controlled by the United States, the state of Nevada, or its political subdivisions.

These laws only apply to public lands. On private lands, permission from the land owner is required. An area is considered paleontologically sensitive if it contains abundant vertebrate fossils or few fossils (large or small, vertebrate or invertebrate) that may provide new and important scientific information. Areas that may contain datable organic remains older than "Recent" and areas that may contain unique new vertebrate deposits, traces, and/or trackways are considered paleontologically sensitive (BLM and USACE 2004).

According to findings presented in the 2004 Las Vegas Valley Disposal Boundary EIS (BLM 2004), potential for sensitive paleontological resources exists along the Las Vegas Wash. These areas are referred to as the Horse Spring Formation, the Muddy Creek Formation, and the Las Vegas Formation. The Horse Spring Formation contains plant fossils and ichnofossils, as well as trackways of extinct animals. It is located in the vicinity of the C-1 and the Lower Las Vegas Wash watersheds. The Muddy Creek Formation contains vertebrate fossils of extinct Miocene and Pliocene taxa, and their trackways. It is located in the vicinity of the Range, the Lower Las Vegas Wash, and the C-1 watersheds. The Las Vegas Formation is highly fossiliferous and has been found to contain numerous vertebrate and megafauna fossils. It is a very large area and is found in portions of the Upper Northern Las Vegas Wash, the Lower Northern Las Vegas Wash, the Gowan, and the Central watersheds. The Tule Spring Fossil bed National Monument was established in December 2104 to conserve, protect, interpret, and enhance the Las Vegas formation. These areas that are considered sensitive within the project area are shown in **Figure G-2**. No subsequent surveys in the Las Vegas Valley have identified any other high potential localities of paleontological resources (BLM 2016).

15.7.6. Cultural Resources

Legislative mandates, including the National Historic Preservation Act of 1966, as amended (NHPA) (36 CFR 800), and the Archaeological Resources Protection Act of 1979, as amended (16 USC 470aa-mm), require federal agencies to assess potential effects federal actions may have on districts, sites, buildings, structures, or objects included, or eligible to be included, in

the National Register of Historic Places. Federal actions are defined as projects planned, constructed, or assisted by federal agencies through funding, technical support, or administrative authorizations such as licenses, permits, and ROW grants.

It is federal policy to avoid or minimize adverse effects to cultural resources when planning, constructing, and/or assisting a federal project. In some cases, it is impossible to avoid disturbance or destruction of cultural resources to implement an approved project. In such instances, it is federal policy to recover the information embodied in those resources through historical and archaeological study before the project begins.

The procedure for addressing cultural resources involves the consultation with other agencies, such as the SHPO, Tribal Historic Preservation Officer, and Advisory Council on Historic Preservation, before proceeding with projects that may adversely affect cultural resources. Section 106 of the NHPA legally mandates this process. The consultation process may be completed on a project-by-project basis or through the preparation of a Programmatic Agreement. The 2013 Nevada Revised Statutes, Chapter 383.121, states that "All departments, commissions, boards and other agencies of the State and its political subdivisions shall cooperate with the Office (SHPO) in order to salvage or preserve historic, prehistoric or paleoenvironmental evidence located on property owned or controlled by the United State, State of Nevada or its political subdivisions."

Previously, projects on BLM land in the Las Vegas Valley were addressed in the Finding of No Significant Impact and Decision Record, October 18, 1996 (EA Log No. NV-054-96-117) for the Bureau of Land Management Programmatic Environmental Assessment for Realty Actions in Las Vegas Valley, September 30, 1996, as amended (File No. 1-5-96-F-23R). Procedures for cultural resources on BLM land in the Las Vegas Valley also are described in these documents. SHPO concurred that "archaeological surveys are not required for proposed actions that accumulate less than 200 acres and are located within the area encompassed by this document" (SHPO 1996). The Las Vegas Valley Disposal Boundary EIS (BLM 2004) included a Class III archeological survey of 46,761 acres on BLM land. With the completion of the survey, BLM concluded that there was limited land remaining in the Valley that had not been disturbed and surveyed for archeological resources.

Based on the BLM's Las Vegas In-Valley Area Multi-Action Analysis Environmental Assessment's (BLM 2016) more recent analysis of cultural resources was conducted for the Las Vegas Valley. The In-Valley EA identified four areas where prehistoric resources are clustered: The Duck Creek Drainage area, the Las Vegas Springs area, the Eglington Escarpment overlooking the Las Vegas Wash, and the area around Tule Springs Fossil Beds National Monument. These areas also contain significance for the Southern Paiute (Nuwu) Native American tribe.

Both the In-Valley EA and the EA Disposal Boundary survey determined a total of nine sites are situated on land administered by BLM that are eligible for inclusion on NRHP, including: Tule Siding of the Las Vegas to Tonopah Railroad, historic segment of the Las Vegas to Bullfrog/Tonopah wagon road, prehistoric open sites, rock shelters, a rock alignment and

several rock-ring sites. SHPO concurred with this finding. Subsequent surveys have been conducted in the Las Vegas Valley, but they have been limited and few new sites have been discovered.

The 1992 changes to the NHPA placed major emphasis on the role of Native American involvement when actions involve tribal property or properties to which tribes attach religious and/or cultural significance as discussed in 36 CFR Part 800.14. These Traditional Cultural Properties (TCPs) are described in the *Guidelines for Evaluating and Documenting Traditional Cultural Properties*, National Register Bulletin No. 38. A TCP is a property where significance is derived from the role the property plays in a community's historically rooted beliefs, customs, and practices. A TCP can be a location associated with traditional ceremonial, medicinal, or religious activities of a Native American group; a rural community whose buildings or patterns of land use reflect cultural traditions valued by its long-term residents; or an urban neighborhood that is the traditional home of a particular group. These types of sites may be difficult to identify without contact with the tribal groups because a TCP can be a mountaintop, a lake, a neighborhood, a field, or a stretch of river. A TCP is eligible for inclusion in the National Register as a "historic property" because of its association with cultural practices or beliefs of a living community that (1) are rooted in that community's history, and (2) are important in maintaining the continuing cultural identity of the community.

Project–specific analysis for cultural resources may be required and would include a site record search and consultation with Native Americans to develop an inventory of potentially affected cultural resources including TCPs. Where sensitive cultural resources are known or have a high potential to occur, this information will be submitted to the SHPO/Tribal Historic Preservation Officer to initiate Section 106 consultation with the Advisory Council on Historic Preservation (SHPO 1998). Depending upon the types of resources identified and potential eligibility for inclusion to the NRHP, preparation of site-specific treatment plans may be required. If the site is important primarily for its information content, adverse impacts may be reduced to acceptable levels by implementing archaeological excavation and analysis plans, or completing detailed architectural recording according to standards developed by the U.S. Department of the Interior. If the site is significant for values other than its information content, a memorandum of agreement must be prepared for Advisory Council on Historic Preservation review.

15.7.7. Visual Resources

The 1998 BLM RMP/FEIS discusses the *Visual Resources Management Plan* (BLM 1986) used by the BLM to evaluate projects occurring on BLM managed lands for sensitivity to visual resources. Management classes describe the degree of modification allowed and are derived based on scenic quality, sensitivity levels, and distance zones.

The BLM has lands classified as Class II, Class III, and Class IV within the study area that were identified in the *Las Vegas Valley Disposal Boundary Environmental Impact Statement* (BLM 2004). The objective of Class II is to retain the existing character of the landscape. Only low levels of change are allowed, and should not attract the attention of the casual observer. The

objective of Class III is to partially retain the existing character of the landscape. The level of change to the characteristic landscape should not exceed moderate. Management activities may attract attention but should not dominate the view of the casual observer. Class IV lands provide for activities that require major modifications. The level of change can be high, and may dominate the view of the casual observer (BLM 1986).

Visual resources of the project area generally are characteristic of the Las Vegas Valley, McCullough Mountain Range, Jean Dry Lake, Sheep Mountain, Ivanpah Valley, and Roach Lake (dry), which are part of the Basin and Range geomorphic province. Major landforms include alternating north-south-oriented valleys with east-west-oriented alluvial fans emanating from the McCullough Mountain Range and Sheep Mountain. Also present are scattered pediments, or bajadas, that are occasionally cut by deeply incised dry-desert washes. The color of the landscape ranges from dark browns and grays to light tans and light green. Textures are medium to coarse in mountain/hill areas, and smooth to fine in valley, alluvial fan, and wash areas.

Impacts to visual resources are identified in the project specific environmental analysis.

15.7.8. Air Quality

The Clean Air Act (CAA) of 1963 and Amendments of 1977 and 1990 (42 USC 7401-7671q) are a set of environmental laws that established primary and secondary standards for national ambient air quality standards (NAAQS) for six criteria pollutants. These six criteria pollutants are carbon monoxide (CO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), particulate matter (including particles less than 10 microns in diameter [PM_{10}] and less than 2.5 microns in diameter [$PM_{2.5}$]), lead (Pb), and ozone (O_3). Of these six pollutants, only O_3 is not emitted directly from sources, but is formed in the atmosphere by the reaction of nitrogen oxides (NOx), volatile organic compounds (VOCs), and sunlight (EPA 2008b). Air quality in a given location is described by the concentrations of these pollutants in the atmosphere. An area that violates the NAAQS for one or more of the criteria pollutants is classified by the EPA as being in non-attainment of the standard. Non-attainment areas are further classified based on the magnitude of the air quality problem. These standards (or limits) are concentrations of the pollutant in the ambient air that is presumed to be protective of human health and the environment.

When the CAA was amended in 1990, the Las Vegas Valley Metropolitan Area (Hydrographic Basin 212) was classified as a “moderate” non-attainment area for both PM_{10} and CO. Under the CAA, states containing areas classified as being in “non-attainment” with the NAAQS are required to submit a state implementation plan (SIP) providing for attainment of health-based air quality standards. A SIP is a collection of state and local regulations and plans to achieve healthy air quality under the CAA. In response to the moderate non-attainment classification, Moderate Area SIPs were developed for each pollutant.

PM_{10} SIP

In response to the "moderate" non-attainment classification for PM_{10}, Clark County developed a Moderate Area PM_{10} SIP in 1991. However, the control measures contained in the 1991 SIP were not sufficient to fully meet the PM_{10} air quality standards. In 1993, the Las Vegas Valley was re-classified as a "serious" non-attainment area for PM_{10}. In 1994, the Clark County Board of Commissioners submitted a new PM_{10} SIP to the EPA, which provided for the implementation of best available control measures. Furthermore, in August 1997, the Board adopted the "Particulate Matter (PM_{10}) Attainment Demonstration Plan" for the Las Vegas Valley, which was later submitted to the EPA for review and approval. On May 3, 2004, the EPA approved the Clark County PM_{10} SIP (Department of Air Quality and Environmental Management [DAQEM] 2001 (note this department is now called the Department of Environment and Sustainability, Air Quality Division)), in which the County adopted a series of rules to control fugitive dust sources (EPA 2008d).

In June of 2007, Clark County demonstrated to the EPA that the Las Vegas Valley met the attainment of the 24-hour PM_{10} NAAQS by the applicable date of December 31, 2006 (Clark County 2007). The EPA published a determination of attainment for PM_{10} for Clark County in the Federal Register in August 2010 (Clark County 2012). In August of 2012, Clark County requested a redesignation of the Las Vegas Valley PM_{10} non-attainment area to attainment status under the 1998 24-hour NAAQS and continued attainment through 2023 (Clark County 2012). As part of the request, Clark County inventoried emissions of PM_{10} for the baseline year of 2008, and projected emissions forward through 2015 and 2023. The EPA approved the redesignation and maintenance plan in October 2014, and updated the Nevada SIP accordingly (EPA 2014).

CO SIP

In 1992, the NDEP submitted the first CO attainment plan to the EPA for approval. Due to CAA amendments of 1990, the Las Vegas Valley CO "moderate" nonattainment area was reclassified as a "serious" nonattainment area in 1997. Several revisions to the CO SIP then were submitted to the EPA. The Clark County Board of Commissioners approved and adopted the Las Vegas Valley CO SIP (DAQEM 2000) on August 1, 2000. On July 23, 2004, EPA finalized its approval of the SIP revisions submitted by the State of Nevada to provide for attainment of the CO NAAQS in the Clark County "serious" CO Nonattainment Area. The CO SIP was revised in 2005 (DAQEM 2005) to update CO emissions budgets using the latest model approved by EPA for transportation conformity determinations. The 2005 CO SIP Revision subsequently was approved by the EPA in August 2006.

On May 20, 2005, EPA made a final decision that Las Vegas, Nevada, and the surrounding area meets the federal public health air quality standards for CO. There have been no exceedances of the CO standard since 1998. However, a finding of attainment does not redesignate the area to attainment. Before an area can be redesignated, the State must submit, and EPA must approve, a maintenance plan showing, among other things, that the area will

continue to maintain the standard for a 10-year period (EPA 2005). In May 2008, Clark County prepared a CO Redesignation Request and Maintenance Plan (DAQEM 2008a). This plan is a formal request to the EPA to redesignate the Las Vegas Valley nonattainment area to attainment of the 8-hour CO NAAQS, and demonstration of continued attainment through year 2020. The EPA approved the redesignation and maintenance plan in September 2010, and the SIP was updated accordingly for the Las Vegas Valley (EPA 2010).

O_3

On April 15, 2004, the EPA designated Clark County as an O_3 nonattainment area for failing to meet the new 8-hour standard. It designated Clark County as a "basic" nonattainment area, which is the least severe of the possible classifications. The EPA established a transportation conformity rule allowing states in nonattainment to submit an early progress plan containing early motor vehicle emission budgets that address the O_3 standards in advance of a complete attainment demonstration. Early budget submittals do not need to demonstrate attainment, but must show some progress consistent with adopted control measures and projected emissions. Progress is demonstrated if projected emissions by the June 15, 2009, attainment date (2008 O_3 season) are less than emissions in the 2002 base year. As required, Clark County prepared the Draft 8-Hour O_3 Early Progress Plan (EPP) for Clark County, Nevada (DAQEM 2008b). The EPA published a notice in May 2009, confirming that the emission budgets outlined in the Clark County 8-Hour EPP will adequately meet future transportation conformity purposes (EPA 2009). In March 2011, the EPA published a final rule, indicating that Clark County met the 1997 8-hour O_3 NAAQS. In March 2011, Clark County prepared an O_3 Redesignation Request and Maintenance Plan (Clark County, 2011). This plan was a formal request to the EPA to redesignate the Clark County O_3 nonattainment area to attainment of the 1997 8-hour O_3 NAAQS, and demonstration of continued attainment through year 2022. The EPA approved the redesignation and maintenance plan in January 2013, and the SIP was updated accordingly for Clark County (EPA 2010).

In September 2016, Clark County submitted its Area Designation Recommendations for the 2015 O_3 NAAQS, recommending portions of the County be designated nonattainment. December 2017, EPA issued a 120-day letter stating that Las Vegas is a multi-jurisdictional nonattainment area that includes Indian tribes. In 2018, Clark County and the NDEP revised its recommendations and submitted a response to the EPA proposed designations requesting that only Las Vegas Valley be designated nonattainment. In June 2018, the EPA designated the Las Vegas Valley as a marginal nonattainment area for the 2015 O_3 NAAQS effective August 2018. In January 2023, the EPA issued a final rule determining that the Las Vegas Valley failed to attain the 2015 O_3 NAAQS by the application marginal nonattainment date and reclassifying the area as a moderate nonattainment area (88FR 775).

Currently, the Las Vegas Valley airshed is classified by the EPA (2023) as being "in attainment" for PM10, CO, NO2, SO2, and Pb; and as "moderate nonattainment" for O_3.

The state of Nevada regulates air quality following the CAA of 1963 and Amendments of 1977 and 1990 (42 USC 7401-7671q) and the NAAQS for criteria pollutants. Clark County has rules

and regulations for Air Quality outlined in Section 12 of the Clark County Air Regulations. Section 12 is applicable to existing and new stationary sources located in Clark County. Stationary sources are fixed emitters of air pollutants, and construction of a new stationary sources must comply with Clark County Air Regulations (Clark County 2014). Stationary sources are regulated as either major or minor sources and have different permitting requirements. Some stationary sources are considered exempt if they emit less than the thresholds defined for minor sources. The differences between major, minor and exempt stationary sources are as follows:

- Major sources - emit more than 100 tons per year for any one regulated pollutant; emit more than 25 tons per year total hazardous air pollutants (HAP); or, emit more than 10 tons per year of any one HAP or is a prevention of significant deterioration (PSD) source or major source on the maximum achievable control technology (MACT).
- Minor sources – emit less than 100 tons per year for any one regulated pollutant; emit less than 25 tons per year total HAP; or, emit less than 10 tons per year of any one HAP.
- Exempt sources – are minor sources with the potential to emit equal to or less than the PSD levels listed in Table 3-4.

The maximum threshold values stipulated in the Clark County Air Quality Regulations for the criteria pollutants broken down by major, minor and exempt stationary sources are listed in **Table 15-2**. These regulations are from Section 12 of the Clark County Air Regulations and apply on a project-specific basis.

Table 15-2 - Maximum Threshold Values for Stationary Sources in Clark County

Pollutant	Exempt Stationary Source	Minor Source PSD Area (Tons per calendar year)	Major Source PSD Area (tons per calendar year)
PM_{10}	≤5	7.5	15
CO	≤25	35	100
VOC*	≤5	20	40
SO_2	≤25	40	40
Pb	≤0.3	0.6	0.6

*Volatile organic compounds are any compound, excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate, which participates in atmospheric photochemical reactions.

Source: Clark County 2014

A project-specific analysis must be performed to identify the potential air impacts that may result from the project, and whether the project would be subject to conformity regulations.

15.7.9. Noise

The EPA (Noise Control Act 42 U.S.C. 4901 [1972]), Federal Aviation Administration (14 CFR Part 150 – Airport Noise Compatibility Planning), Department of Housing and Urban

Development (Subpart B of 24 CFR Part 51 – Noise Abatement and Control), Federal Highway Administration (23 CFR Part 771 – Procedures for Abatement of Highway Traffic Noise and Construction Noise), Occupational Safety and Health Administration (29 CFR Part 1926.52(d) – Safety and Health Regulations for Construction), and the Federal Transit Administration (FTA-VA-90-1003-06 – Noise and Vibration Impact Assessment) regulate noise generation from specific sources. Clark County regulates noise through rules generally based on the federal regulations.

Based on federal regulations, Clark County has developed codes for noise performance standards (Title 30.68.020) that set specific noise standards for facility operations and other uses. Although construction activities would have short-term noise effects on the residential and natural areas along any proposed construction, Title 30.68.020 states that no noise provision would be applied to temporary construction or demolition activities when conducted during daytime hours.

15.7.10. Hazardous Material

Environmental concerns have become an important factor in property acquisition because hazardous waste cleanups can be very expensive and take years to complete. A Phase I Environmental Site Assessment is an important action a purchaser can take to learn about the property's past use, the environmental conditions at the site and adjoining sites, and the likely presence of hazardous substances.

The Superfund Amendments and Reauthorization Act of 1986 (SARA) has dramatically changed certain portions of the previous legislation under the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) in the area of real property transactions. SARA recognized the fact that a landowner who had no connection with the release of hazardous substances at a property would still be liable under CERCLA. To remedy this problem, SARA provided an important defense, known as the “innocent landowner defense,” which is contingent upon a defendant having had no reason to know a property was contaminated prior to holding title (42 USC §9607 (b)(3)(a) and (b)). To establish an innocent landowner defense, SARA states “the defendant must have undertaken at the time of acquisition an all appropriate inquiry (AAI). In 2002, the Small Business Liability Relief Act to CERCLA (40 CFR Part 312), required that EPA establish standards for conducting an AAI. The AAI final rule was published in the Federal Register on November 1, 2005 (70 FR 66070). The standards identified the previous ownership and uses of the property consistent with good commercial or customary practice in an effort to minimize liability.” The minimum efforts to establish the SARA innocent landowner defense would require most real estate transactions (especially commercial and industrial) be assessed for environmental impairment prior to consummation of a property transfer to evaluate the risk of the transfer in light of potential environmental liabilities (Impact Environmental 2008).

Phase I Environmental Site Assessments include records reviews, a site visit, and interviews with owners, occupants, and local government officials. Phase I Environmental Site

Assessments do not involve sampling or laboratory analysis, but must be conducted by a trained and experienced environmental professional. Because Phase I Environmental Site Assessments include time-consuming reviews of government files and interviews, it is important to ensure adequate time is given to complete the Environmental Site Assessment to ensure the quality of the assessment. If the Phase I Environmental Site Assessment identifies potential hazardous substances, a Phase II Environmental Site Assessment usually is conducted to confirm the presence and extent of contamination. Phase II Environmental Site Assessments involve the collection and analysis of samples (Impact Environmental 2008).

In November 2005, the EPA approved the American Society for Testing and Materials (ASTM) Standard E1527-05, which was later updated in December 2013 (ASTM E1527-13) and most recently December 2021 (ASTM E1527-21). This Standard offers guidelines on how to conduct a Phase I Environmental Site Assessment. All appropriate inquiries must be done in compliance with either the latest ASTM Standard E1527-21 or with the requirements of the AAI Final Rule to obtain protection from potential liability under CERCLA (EPA 2017).

15.7.11. Socioeconomics

Socioeconomic factors often play an important role in facility locations and construction. However, when determining the location of proposed flood control facilities, stormwater flow patterns and existing topography, drainage, and washes are the prime determining factors. RFCD priorities to protect life and property from the 100-year frequency flood event dictate the need, size, and location for proposed facilities. These priorities were developed in response to the rapid growth and development in the Valley. This rapid growth is projected to continue.

Flood protection (or the lack of flood protection) affects the market value of property. Interviews conducted with realtors for preparation of the Final Environmental Impact Statement, Flood Control Master Plan, Clark County Regional Flood Control District (Dames & Moore 1991) found that value is based on the property owner's or buyer's perception of the degree of safety, physical building limitations, and the extra expense associated with protection of flood-prone properties. Therefore, a flood control provision is deemed economically beneficial and necessary for area development and resident safety (PBS&J 2002).

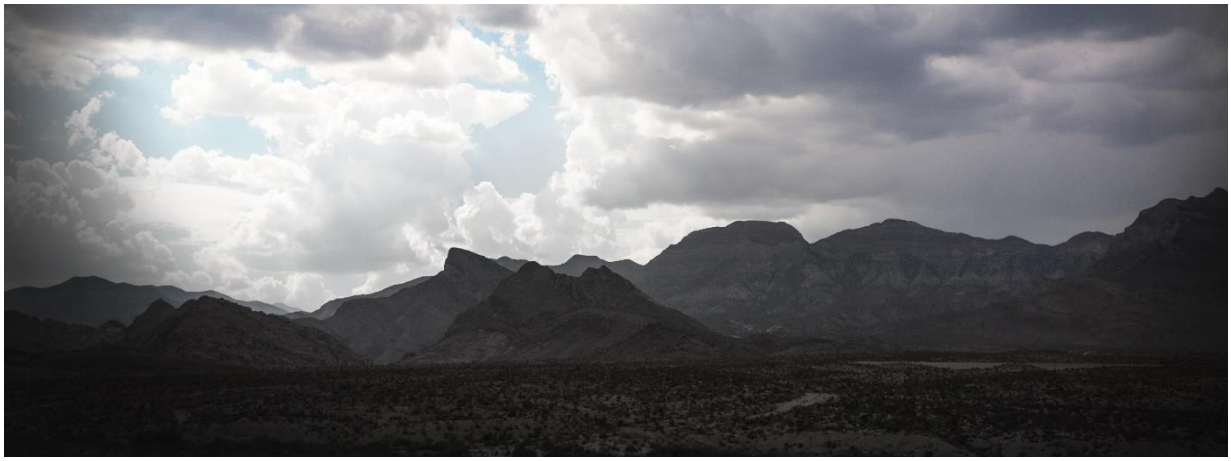
15.8. Environmental Justice

Executive Order 12898, signed on February 11, 1994, requires all "federal actions to address environmental justice in minority populations and low-income populations." The purpose of environmental justice is to determine whether a disproportionate share of a proposed project's adverse socioeconomic impacts is borne by minority and low-income communities. Federal agencies must take the appropriate and necessary steps to identify and address the disproportionately high and adverse effects of federal projects on this group of the population to the greatest extent practicable and permitted by law.

Executive Order 13045, signed on April 21, 1997, requires the "Protection of Children from Environmental Health Risks and Safety Risks." Executive Order 13045 directs that, to the extent permitted by law, and consistent with the agency's mission, each federal agency will:

- Make it a high priority to identify and assess environmental health risks and safety risks that may disproportionately affect children.
- Ensure that its policies, programs, activities, and standards address disproportionate risks to children that result from environmental health risks or safety risks.

According to the 2004 SEIS, no impacts were expected to occur to minority or low-income populations in the Las Vegas Valley (BLM and USACE 2004b). Based on U.S. Census Bureau data from 2015 from the *BLM Las Vegas In-Valley EA*, the Las Vegas Valley population was composed of 65 percent white/ Caucasian (BLM 2017). The median household income was $50,903 in 2014 with approximately 30 percent of combined individuals and families living below the poverty line, which is comparable to the national average (BLM 2016). Based on data from 2022 from the U.S. Census Bureau, the Las Vegas Valley population was composed of 52 percent white alone. The median household income was $66,356 with approximately 15 percent persons in poverty (U.S. Census Bureau, 2022). The income for the Las Vegas Valley is not considered low-income and minority communities must make up more than 50 percent of the population to be considered a minority population. Therefore, no mitigation would be required for Environmental Justice populations (BLM and USACE 2004b; BLM 2016).



CHAPTER 16

Literature Cited

16.1. Laws

16 United States Code (USC) 431-433. Antiquities Act of 1906.

16 USC 469-469c. Archaeological and Historic Preservation Act of 1974 (Moss-Bennett Act).

16 USC 470aa-mm. The Archaeological Resources Protection Act of 1979, as amended.

16 USC 703-711. Migratory Bird Treaty Act of 1918.

16 U.S.C. 1531-1544. Endangered Species Act of 1973.

26 USC 4611-4682. Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA).

33 USC 403. Section 10 of the Rivers and Harbors Act approved March 3, 1899.

33 USC 1251. Restoration and Maintenance of Chemical, Physical and Biological Integrity of Nation's Waters.

33 USC 1341. Section 401 of the Clean Water Act (Federal Water Pollution Control Act Amendments of 1972. As amended in 1977).

33 USC 1344. Section 404 of the Clean Water Act (Federal Water Pollution Control Act Amendments of 1972. As amended in 1977).

42 USC 4321-4347. The National Environmental Policy Act of 1969, as amended.

42 USC 4901. Noise Control Act of 1972.

42 USC 7401-7671q. Clean Air Act Amendments of 1990.

42 USC 9607 (b)(3)(a) and (b)). The Superfund Amendments and Reauthorization Act of 1986 (SARA).

43 USC §1701, 1761-1771. Federal Land Policy and Management Act of 1976.

14 Code of Federal Regulations (CFR), Part 150 Airport Noise Compatibility Planning.

23 CFR Part 771. Procedures for Abatement of Highway Traffic Noise and Construction Noise.

24 CFR Part 51 Subpart B. Noise Abatement and Control.

29 CFR Part 1926.52(d). Safety and Health Regulations for Construction.

33 CFR, Vol. 3, 328, Definition of Waters of the United States, Section 328.3. Definitions. Revised.

36 CFR 800. National Historic Preservation Act of 1966, as amended.

40 CFR 122.26 (b) (14). EPA Administered Permit Programs: The National Pollutant Discharge Elimination System.

59 Federal Register (FR) 5820. Critical Habitat Designated for the Desert Tortoise. February 8, 1994.

Executive Order 12898. Federal Actions to Address Environmental Justice in Minority Populations and Low-income Populations. February 11, 1994.

Executive Order 13045. Protection of Children from Environmental Health Risks and Safety Risks. April 21, 1997.

FTA-VA-90-1003-06. Federal Transit Administration Noise and Vibration Impact Assessment.

National Register Bulletin No. 38. Guidelines for Evaluating and Documenting Traditional Cultural Properties.

Nevada Revised Statutes (NRS) 383.121. Historic Preservation and Archeology

NRS 445a. Water Pollution Control.

NRS 501. Wildlife Administration and Enforcement.

NRS 501.100 to 503.104. Wildlife “protected” in the State of Nevada.

NRS 527. Protection and Preservation of Timbered Lands, Trees and Flora.

NRS 527.101. Cacti and yucca.

NRS 527.270 to 527.300. Plants “protected” in the State of Nevada.

NRS 555. Control of Insects, Pests, and Noxious Weeds, Nevada Department of Agriculture Weed Action Committee.

Nevada Administrative Code (NAC) 503. Hunting, Fishing and Trapping; Miscellaneous Protective Measures. February 2018.

NAC 503.020. Nevada State Game Species.

NAC 527. Protection and Preservation of Timbered Lands, Trees and Flora.

NAC 555. Control of Insects, Pests and Noxious Weeds.

Title 30.68.020. Clark County codes for noise performance standards.

16.2. General

American Society for Testing and Materials (ASTM) Standard 1527-00 (2021). Standard Practice for Environmental Site Assessments: Phase 1 Environmental Site Assessment Process.

ASTM. E1528-00 (2017). Standard Practice for Environmental Site Assessments: Transaction Screen Process

Berry, K.H., and L.L. Nicholson. (1984). *The Distribution and Density of Desert Tortoise Populations in California in the 1970s.* Pp. 26–60.

Berry, K.H. (Ed.). (1984). The Status of the Desert Tortoise (*Gopherus agassizii*) in the United States. Report to the U.S. Fish and Wildlife Service from the Desert Tortoise Council on Order No. 11310–0083–81BLM. (1986). Bureau of Land Management Manual Handbook 8431-1. Visual Resource Contrast Rating. Washington, DC: BLM.

Bureau of Land Management (BLM). (1997). Nevada Weed Management Strategy. Las Vegas, NV: U.S. Department of the Interior, Bureau of Land Management, Nevada State Office.

BLM. (1998a). Proposed Las Vegas Resource Management Plan and Final Environmental Impact Statement (RMP/FEIS). Las Vegas, NV: U.S. Department of the Interior, Bureau of Land Management Las Vegas Field Office.

BLM. (1998b). Rangewide Plan for Managing Bighorn Sheep Habitat on Public Lands. Washington, DC: BLM.

BLM. (2000). Phone conversation with G. Marrs-Smith. Bureau of Land Management and Billye Sisler (PBS&J) regarding Mojave Creosote Bush Scrub Seed Mix. June.

BLM. (2001). Proposed General Management Plan and Final Environmental Impact Statement for Red Rock Canyon National Conservation Area. Las Vegas, NV: U.S. Department of the Interior, Bureau of Land Management Las Vegas Field Office.

BLM. (2002). Personal Communication with Gayle Marrs-Smith, Vegetation Specialist, Bobby Tuttle (PBS&J), and Billye Sisler (PBS&J). May 8, 2002.

BLM. (2003). Nevada Bureau of Land Management Sensitive Species List.

BLM. (2004). Las Vegas Valley Disposal Boundary Environmental Impact Statement. Washington, DC: BLM.

BLM. (2006a). Red Rock Herd Management Area Draft Emergency Gather Plan Environmental Assessment. Washington, DC: BLM.

BLM. (2006b). Conservation Management Strategy for Mesquite and Acacia Woodlands In Clark County, Nevada. Washington, DC: BLM.

BLM. (2008a). National Environmental Policy Act Handbook, H-1790-1. Washington, DC: U.S. Department of the Interior, Bureau of Land Management.

BLM. (2008b). BLM Manual Transmittal Sheet 6840—Special Status Species Management. Available at: https://www.blm.gov/sites/blm.gov/files/uploads/mediacenter_blmpolicymanual6840.pdf. Site accessed 2024.

BLM. (2013). Using Science to Improve the BLM Wild Horse Program: A Way Forward. National Research Council. Available at: https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprd3796106.pdf. Site accessed 2024.

BLM. (2023a). Program Data: 1971 Wild Free-Roaming Horses and Burros Act. Available at: https://www.blm.gov/programs/wild-horse-and-burro/about-the-program/program-data. Site accessed February 2024.

BLM. (2023b). Herd Area and Herd management Area Statistics. Available at: https://www.blm.gov/sites/default/files/docs/2023-04/2023_HMA-HA_PopStats_4-3-2023_Final.pdf. Site accessed February 2024.

BLM. (2023c). BLM Nevada Special Status Species List. NV-IM-2024-003. Available at: https://www.blm.gov/policy/nv-im-2024-003. Site accessed February 2024.

BLM. (2017). *Las Vegas In-Valley Area Multi-Action Analysis Environmental Assessment.* DOI-BLM-NV-S010-2016-0054-EA. Available at: https://eplanning.blm.gov/public_projects/nepa/60096/116888/142565/Final_EA_FONSI_Decision_Response_508_Compliant.pdf. Site accessed February 2024.

BLM and U.S. Army Corps of Engineers (USACE). (2004a). *Record of Decision. Final Supplemental Environmental Impact Statement Clark County Regional Flood Control District 2002 Master Plan Update.* Washington, DC: BLM and USACE.

BLM and USACE. (2004b). *Supplemental Programmatic Environmental Impact Statement, Clark County Regional Flood Control District, 2002 Master Plan Update, Final*. Prepared by SWCA Environmental Consultants.

Clark County Division of Air Quality. (2007). PM10 State Implementation Plan Milestones Achievement Report. Clark County, Nevada: Clark County.

Clark County Division of Air Quality. (2012). Redesignation Request and Maintenance Plan for Particulate Matter (PM10). Clark County, NV: Clark County.

Clark County Division of Air Quality. (2014) Clark County Air Quality Regulations: Section 12. Preconstruction Review for New or Modified Stationary Sources. Amended April 18, 2014. Available at: http://www.clarkcountynv.gov/airquality/regulations/Pages/Rules_CurrentRulesandRegulations.aspx

Clark County. (2024). Clark County Air Quality Regulations: Section 12.0. Applicability and General Requirements for Permitting Stationary Sources. Amended February 20. Available at: https://webfiles.clarkcountynv.gov//Sect12.0_02-20-2024.pdf

Clark County. (1995). Desert Conservation Plan. Las Vegas, NV: Clark County.

Clark County. (2000). *The Multiple Species Habitat Conservation Plan and Environmental Impact Statement for Issuance of Permit to Allow Incidental Take of 79 Species in Clark County, Nevada*. Las Vegas, NV: Clark County.

Department of Air Quality and Environmental Management (DAQEM). (2000). Carbon Monoxide State Implementation Plan Las Vegas Valley Nonattainment Area. Las Vegas, NV: Clark County.

DAQEM. (2001). PM10 State Implementation Plan for Clark County. Las Vegas, NV: Clark County.

DAQEM. 2005. Carbon Monoxide State Implementation Plan Revision Las Vegas Valley Nonattainment Area. Las Vegas, NV: Clark County.

DAQEM. 2008a. *Carbon Monoxide Redesignation Request and Maintenance Plan, Las Vegas Valley Nonattainment Area.* Las Vegas, NV: Clark County.

DAQEM. (2008b). *Draft 8-Hour Ozone Early Progress Plan for Clark County, Nevada.* Las Vegas, NV: Clark County.

ESRI. (2017). *ESRI World Imagery 2017*. Eris, DigitalGlobe, GeoEye, Earthstar, Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

CCRFCD. (2001). Hydrologic Criteria and Drainage Design Manual. Revised December. Las Vegas, NV: CCRFCD.

CCRFCD. (2002). Policies and Procedures Manual. Las Vegas, NV: CCRFCD.

CCRFCD. (2004). Supplemental Environmental Impact Statement. Las Vegas, NV: Clark County.

Council on Environmental Quality (CEQ). (1987). *Council on Environmental Quality (CEQ) Regulations for Implementing Procedural Provisions of the National Environmental Policy Act, as amended.* 40 CFR Parts 1500-1508.

Dames & Moore. (1991). *Final Environmental Impact Statement, Flood Control Master Plan, Clark County Regional Flood Control District*. Las Vegas, NV: CCRFCD.

Dettinger, M.D., J.R. Harrill, and D.L. Schmidt. (1995). *Distribution of Carbonate-Rock Aquifers and the Potential for their Development, Southern Nevada and Adjacent Parts of California, Arizona, and Utah.* U.S. Geological Survey Water-Resources Investigations Report 91-4146. Washington, DC: U.S. Government Printing Office.

Environmental Laboratory. (1987). *Corps of Engineers Wetland Delineation Manual*. Technical Report Y-87-1. Vicksburg, MS: U.S. Army Corps of Engineers Waterways Experiment Station.

Environmental Protection Agency (EPA). (2018). State Implementation Plans and Status of Air Pollutants within Clark County. http://www.clarkcountynv.gov/airquality/planning/Pages/StateImplementationPlans.aspx. Site Accessed 2024

EPA. (2005). Region 9 Fact Sheet: Nonattainment Area Determination of Attainment of the Carbon Monoxide Standard for the Las Vegas Metropolitan Area. May.

EPA. (2008a). Surf Your Watershed, Las Vegas Wash Watershed Profile. Available at: http://cfpub.epa.gov/surf/huc.cfm?huc_code=15010015. Site accessed 2024.

EPA. (2008b). National Ambient Air Quality Standards. Air and Radiation. Available at: http://www.epa.gov/air/criteria.html. Site accessed 2024.

EPA. (2008c). Region 9: Air Programs, Air Quality Maps. Available at: http://www.epa.gov/region09/air/maps/maps_top.html]. Site accessed 2024.

EPA. (2008d). Las Vegas (Clark County) Particulate Matter Pollution. Available at: http://www.epa.gov/region09/air/vegaspm/index.html. Site accessed 2024.

EPA. (2008e). EPA Published Final Rule on All Appropriate Inquiries. Available at: http://www.epa.gov/swerosps/bf/regneg.htm. Site accessed 2024.

EPA. (2009). Notice of Adequacy. Federal Register. Volume 74, No. 92. May 14, 2009. Rules and Regulations.

EPA. (2010). EPA Notice of Final Approval. Federal Register. Volume 75, No. 186. September 27, 2010. Rules and Regulations.

EPA. (2014). EPA Notice of Final Approval. Federal Register. Volume 79, No. 193. October 6, 2014. Rules and Regulations.

Harrill, J.R. and D.E. Prudic. (1998). *Aquifer Systems in the Great Basin Region of Nevada, Utah, and Adjacent States: summary report.* U.S. Geological Survey Professional Paper 1409-A. Washington, DC: U.S. Government Printing Office.

Holland, R.F. (1986). *Preliminary Descriptions of the Terrestrial Natural Communities of California.* California Department of Fish and Game. Miscellaneous publication.

House, P. Kyle (2001). “Late Holocene Paleoflood History of Mormon Wells Wash, Desert National Wildlife Range, Nevada”. Nevada Bureau of Mines and Geology. University of Nevada. Reno, Nevada.

Impact Environmental. (2008). Phase I Environmental Site Assessments. Available at: http://www.impactenvironmental.com. Site accessed 2024.

Krueger, Jeri. (2000). Telephone communication between Jeri Krueger (U.S. Fish & Wildlife Service bird specialist) and Kelly Shook (PBS&J) regarding the Migratory Bird Treaty Act of 1918 and mitigation measures.

Las Vegas Valley Groundwater Management Program (LVVGMP), 2024 website. Accessed June 2023 from: https://www.lasvegasgmp.com/wells-groundwater/facts)

Las Vegas Valley Water District (LVVWD), 2024 website. Accessed June 2024 from: https://www.lvvwd.com/water-system/where-your-water-comes-from)

Las Vegas Wash Coordination Committee (LVWCC), 2000. Las Vegas Wash Comprehensive Adaptive Management Plan, Chapter 7. Accessed June 2024 from: https://www.lvwash.org/reports-and-studies/comprehensive-adaptive-management-plan/index.html. Site accessed 2024.

Mifflin, M.D. (1988). “Region 5, Great Basin,” in Back, W., J.S. Rosenshein, and P.R. Seaber, eds., *Hydrogeology: the Geology of North America*, v. O-2. The Geological Society of America. Boulder, Colorado.

Mozingo, H.N. and Williams, M. (1980). *Threatened and Endangered Plants of Nevada, An Illustrated Manual.* Washington, DC: Government Printing Office.

National Oceanic and Atmospheric Administration (NOAA). (1973). *National Oceanic and Atmospheric Administration Atlas 2, Precipitation Frequency Atlas of the Western United States.* Volume VII. Revised by the U.S. Army Corps of Engineers, 1988.

NatureServe. (1988). Chylismia megalantha. Intermountain Evening-primrose. Available at: https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.149635/Chylismia_megalantha. Site accessed February 2024.

NatureServe. (1989). Penstemon albomarginatus. White-margin Beardtongue. Available at: https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.127884/Penstemon_albomarginatus. Site accessed February 2024.

NatureServe. (1999). Astragalus nyensis. Nye Milkvetch. Available at: https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.144197/Astragalus_nyensis. Site accessed February 2024.

NatureServe. (2002). Cympoterus ripleyi. Ripley’s Cympoterus. Available at: https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.148154/Cymopterus_ripleyi. Site access February 2024.

NatureServe. (2008a). Phainopepla nitens Swainson 1838, Phainopepla. Available at: http://www.natureserve.org/explorer/servlet/NatureServe?sourceTemplate=tabular_report.wmt&loadTemplate=species_RptComprehensive.wmt&selectedReport=RptComprehensive.wmt&summaryView=tabular_report.wmt&elKey=104859&paging=home&save

=true&startIndex=1&nextStartIndex=1&reset=false&offPageSelectedElKey=104859&offPageSelectedElType=species&offPageYesNo=true&post_processes=&radiobutton=radiobutton&selectedIndexes=104859. Site accessed June 2.

NatureServe. (2008b). Opuntia whipplei var. multigeniculata. Blue Diamond Cholla. LBenson. Available at: http://www.natureserve.org/explorer//servlet/NatureServe?searchName=Opuntia+whipplei+var.+multigeniculata. Site accessed, 2024.

NatureServe. (2008c). Astragalus preussii var. laxiflorus. Lancaster Milkvetch. Available at: https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.138949/Astragalus_preussii_var_laxiflorus. Site accessed February 2024.

NatureServe. (2015a). Astragalus gimanii. Gilman's Milkvetch. Available at: https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.151903/Astragalus_gilmanii. Site accessed February 2024.

NatureServe. (2015b). Astragalus mohavensis var. hemigyrus. Half-ring Pod Milkvetch. Available at: https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.139166/Astragalus_mohavensis_var_hemigyrus. Site accessed February 2024.

NatureServe. (2015c). Chloropyron tecopense. Tecopa Bird's-beak. Available at: https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.158897/Chloropyron_tecopense. Site accessed February 2024.

NatureServe. (2015d). Sclerocactus polyancistrus. Mohave Fishhook Cactus. Available at: https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.155505/Sclerocactus_polyancistrus. Site accessed February 2024.

NatureServe. (2017a). Agave utahensis var. eborispina. Ivory Spined Agave. Available at: https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.153083/Agave_utahensis_var_eborispina. Site accessed February 2024.

NatureServe. (2017b). Chrysothamnus eremobius. Pintwater Rabbitbrush. Available at: https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.144838/Chrysothamnus_eremobius. Site accessed February 2024.

NatureServe. (2019b). Astragalus lentiginosus var. stramineus. Mottled Milkvetch. Available at: https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.154592/Astragalus_lentiginosus_var_stramineus. Site accessed February 2024.

NatureServe. (2020a). Agave utahensis var. nevadensis. Clark Mountain Agave. Available at: https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.139416/Agave_utahensis_var_nevadensis. Site accessed February 2024.

NatureServe. (2020b). Cryptantha insolita. Unusual Cat's-eye. Available at: https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.142439/Cryptantha_insolita. Site accessed February 2024.

NatureServe. (2021a). Entosthodon planovonvexus. Planoconvex Cord-moss. Available at: https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.127169/Entosthodon_planoconvexus. Site accessed February 2024.

NatureServe. (2021b). Lathyrus hitchcockianus. Bullfrog Hills Sweetpea. Available at: https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.154908/Lathyrus_hitchcockianus. Site accessed February 2024.

NatureServe. (2022a). Astragalus funereus. Black Milkvetch. Available at: https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.155929/Astragalus_funereus. Site accessed February 2024.

NatureServe. (2022b). Atriplex argentea var. longitrichoma. Pahrump Orach. Available at: https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.638276/Atriplex_argentea_var_longitrichoma. Site accessed February 2024.

NatureServe. (2022c). Cirsium mohacense. Mojave Thistle. Available at: https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.142524/Cirsium_mohavense. Site accessed February 2024.

NatureServe. (2022d). Monardella mojavensis. Granite Mountains Monardella. Available at: https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.1231522/Monardella_mojavensis. Site accessed February 2024.

Nevada Department of Agriculture. (2021). Nevada Noxious Weed List. Available at: https://agri.nv.gov/Plant/Noxious_Weeds/Noxious_Weed_List/. Site accessed February 2024.

Nevada Division of Environmental Protection (NDEP). (2008a). Stormwater Discharge Permits. Available at: http://ndep.nv.gov/bwpc/ storm01.htm. Site accessed 2024.

NDEP. (2008b). Permit Forms & Fee Schedules. Available at: http://ndep.nv.gov/bwpc/forms.htm. Site accessed 2024.

NDEP. (2018a). Stormwater Discharge Permits. [Available at: https://ndep.nv.gov/water/water-pollution-control/permitting/stormwater-discharge-permits/construction-sites-greater-than-1-acre. Site accessed 2024.

NDEP. (2018b). Temporary Discharge Permits. Available at: https://ndep.nv.gov/water/water-pollution-control/permitting/temporary-discharge-working-in-waterway. Site accessed 2024.

Nevada Department of Wildlife. (2022). The 2022 - 2032 Wildlife Action Plan. Barnes, J., Davis, L., Kleiber, J., Newmark, J., Mack. L., & Hessenius. A. (eds). Reno, NV 298 pages. https://www.ndow.org/wp-content/uploads/2023/11/2022-SWAP-Full-Doc-FINAL-print.pdf. Site accessed March 2024

Nevada National Heritage Program (NNHP). (2001). Rare Plant Fact Sheet, Penstemon bicolor (Brandegee) Clokey & Keck ssp. roseus Clokey & Keck, Rosy Twotone Beardtongue. June 25.

NNHP. (2007). Animal and Plant Watch List. Available at: http://heritage.nv.gov/lists/ watch.pdf. Site accessed 2024.

NNHP. (2008). Recorded endangered, threatened, candidate, and at-risk plant and animal elements (taxa) within the Las Vegas Valley Flood Control Master Plan Update Project. April 3.

NNHP. (2018a). Animal and Plant Watch List. Available at: http://heritage.nv.gov/sites/default/files/library/2018-01%20Watch%20List.pdf. Site accessed 2024.

NNHP. (2018b). Recorded endangered, threatened, candidate, and at-risk plant and animal elements (taxa) listed for Clark County, Nevada. Available at: http://heritage.nv.gov/species/lists.php. Site accessed 2024.

NNHP. (2021). At-Risk Plant and Animal Tracking List. July 2021. Available at: https://dcnr.nv.gov/uploads/heritage/2021-07_Track_List.pdf?fbclid=IwAR1WGMoH_kw6IuH1vp1_wKeCErBcAbO3LagvaN0aL_wjwIQFS8dhvP0iLbw . Site accessed February 2024.

O'Brian, J. (2000). Personal communication between John O'Brian (U.S. Department of Agriculture vegetation specialist) and Kelly Shook (PBS&J) regarding known noxious weeds in the Las Vegas Valley, Clark County, Nevada. July 17.

PBS&J. (2008). Clark County Regional Flood Control District 2008 Las Vegas Valley Flood Control Master Plan Update. Las Vegas, NV: CCRFCD.

Rowlands, P.G., H. Johnson, E. Ritter, and A. Endo. (1982). "The Mojave Desert." In: *Reference Handbook on the Deserts of North Americ*a. G. L. Bender (ed.). Westport, Connecticut, and London, England: Greenwood Press.

Smith, H.M. and E.D. Brodie. (1982). *A Guide to Field Identification of Reptiles of North America*. New York: Golden Press.

Southern Nevada Regional Planning Coalition. (1999). The Southern Nevada Strategic Planning Authority, Strategic Plan to Address Growth in Southern Nevada. Las Vegas, NV: SNRPC.

State Historic Preservation Office (SHPO). (1998). Guidelines for Section 106 Submissions to the Nevada State Historic Preservation Office. Nevada Department of Cultural Affairs, State Historic Preservation Office. Available at: http://dmla.clan.lib.nv.us/docs/shpo/guide/guide.htm. Site accessed 2024.

SHPO. (1996). State Historic Preservation Office letter of concurrence for the *Bureau of Land Management Programmatic Environmental Assessment for Realty Actions in Las Vegas Valley*, 1996, as amended. Las Vegas, NV: SHPO.

Stebbins, R.C. (1985). *A Field Guide to Western Reptiles and Amphibians*. Second Edition. Boston, MA and New York: Houghton Mifflin Company.

USACE. (2006). Interim Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Arid West Region. Vicksburg, MS: USACE.

USACE. (2007a). Jurisdictional Determination Form Instructional Guidebook. May 30.

USACE. (2008a). The Regulatory Permit Program. Available at: http://www.spk.usace.army.mil//organizations/cespk-co/regulatory/program.html. Site accessed 2024.

USACE. (2008b). Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Arid West Region. Version 2.0. Vicksburg, MS: USACE.

USACE. (2016). USACE Regulatory Guidance Letter: Jurisdictional Determinations. No. 16-01. October 2016. Available at: http://www.usace.army.mil/Portals/2/docs/civilworks/RGLS/rgl_16-01.pdf?ver=2016-11-01-093306-010. Site accessed 2024.

USACE. (2017b). Final Sacramento District Nationwide Permit Regional Conditions for Nevada and the Lake Tahoe Basin in California. March 19, 2017 until March 18, 2022.

USACE. (2021). Nationwide Permit 43 Stormwater Management Facilities. As Amended March.

USACE. (2024). Regional General Permit. Regulatory Division: SPK-2007-00300. Available at: https://ndep.nv.gov/uploads/documents/NV40124001_DraftPermit.pdf.

USACE, Hydrologic Engineering Center (HEC). (2006). *Hydrologic Modeling System (HEC-HMS)*, Version 3.1.0, November 2006.

U.S. Census Bureau. (2023). Las Vegas city, Nevada. Available at: https://www.census.gov/quickfacts/fact/table/lasvegascitynevada/PST045223. Site accessed February 2024.

U.S. Department of Agriculture, U.S. Forest Service. (1996). Spring Mountains NRA General Management Plan, dated October 1996

U.S. Department of Agriculture, Natural Resources Conservation Service. (2001). Unpublished soils data for outlying areas of the Las Vegas Valley, obtained 2001.

U.S. Department of Agriculture, Natural Resources Conservation Service. (1995). State Soil Geographic (STATSGO) Database, dated September 1995.

U.S. Department of Agriculture, Natural Resources Conservation Service. (1995). Supplemental Soil Survey of the Las Vegas Valley Area, dated December 1995.

U.S. Department of Agriculture, National Resources Conservation Service. (1985). Soil Survey of Las Vegas Valley Area, dated July 1985.

U.S. Department of Agriculture, Natural Resources Conservation Service. (1980). Soil Survey of Virgin River Area, dated July 1980.

U.S. Fish and Wildlife Service (USFWS). (1992). List of Threatened and Endangered Species.

USFWS. (1993a). Plant taxa for listing as endangered or threatened species; Notice of review. Federal Register, 58 (188): 51144-51190.

USFWS. (1993b). Biological Opinion on Clark County Regional Flood Control District's Master Plan. Las Vegas Field Office. April 28.

USFWS. (1995). Incidental Take Permit PRT-801045. August 1.

USFWS. (1997). Biological Opinion for Implementation of Multiple Use Activities Within the Las Vegas Field Office. November 25.

USFWS. (2007). What You Should Know About Burrowing Owls. March 16.

USFWS. (2014). 12-month finding on petition to list Erigonum corymbosum var. nilesii and Erigonum diatomaceum. Federal Register. Volume 79. No. 185. September 24, 2014.

USFWS. (2017). USFWS National Wetland Inventory. Wetland Mapper. Available at: https://www.fws.gov/wetlands/data/mapper.HTML. Accessed March 2024.

USFWS. (2024). Environmental Conservation Online System. List of Federal Threatened, Endangered, Candidate, Proposed, Non-Essential and Essential Experimental Populations, and Emergency Listings for all Plants. Available at: https://www.fws.gov/endangered/. Accessed March 2024.

U.S. Geological Survey (USGS). (2013). Desert Tortoise Species Distribution Model. Available at: https://databasin.org/datasets/a1f5e25b9b944f9fa6aa3be8f54f8a2e. Site accessed April 2024.

Vasek, F.C. and M.G. Barbour. (1977). "Mojave Desert Scrub Vegetation." Barbour, M.G. and Major, J. (eds.). *Terrestrial Vegetation of California.* New York: John Wiley and Sons.

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