BUREAU OF RECLAMATION

Lower Colorado River Mainstream Evaporation and Riparian Evapotranspiration Losses Report

Interior Region 8: Lower Colorado Basin

U.S. Department of the Interior

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Mission Statements

The U.S. Department of the Interior protects and manages the Nation's natural resources and cultural heritage; provides scientific and other information about those resources; honors its trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated Island Communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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Cover Photo: Sunrise at the Laguna Division Conservation Area, downstream of Imperial Dam.

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Acronyms and Abbreviated Terms

AF	Acre-feet
ASCE	American Society of Civil Engineers
AZMET	Arizona Meteorological Network
CIMIS	California Irrigation Management Information System
CRMMS	Colorado River Mid-Term Modeling System
CRSS	Colorado River Simulation System
ESP	Ensemble Streamflow Prediction
ET	Evapotranspiration
ft	Feet
GIS	Geographic Information Systems
HDB	Hydrologic Database
kAF	Thousand acre-feet
LCRAS	Lower Colorado River Annual Summary
NAIP	National Agricultural Imagery Program
NIB	Northerly International Boundary
NWS	National Weather Service
Reclamation	United States Bureau of Reclamation
SIB	Southerly International Boundary
US	United States
USGS	United States Geological Survey

Glossary

AZMET: A network of automated weather stations within the state of Arizona that provide reference evapotranspiration estimates.

CIMIS: A network of automated weather stations within the state of California that provide reference evapotranspiration estimates.

Evaporation: The process of converting liquid water to a vapor

Evapotranspiration: The combined effect of evaporation from the soil surface and transpiration from the plant canopy.

Geographic Information System: An information system that integrates, stores, edits, analyzes, shares, and displays geographic information.

National Weather Service: An agency of the United States federal government that is tasked with providing observed climate data, weather forecasts, warnings of hazardous weather, and other weather-related products to organizations and the public for the purposes of protection, safety, and general information.

Reference Evapotranspiration: The evapotranspiration rate from a reference surface. The reference surface is a hypothetical reference crop with specific characteristics.

Riparian Vegetation: Riparian vegetation refers to the vegetation that grows along the shores of freshwater rivers and lakes, or along some canals. As used in this report, riparian vegetation classes also include wetland types and natural vegetation within the lower Colorado River floodplain.

Seepage: The slow movement or percolation of water through soil or rock. Movement of water through soil without formation of definite channels. The movement of water into, through, and out of the soil from unlined canals, ditches, and water storage facilities.

Spectral Characteristics: The amount of spectral reflectance from the Earth's surface recorded by the satellite sensors in different portions of the electromagnetic spectrum for different land cover types.

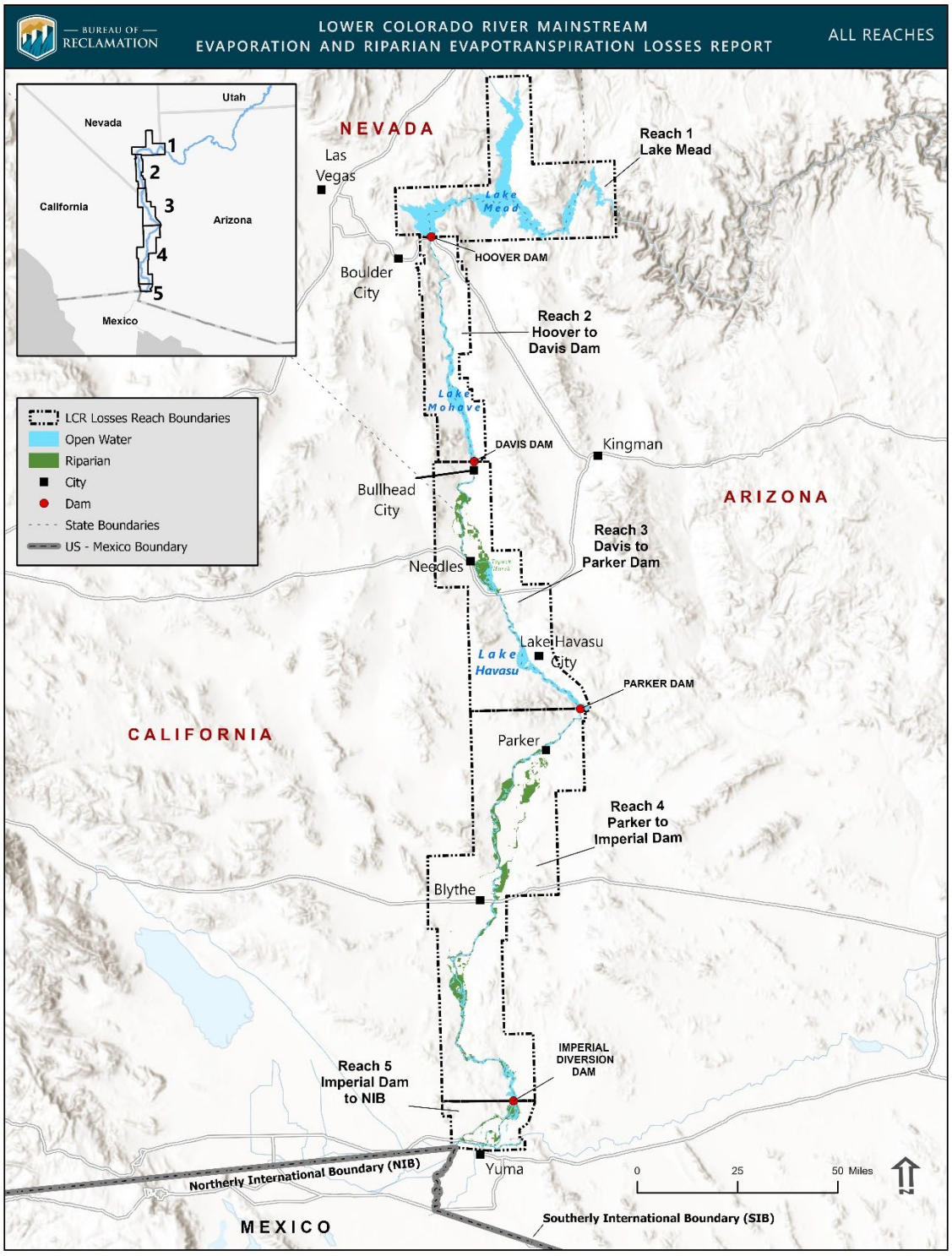

Figure 1. Map of reaches identified in the Lower Colorado River Mainstream Evaporation and Riparian Evapotranspiration Losses Report

Executive Summary

On August 16, 2022, the Bureau of Reclamation (Reclamation) and Department of the Interior announced several administrative actions for consideration to improve and protect the long-term sustainability of the Colorado River System. The System is currently experiencing prolonged drought and low runoff conditions accelerated by climate change that have led to historically low water levels in Lakes Powell and Mead (Reclamation, 2021). One of the actions included reviewing and prioritizing additional administrative initiatives to address system losses in the lower Colorado River mainstream. As part of that action, this report provides an overview of historical mainstream evaporation and riparian evapotranspiration (ET) losses along the lower Colorado River and presents methodologies used to develop those datasets. This report does not make recommendations on how to account for system losses in the lower Colorado River mainstream.

Data provided in this report were divided into five reaches, listed below. Data sources used for each reach are described in Chapter 2.

- Reach 1: Lake Mead
- Reach 2: Hoover Dam to Davis Dam
- Reach 3: Davis Dam to Parker Dam
- Reach 4: Parker Dam to Imperial Dam
- Reach 5: Imperial Dam to the Northerly International Boundary (NIB) with Mexico

This report presents two datasets: (1) Lower Colorado River Annual Summary (LCRAS) of ET and Evaporation; and (2) Reclamation's hydrologic database (HDB). The LCRAS dataset uses aerial imagery to determine open water and riparian acreages, then applies area and cover type ET coefficients to calculate evaporation and riparian ET estimates along the mainstream lower Colorado River and reservoirs between Hoover Dam and Mexico. HDB contains a computational processor that estimates evaporation losses from the lower Colorado River mainstream reservoirs (Lake Mead, Lake Mohave and Lake Havasu) based on lake elevations, the related surface water area, and monthly evaporation coefficients specific to each reservoir. HDB stores these estimates in its database. It does not provide evaporation estimates from the river sections between reservoirs and does not provide estimates of riparian ET. Methodologies to develop these datasets are described in more detail in Chapter 3.

Chapter 4 separately summarizes evaporation loss estimates available from LCRAS and HDB, then compares these two datasets at Lake Mohave and Lake Havasu, since both datasets can be used to estimate evaporation at these reservoirs. From 2017 to 2021, the average annual evaporation loss for Reach 1 through Reach 5 is estimated to be about 860 thousand acre-feet (kAF). This estimate uses HDB evaporation data for Reach 1, since LCRAS data is not available for that reach, then uses LCRAS data for Reaches 2 through Reach 5 to maintain as much consistency in the data sources as possible.

Chapter 5 summarizes riparian ET estimates available using LCRAS. Riparian ET estimates are not available for Reach 1: Lake Mead but is available for Reach 2 through Reach 5. From 2017

to 2021, the average annual riparian ET loss for Reach 2 through Reach 5 is estimated to be about 445 kAF.

Chapter 6 summarizes the total system losses, which is the combined evaporation and riparian ET data for each reach. From 2017 to 2021, the average annual total system loss (evaporation and riparian ET) for Reach 1 through Reach 5 is estimated to be about 1,304 kAF. Chapter 7 provides a summary of the data from the report.

1 Introduction

The Colorado River System provides essential water supplies to approximately 40 million people, nearly 5.5 million acres of agricultural lands, hydroelectric renewable power, recreational opportunities, habitat for ecological resources, and other benefits across the southwestern United States and northwestern Mexico (Reclamation, 2012). While the annual flow of the Colorado River and its tributaries varies considerably from year to year, the Colorado River System is currently experiencing prolonged drought and low runoff conditions accelerated by climate change that have led to historically low water levels in Lakes Powell and Mead (Reclamation, 2021). The period from 2000 through 2022 is the driest 23-year period in more than a century[1] and one of the driest periods in the last 1,200 years (Meko et al., 2007).

On August 16, 2022, the Bureau of Reclamation (Reclamation) and Department of the Interior announced several administrative actions for consideration to improve and protect the long-term sustainability of the Colorado River System (Reclamation, 2022a). These actions were identified in the context of the low reservoir conditions as described in Reclamation's Colorado River Basin August 2022 24-Month Study[2].

The administrative actions in the Lower Basin included reviewing and prioritizing additional administrative initiatives that would ensure maximum efficient and beneficial use of urban and agricultural water, and address evaporation, seepage, and other system losses in the Lower Basin. As part of that action, this report provides an overview of evaporation and riparian evapotranspiration (ET) losses along the lower Colorado River mainstream. The report presents methodologies that have been used to develop those datasets; however, it does not make recommendations on how to implement or account for system losses from the lower Colorado River mainstream. Data regarding seepage to groundwater were not included in this report. Seepage along the mainstream of the lower Colorado River is not considered to be a loss from the system as water entering the aquifer will re-emerge further downstream within the Colorado River.

Estimates of lower Colorado River mainstream evaporation and riparian ET losses provided in this report were divided into five reaches, as follows:

- Reach 1: Lake Mead
- Reach 2: Hoover Dam to Davis Dam
- Reach 3: Davis Dam to Parker Dam
- Reach 4: Parker Dam to Imperial Dam
- Reach 5: Imperial Dam to the Northerly International Boundary (NIB) with Mexico

[1] The Colorado River Basin natural flow record is available at https://www.usbr.gov/lc/region/g4000/NaturalFlow/provisional.html.
[2] For more information on the 24-Month Study Projections, see https://www.usbr.gov/lc/region/g4000/riverops/24ms-projections.html.

A map of the reaches is provided in Figure 1, on page ix. More detail on each individual reach is provided in maps included in Appendix 1.

2 Data Sources

This report summarizes data from two datasets: (1) Lower Colorado River Annual Summary (LCRAS) of ET and Evaporation[3]; and (2) Reclamation's hydrologic database (HDB)[4]. These two datasets were developed using separate methodologies for calculating evaporation and riparian ET losses, as described below:

1) The LCRAS dataset is derived from Reclamation's LCRAS reports, which provide estimates of annual agricultural, riparian vegetation, and open-water evaporation and evapotranspiration along the lower Colorado River from Hoover Dam to the Southerly International Boundary (SIB) with Mexico. The method used to create this dataset involves estimation of water use for a specific land cover type (open water, riparian vegetation type, or crop) using acreages derived yearly from Geographic Information Systems (GIS), a daily standardized ASCE Penman-Monteith reference ET rate for short crops, and a daily cover-type-specific coefficient.

2) HDB calculates and stores evaporation data from the lower Colorado River mainstream reservoirs (including Lake Mead, Lake Mohave, and Lake Havasu) based on lake elevations and related surface-water area, along with monthly evaporation coefficients that have been previously determined for each reservoir. The computational processor in HDB derives an average water surface area for the reservoir based on the area-capacity tables[5], then multiplies that surface area by the monthly evaporation coefficients specific to the reservoir. These calculations are completed on a daily timestep, and daily values are summed to get monthly and annual data. This method does not calculate evaporation or riparian ET losses along the Colorado mainstream.

Reclamation's operations and planning models, such as the Colorado River Mid-term Modeling System (CRMMS) and the Colorado River Simulation System (CRSS), cannot be used to calculate historical evaporative and riparian losses. Instead, these models are used to calculate possible future evaporation losses based on possible future reservoir conditions. To do this, these models use the same method that HDB uses to calculate historical evaporation, except that the evaporation projections in the models use a monthly timestep instead of a daily timestep[6]. Reclamation does model estimates of historical intervening flows or losses from Lees Ferry to the Northerly International Boundary (NIB) with Mexico using the Lower Colorado Gain/Loss Model, but they are calculated as the residual of a water balance equation and do not provide a

[3] For more information on LCRAS, see https://www.usbr.gov/lc/region/g4000/wtraccttypes.html#LCRAS.
[4] HDB is the foundation for Reclamation's Database of Record. More information on HDB is available at: http://www.hydrodb.net/#:~:text=The%20Hydrologic%20Database%20(HDB)%20is,various%20systems%20and%20personal%20spreadsheets.
[5] Lake Mead's elevation and the area and capacity tables are available at https://www.usbr.gov/lc/region/g4000/LM_AreaCapacityTables2009.pdf.
[6] While HDB calculates evaporation on a daily timestep, then sums the daily estimates to obtain monthly and annual values, the models only calculate evaporation on a monthly timestep, therefore evaporation estimates in the models will slightly differ from HDB.

breakdown of the mainstream evaporative or riparian ET losses, and are also computed on a monthly timestep instead of a daily timestep.

Reach 1, which only includes Lake Mead, calculates evaporation losses from HDB using evaporation coefficients specific to the lake[7]. There are no LCRAS data for this reach.

Mainstream evaporation and riparian evapotranspiration estimates for Reaches 2 through 5 are from the LCRAS dataset. The LCRAS open water data accounts for the mainstream lower Colorado River, reservoirs, lakes, lagoons, and other backwater area surfaces. These estimates utilize the acreage of water derived from GIS combined with three sets of evaporation coefficients that are specific for reaches two and three, four, and five. Mainstream evaporation losses from the lower Colorado River reservoirs were included in the reach datasets (for example, Lake Mohave evaporation was included in Reach 2). The LCRAS riparian data accounts for all the riparian habitat within floodplain of the lower Colorado River to the SIB. Riparian losses for Reaches 2 through 5 also use a GIS layer to determine the acreage of six different riparian vegetation classes. Each vegetation class has its own specific coefficients that are used in all reaches.

In addition to being used to estimate evaporation losses for Reaches 2 through 5, the LCRAS open water GIS dataset was used to estimate evaporation from Lake Mohave and Lake Havasu separately, to provide comparison to the evaporation estimates from HDB.

HDB includes estimates of evaporation losses from Lake Mead, Lake Mohave, and Lake Havasu. The original evaporation coefficients used to estimate evaporative losses were based on Class-A Pan evaporation studies. Those coefficients are still used to estimate evaporation at Lake Havasu. Evaporation coefficients for Lake Mead and Lake Mohave were updated in 2021 after a multi-year evaporation study was performed by the United States Geological Survey's (USGS) Nevada Water Science Center in Boulder City, Nevada (USGS, 2017). Reclamation's Boulder Canyon Operations Office completed a sensitivity analysis, following Reclamation's formal Peer Review process, on the new evaporation coefficients before updating the coefficients for modeling and reporting purposes[8] (Reclamation, 2022b). The new evaporation coefficients were applied to the entire Lake Mead 2001 – 2021 dataset and the Lake Mohave 2017 – 2021 dataset for this report since they provide a more accurate temporal distribution and evaporation magnitude at Lake Mead and Lake Mohave. These evaporation coefficients may be revisited and adjusted in the future to incorporate the most recent reservoir elevation and regional climate trends.

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[7] Evaporation losses between Lees Ferry and Lake Mead, and riparian ET losses between Lees Ferry and Hoover Dam, are not included since those data are not available in current Reclamation datasets. While Reclamation's operations and planning models provide a gains/losses term between Lee's Ferry and Lake Mead, it is calculated as the residual of a water balance equation and does not provide a breakdown of the evaporative or riparian ET losses.

[8] The new USGS coefficients are used in the official HDB record starting in October 2021. Reclamation's operations and planning models were updated after Reclamation completed the sensitivity analysis (Reclamation, 2022b). The USGS coefficients were implemented in the Colorado River Mid-Term Modeling System (CRMMS) in April 2022, and in the Colorado River Simulation System (CRSS) in version 6, released in April 2023. More information on these models is available at: https://www.usbr.gov/lc/region/g4000/riverops/model-info.html#policy.

Table 1 summarizes the evaporation and riparian ET data sources used for each reach. Additional details on the methodology used to estimate evaporation and riparian ET loss estimates are provided in Chapter 3 of this report. Evaporation losses are summarized in Chapter 4 and provided in Appendix 2 (LCRAS Data) and Appendix 3 (HDB Data). Riparian ET losses are summarized in Chapter 5 and provided in Appendix 4.

Table 1. Data source for mainstream evaporation and riparian ET losses.

Reach	Evaporation Data Source	Riparian ET Data Source
Reach 1: Lake Mead	HDB	N/A
Reach 2: Hoover Dam to Davis Dam	HDB (Lake Mohave only) & LCRAS Open Water	LCRAS Riparian
Reach 3: Davis Dam to Parker Dam	HDB (Lake Havasu only) & LCRAS Open Water	LCRAS Riparian
Reach 4: Parker Dam to Imperial Dam	LCRAS Open Water	LCRAS Riparian
Reach 5: Imperial Dam to NIB	LCRAS Open Water	LCRAS Riparian

3 Methodology

This section describes the methodologies used to develop the loss datasets in LCRAS and HDB, which were compiled for this report.

The LCRAS loss estimates were compiled in this study to estimate evaporation and riparian ET losses along the mainstream lower Colorado River and reservoirs between Hoover Dam and the NIB. While LCRAS data are available to the SIB, the NIB is the location at which water is officially delivered to Mexico and no longer under US jurisdiction. As a result, this report only presents data to the NIB. The methodology to develop the LCRAS dataset is described in Section 3.1. HDB was used to estimate evaporation from Lake Mead, Lake Mohave, and Lake Havasu based on lake elevations. The methodology for that dataset is described in Section 3.2.

Evaporation estimates using the LCRAS data were compiled for Lake Mohave and Lake Havasu separately to compare those evaporation estimates to the data from HDB.

3.1 Data from LCRAS

Reclamation routinely estimates mainstream evaporation and riparian ET losses for Reaches 2 through 5. The estimates are calculated using a combination of weather data and GIS databases containing the spatial boundaries of open water and riparian cover along the mainstream of the lower Colorado River below Hoover Dam.

Key components of the calculations include:

1) Identifying open-water and riparian areas and tabulating acreages associated with each land cover type (riparian vegetation group or open water) on a yearly basis.
2) Determining the average daily reference ET for each reach.
3) Applying the daily evaporation and ET coefficients for each land cover type (riparian vegetation group or open water) to derive a daily, monthly, or yearly ET rate for each land cover type.

These components are described in more detail in the following sections.

3.1.1 LCRAS Open Water GIS Layer

The initial LCRAS open-water spatial dataset was digitized based on aerial imagery at the beginning of the LCRAS program in 1995 (Reclamation, 1997). Water body types included in this report from the open water dataset are described in Table 2.

Table 2. Water body types from the open water dataset included in this report.

Water Type	Description
Main Channel	The main channel of the lower Colorado River, including all mainstream reservoirs.
Backwater	A water body that is hydrologically connected to, but not part of, the main channel of the Colorado River.
Marina	Main channel reaches or backwaters that are being used as marinas.

3.1.1.1 Yearly Updates of the Open Water GIS Layer

Each year, the open water GIS layer is updated by comparing it to the most recent aerial and satellite imagery available. Imagery and datasets from previous years may be consulted to ensure that the changes seen in a particular year are not the result of yearly fluctuation of water levels or differences due to the timing of image acquisition.

3.1.2 LCRAS Riparian GIS Layer

The current LCRAS riparian layer was created beginning with the 2010 calendar year (Reclamation, 2014). During this effort, the riparian areas along the mainstream were classified into 6 different vegetation types using 1-meter resolution National Agricultural Imagery Program (NAIP) imagery and object-based image analysis with eCognition® Developer software (Trimble, Inc.).

Riparian vegetation classes are shown in Table 3.

Table 3. Riparian vegetation types in the LCRAS GIS Layer.

Riparian Vegetation Type	Description
Barren	Less than 10% vegetation
Cottonwood/Willow	61% to 100% cottonwood and willow
Marsh	40% cattail, bulrush, and phragmites
Mixed Veg Low	Mixed vegetation types that may include salt cedar, mesquite, or arrowweed with crown closure greater than or equal to 10% and less than 40%
Mixed Veg Medium	Mixed vegetation types that may include salt cedar, mesquite, or arrowweed with crown closure greater than or equal to 40% and less than or equal to 80%
Salt Cedar Dense	Predominant salt cedar with crown closure greater than 80%

3.1.2.1 Yearly updates of the Riparian GIS layer

Since 2010, the riparian GIS layer has been updated each year by comparing the current year's satellite imagery (Landsat or Sentinel) to the previous year's imagery and determining where changes have occurred.

The change detection procedure is as follows:

1) Create a principal components image from a mosaiced image of the entire area of interest (the mainstream of the river from Hoover Dam to NIB) in the current year. Principal components compress data from a multiband raster into one band to be used for comparison.

2) Compare the new principal component image and other imagery to the previous year's imagery to visualize where change has occurred. It is important that the two images being compared are as close as possible to exactly one year apart.

3) Review areas where change has occurred and edit the riparian layer to reflect those changes in the current year. Due to the relatively coarse resolution of the satellite imagery, only changes greater than a few acres are detected, such as new development, land clearing or burned areas.

4) Additional updates are made when higher resolution imagery is available (e.g. NAIP).

3.1.3 Calculating Reference ET

Reference ET represents a standardized measure of the rate of water use by vegetation (in linear units, such as inches) to which the rate of water use of all types of vegetation (as well as the rate of evaporation from a body of water) can be related.

Reclamation uses reference ET values calculated with the standardized Penman-Monteith equation developed by the American Society of Civil Engineers (standardized equation) for short crops (ASCE 2005), and climatological data provided by the Arizona Meteorological Network (AZMET) and California Irrigation Management Information System (CIMIS) automated weather stations. These stations are located in irrigated areas along the Colorado River from Davis Dam to Mexico. The AZMET and CIMIS stations continuously collect maximum, minimum, and average air temperature and relative humidity; average soil temperature, wind speed, and precipitation data; and calculate net solar radiation. Reclamation downloads these parameters from the AZMET and CIMIS websites[9] and uses them to calculate hourly and daily reference ET rates. Reclamation maintains a contract with the University of Arizona, which is the operator of the AZMET network, to provide data quality review for those AZMET and CIMIS stations used in the LCRAS program.

Table 4 provides a list of the stations used to collect the reference ET data used in Reclamation's calculations and the corresponding geographical areas and reaches for which each station's data are applied.

[9] The AZMET website can be found here: https://cals.arizona.edu/azmet/. The CIMIS website can be found here: https://cimis.water.ca.gov/.

Table 4. LCRAS areas and associated weather stations for the calculation of reference ET along each reach.

Area	Reach	Weather Stations	
		AZMET	CIMIS
Mohave Valley area	Reach 2: Hoover Dam to Davis Dam Reach 3: Davis Dam to Parker Dam	Mohave Mohave II Mohave ETo	--
Parker/Palo Verde valleys	Reach 4: Parker Dam to Imperial Dam	Parker Parker II	Blythe NE Ripley Palo Verde II
Yuma area	Reach 5: Imperial Dam to the NIB	Yuma North Gila Yuma South Yuma Valley Yuma Valley ETo	--

3.1.4 ET Coefficients for Open Water and Riparian Types

ET coefficients (abbreviated Kc) are the values that relate reference ET rates to the ET rate of a specific riparian vegetation group, as well as to the open-water evaporation rate from a body of water. Multiplying the reference ET by the ET coefficient for a type of riparian vegetation or body of water results in an estimate of the amount of water consumed by that land cover type for a particular day. *Coefficients for Vegetative Evapotranspiration and Open Water Evaporation for the Lower Colorado River Accounting System*, Jensen, Marvin E. (1998*),* presents the rationale used to develop the original riparian vegetation groups along the lower Colorado River and the Bill Williams River, their respective ET coefficients, and open water evaporation coefficients. *Vegetative and Open Water Coefficients for the Lower Colorado River Accounting System (LCRAS), Addendum to the 1998 Report*, Jensen, Marvin E. (2003), presents the adjustments made to the crop and riparian vegetation groups and the ET and evaporation coefficients. In general, open water coefficients were developed using an energy balance - aerodynamic approach (Jensen 1998, 2003). Development of riparian vegetation coefficients for cottonwood/willow and marsh cover types also used a similar approach along with the linear segment crop coefficient curve (FAO-24, 1977, Jensen 1998, 2003) to account for plant phenology.

ET Coefficients for salt cedar dense, mixed vegetation medium, mixed vegetation low, and barren vegetation types were based on USGS (2006), *Evaporation by Phreatophytes Along the Lower Colorado River at Havasu National Wildlife Refuge, Arizona*. In this study, ET was directly measured using Bowen ratio stations to generate updated daily ET coefficients for these four riparian vegetation types. Study areas for cottonwood/willow and marsh were not updated in this study, therefore, coefficients for these vegetation types were maintained from Jensen (2003).

Evaporation calculations for open-water surfaces along the mainstream of the lower Colorado River use unique evaporation coefficients for each geographical area (Jensen, 2003), as described

in Table 5. The coefficients are included in Appendix 5. The final ET rates based on the reference ET and daily coefficients are presented in Appendix 6.

Table 5. Source for evaporation and evapotranspiration daily coefficients.

Land Cover Type	Applicable Reaches	Source
Open Water	Hoover Dam to Parker Dam	Jensen (2003) Page 69, Column 2
Open Water	Parker Dam to Imperial Dam	Jensen (2003) Page 69, Column 3
Open Water	Imperial Dam to NIB	Jensen (2003) Page 69, Column 4
Barren	All Reaches	USGS (2006) (Barren)
Cottonwood/Willow	All Reaches	Jensen (2003)
Marsh	All Reaches	Jensen (2003)
Mixed Veg Low	All Reaches	USGS (2006) (Arrowweed)
Mixed Veg Medium	All Reaches	USGS (2006) (Mixed Vegetation)
Salt Cedar Dense	All Reaches	USGS (2006) (Salt Cedar Dense)

3.1.5 Calculating LCRAS Open Water Evaporation

Reclamation calculates estimates of evaporation from Lake Mohave and Lake Havasu, and the open water areas of the mainstream Colorado River channel and its adjacent backwaters (such as Topock Marsh and Mittry Lake) from below Hoover Dam to the NIB. For the purposes of this report, to be consistent with calculations in Reach 1, the method used in this report departs from the normal LCRAS method in that it does not subtract precipitation from estimates of evaporation. Therefore, the following equation is used to calculate evaporation from open water areas:

$$\text{Annual EVAP} = \sum_{t=0}^{n} \frac{[(ET_o \times K_c)]\ AC}{12 \text{ inches/foot}}$$

Where:

EVAP = Annual Evaporation by open water (acre-feet [AF])

n = Time-step (monthly)

ET_o = Daily reference ET (inches)

K_c = Monthly Evaporation coefficient for water (dimensionless)

AC = Acres of water

Evaporation is summed by reach for the LCRAS open water data.

3.1.6 Calculating Riparian ET

To calculate ET from riparian vegetation, Reclamation calculates an ET rate for each vegetation type by multiplying the average daily reference ET values by each type's unique daily ET coefficient (dimensionless). Reclamation sums the daily ET rates to produce a monthly ET rate for each vegetation type. Reclamation calculates the ET within each reach by multiplying the ET rate for each vegetation type by its acreage. These calculations are performed on a monthly

time-step and the results summed to produce annual riparian ET values. The following equation is used to calculate ET for a specific vegetation type:

$$\text{Annual ET} = \sum_{t=0}^{n} \frac{[(ET_o \times K_c)]\ AC}{12 \text{ inches/foot}}$$

Where:

ET	=	Annual ET by vegetation type (AF)
n	=	Time-step (monthly)
ET_o	=	Daily reference ET (inches)
K_c	=	Daily ET coefficient for a specific vegetation type (dimensionless)
AC	=	Acres of riparian vegetation type

In this report, ET is summed by vegetation type and reach for LCRAS riparian data.

3.2 Data from HDB

Reclamation's HDB estimates and stores evaporation data from Lake Mead, Lake Mohave, and Lake Havasu using evaporation coefficients and lake elevations. It does not calculate evaporation or riparian ET losses along the Colorado mainstream. In HDB, daily reservoir surface areas are calculated from the area-capacity tables[10] and the average of the current and previous day's instantaneous midnight lake elevations, then multiplied by the standard evaporation coefficients specific to each month to estimate daily evaporation. Daily evaporation is summed to get monthly and annual evaporation.

The original evaporation coefficients used to calculate evaporative losses were based on pan evaporation studies. Those coefficients are still used to estimate evaporation at Lake Havasu. New evaporation coefficients for Lake Mead and Lake Mohave were recently developed from field data, evaluated, and then updated through a multi-year evaporation study performed by the USGS's Nevada Water Science Center in Boulder City, Nevada, and funded by Reclamation.

The goal of the USGS study was to determine new static monthly coefficients for calculating evaporation losses from Lake Mead based on the average monthly surface area. An Eddy Covariance station and a floating meteorological platform were set up on Lake Mead in March 2010 to collect sub-daily datasets of multiple physical parameters to accurately determine new static evaporation coefficients (average feet of evaporation per month) for Lake Mead. The USGS published an initial Scientific Investigations Report with the study's methodology and findings from March 2010 – February 2012 (Moreo & Swancar, 2013). In 2013, the study was expanded to collect data at Lake Mohave, the immediate downstream reservoir from Lake Mead,

[10] Lake Mead's area and capacity tables are available at https://www.usbr.gov/lc/region/g4000/LM_AreaCapacityTables2009.pdf.

using identical methods. The USGS published an Open File Report detailing the data collection and results for both Lake Mead and Lake Mohave from March 2010 – April 2019 (Earp & Moreo, 2021). At the time of this report, Reclamation continued to collaborate with the USGS to collect evaporation data at Lake Mead through the real-time Eddy Covariance station.

Reclamation's Boulder Canyon Operations Office performed sensitivity analyses and evaluated the impacts of the new evaporation coefficients on the daily, mid-term operations and long-term planning models, in accordance with Reclamation's Peer Review policy for influential scientific data (Reclamation, 2016). The new monthly evaporation coefficients replaced the values that were originally published in 1958 for Lake Mead using evaporation pans (Harbeck et al., 1958). The updated evaporation coefficients resulted in minimal impacts to projected elevations and operations tiers as simulated in the CRMMS deterministic 24-Month Study Model, the probabilistic runs using the CRMMS ensemble streamflow prediction (ESP) mode (known as CRMMS-ESP), and CRSS. Reclamation is continuing to monitor real-time evaporation at Lake Mead to better understand how evaporation is impacted by Lake Mead's declining elevation and regional climate change impacts. The evaporation coefficients will be revisited and adjusted in the future to incorporate the most recent trends.

The USGS evaporation study at Lake Mead and Lake Mohave resulted in a better understanding of the seasonality and magnitude of evaporation at two of the Lower Colorado Basin Region's largest reservoirs. With this information, the new evaporation coefficients were implemented in the operations models to provide the Colorado River Basin's management and stakeholders with model projections that incorporate the best available information[11]. For this report, the new evaporation coefficients were applied to the entire Lake Mead 2001 – 2021 dataset and the Lake Mohave 2017 – 2021 dataset since they provide a more accurate temporal distribution and evaporation magnitude at Lake Mead and Lake Mohave. The coefficients from the USGS study are provided in Appendix 5.

The methods deployed by the USGS were chosen based on the ability to deliver highly accurate monthly evaporation rates for each reservoir. For a more in-depth analysis regarding the energy budget methodology, instrumentation, and data collection results, the peer-reviewed Moreo & Swancar (2013) and Earp & Moreo (2021) USGS study reports are referenced. More in-depth analysis regarding the sensitivity analysis is available in the peer-reviewed Reclamation technical memorandum (Reclamation, 2022b).

3.2.1 Calculating Reservoir Evaporation

To calculate HDB evaporation from the lower Colorado River mainstream reservoirs, a daily surface area is estimated based on an average of the midnight reservoir elevations from the current and previous day, and the area-capacity tables. The daily surface area is then multiplied by the evaporation coefficient specific to each month (see Appendix 5). These calculations are performed on a daily time-step and the results summed to produce monthly and annual evaporation values. In this report, annual evaporation is reported on a calendar year basis

[11]The USGS coefficients were implemented in the CRMMS in April 2022, and in the CRSS in version 6, released in April 2023. More information on these models is available at: https://www.usbr.gov/lc/region/g4000/riverops/model-info.html#policy.

(January 1 – December 31). The following equation is used to calculate evaporation for a specific reservoir:

$$\text{HDB Reservoir Evaporation (AF)} = \sum_{t=0}^{n} SA \times K_c$$

Where:

n = Timestep. A daily timestep is used to calculate reservoir evaporation in HDB. Daily values are summed to get monthly and annual evaporation estimates.

SA = Surface area (acres). The daily surface area is based on the average of the midnight reservoir elevations from the current day (t) and previous day (t – 1). The average daily reservoir elevation is converted to surface area using the reservoir specific area-capacity tables.

K_c = Evaporation coefficient (ft/day). Monthly coefficients in ft/month are provided in Appendix 5. The monthly coefficient is divided by the number of days in the month for use in daily calculations.

The new evaporation coefficients from the USGS study were applied to the Lake Mead and Lake Mohave HDB datasets in this report. The pan evaporation coefficients are still used at Lake Havasu and were used for this report. These results are summarized in Section 4.2 and provided in Appendix 3.

4 Mainstream Evaporation Losses

Evaporation losses in this report were calculated using two data sources, LCRAS and HDB. LCRAS provides data for Reaches 2 through 5, which includes the mainstream lower Colorado River and reservoirs, lakes, lagoons, and other backwater area surfaces below Hoover Dam to the NIB. The LCRAS data are summarized in Section 4.1. HDB provides evaporation data for only Lakes Mead, Mohave, and Havasu. HDB data are summarized in Section 4.2. Since evaporation data for Lake Mohave and Lake Havasu are available using both LCRAS and HDB, the data sources are compared in Section 4.3.

For purposes of this report, the evaporation data were divided into five reaches:

- Reach 1: Lake Mead
    - LCRAS data are not available for this reach.
    - Lake Mead evaporation data from HDB, using the USGS coefficients, are provided in Section 4.2.
- Reach 2: Hoover Dam to Davis Dam
    - LCRAS evaporation data are provided for this reach in Section 4.1. It includes evaporation from Lake Mohave.
    - Lake Mohave evaporation data from HDB, using the USGS coefficients, are provided in Section 4.2.
    - The LCRAS open water data and HDB data using the USGS coefficients are compared for Lake Mohave in Section 4.3.
- Reach 3: Davis Dam to Parker Dam
    - LCRAS data are provided for this reach in Section 4.1. It includes evaporation from Lake Havasu.
    - Lake Havasu evaporation data from HDB are provided in Section 4.2.
    - The LCRAS open water data and HDB data are compared in Section 4.3.
- Reach 4: Parker Dam to Imperial Dam
    - LCRAS open water data are provided for this reach in Section 4.1, which includes evaporation from reservoirs within the reach.
- Reach 5: Imperial Dam to the NIB
    - LCRAS open water data are provided for this reach in Section 4.1, which includes evaporation from reservoirs within the reach.

A map of the reaches is provided in Figure 1, on page ix. More detail on each individual reach is provided in maps included in Appendix 1.

4.1 LCRAS Open Water Data

LCRAS open water data are not available upstream of Hoover Dam, therefore this report only provides estimates of evaporation losses calculated using LCRAS data for Reach 2 through Reach 5.

These data are summarized annually from 2017 to 2021 in Table 6 below and are provided monthly in Appendix 2. Due to rounding to the nearest acre foot in the monthly data, the sum of the losses from each reach within a year may differ from the total value.

Table 6. Evaporation losses calculated using LCRAS open water data for Reach 2 through Reach 5.

Year	LCRAS Evaporation Loss (AF)				
	Reach 2	Reach 3	Reach 4	Reach 5	Total
2017	138,505	117,424	67,080	8,415	331,424
2018	144,980	123,179	66,535	8,254	342,948
2019	135,996	115,547	66,664	8,182	326,389
2020	146,212	124,224	70,748	8,535	349,719
2021	146,643	124,459	71,470	8,512	351,084
Average	142,467	120,967	68,499	8,380	340,313

4.2 HDB Data

Reservoir evaporation estimates are available from HDB for Lake Mead, Lake Mohave, and Lake Havasu. The evaporation coefficients for Lake Mead and Lake Mohave that are used in this report were updated in 2021, based on a Reclamation-funded USGS Study (USGS 2017). That study also estimated average annual evaporation at Lake Mead and Lake Mohave to be 6.22 ft and 5.64 ft, respectively. The evaporation coefficients for Lake Havasu were not updated in the USGS study. Monthly and annual data are provided in Appendix 3. Since Lake Mead's elevation and evaporation can vary significantly on an annual basis, Table 7 below summarizes the annual evaporation from Lake Mead for the period 2001-2021. Table 8 summarizes annual evaporation from Lake Mohave and Lake Havasu only for the period 2017-2021 as these reservoirs are maintained by a seasonal elevation guide curve, resulting in minimal annual variation in evaporation.

Table 7. Lake Mead annual evaporation losses using HDB with the updated 2021 USGS coefficients compared to elevation and average surface area.

Year	Low Elevation (ft)	High Elevation (ft)	Average Surface Area[12] (acres)	Evaporation (AF)
2001	1,178	1,197	136,049	842,089
2002	1,152	1,178	120,874	744,923
2003	1,139	1,155	109,477	678,240
2004	1,126	1,141	102,485	635,472
2005	1,130	1,148	106,124	661,620
2006	1,125	1,141	102,458	635,222
2007	1,110	1,130	96,616	598,044
2008	1,104	1,118	93,325	577,847
2009	1,093	1,113	89,460	553,559
2010	1,082	1,103	86,409	537,015
2011	1,086	1,133	91,971	577,495
2012	1,115	1,135	98,216	608,277
2013	1,104	1,123	93,649	580,228
2014	1,080	1,109	86,447	533,534
2015	1,075	1,089	83,054	515,859
2016	1,072	1,084	81,895	508,910
2017	1,079	1,090	83,826	521,725
2018	1,076	1,088	83,340	518,023
2019	1,081	1,090	84,587	523,928
2020	1,081	1,099	85,646	532,147
2021	1,065	1,087	80,771	500,743
Average	**1,103**	**1,122**	**95,080**	**589,757**
2017-2021 Average	**1,077**	**1,091**	**83,634**	**519,313**

[12] This is the annual average surface area at Lake Mead, calculated by utilizing the average daily surface area to obtain a monthly average surface area, which was subsequently averaged to provide the annual average surface area. A dynamic surface area is used for evaporation calculations in Reclamation's HDB, which is based on Lake Mead's elevation and the area and capacity tables: https://www.usbr.gov/lc/region/g4000/LM_AreaCapacityTables2009.pdf.

Table 8. Lake Mohave and Lake Havasu annual evaporation. Lake Mohave evaporation uses the 2021 USGS coefficients.

Year	Lake Mohave Evaporation (AF)	Lake Havasu Evaporation (AF)
2017	152,350	140,019
2018	151,592	139,506
2019	152,094	139,880
2020	151,489	139,047
2021	151,085	139,677
Average	**151,722**	**139,626**

4.3 Comparison of LCRAS and HDB Evaporation Data at Lake Mohave and Lake Havasu

A comparison of evaporation losses from the LCRAS open water data and HDB are provided in Table 9 for Lake Mohave and Table 10 for Lake Havasu. The same reservoir surface area was used in the calculations for both datasets. While the LCRAS data takes weather variations, such as temperature, into account, HDB calculates evaporation from the reservoir's elevation/surface area and evaporation coefficients previously calculated by Reclamation for these reservoirs.

The comparison in this section shows the difference between the LCRAS and HDB data at Lake Mohave, with an average 8% difference. At Lake Havasu, there is a more significant difference between LCRAS and HDB evaporation estimates, with an average difference of 35%. Use of Class-A Pan evaporation coefficients in HDB for Lake Havasu evaporation data likely contributes to the large difference. The update to Lake Mohave evaporation coefficients reduced the annual Mohave evaporation estimates in HDB from about 198 kAF per year to about 152 kAF per year, and concurrently reduced the percent difference between HDB and LCRAS data from about 26% to about 8% on average (based on data from 2017–2021). A similar trend could be expected at Lake Havasu if the evaporation coefficients were updated. In both cases, however, the LCRAS data provides a lower estimate of evaporation from the reservoirs compared to HDB.

Total mainstream evaporation and riparian ET losses are summarized in Chapter 6. Where LCRAS and HDB evaporation data overlap at Lake Mohave and Lake Havasu for Reach 2 and Reach 3, the LCRAS data are used to provide methodologically consistent data within the reach, as the values for the updated USGS coefficients are comparable. Since LCRAS data is not available for Reach 1, however, the Lake Mead HDB data are used in that reach.

Table 9. Comparison of evaporation losses at Lake Mohave.

Year	Average Surface Area (acres)	Evaporation (AF)		Percent Difference
		LCRAS	HDB	
2017	27,115	137,316	152,350	10%
2018	27,007	143,159	151,592	6%
2019	27,095	134,706	152,094	12%
2020	26,955	144,075	151,489	5%
2021	26,939	144,418	151,085	5%
Average	**27,022**	**140,735**	**151,722**	**8%**

Table 10. Comparison of evaporation losses at Lake Havasu.

Year	Average Surface Area (acres)	Evaporation (AF)		Percent Difference
		LCRAS	HDB	
2017	18,890	95,660	140,019	38%
2018	18,865	99,998	139,506	33%
2019	18,941	94,167	139,880	39%
2020	18,711	100,008	139,047	33%
2021	18,915	101,398	139,677	32%
Average	**18,864**	**98,246**	**139,626**	**35%**

4.4 Mainstream Evaporative Losses

Evaporative data produced by LCRAS were not available upstream of Hoover Dam, therefore this section presents HDB data for Reach 1 and LCRAS data from Reach 2 through Reach 5. LCRAS data were used for Reach 2 through Reach 5 to provide methodologically consistent data where available. The evaporative losses along the mainstream are presented in Table 11 below. While the 5 year period from 2017 to 2021 showed minimal variation in the evaporative losses for Reach 1, this reach can experience significant variations depending on Lake Mead's elevation and surface area, as shown in Table 7. The monthly and annual LCRAS data are provided in Appendix 2, and HDB data are provided in Appendix 3.

Table 11. Evaporation losses for Reach 1, using HDB, and Reaches 2 through 5, using LCRAS.

Year	HDB Evaporation Loss (AF)	LCRAS Evaporation Loss (AF)				Total Evaporation Loss (AF)
	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	
2017	521,725	138,505	117,424	67,080	8,415	853,149
2018	518,023	144,980	123,179	66,535	8,254	860,971
2019	523,928	135,996	115,547	66,664	8,182	850,317
2020	532,147	146,212	124,224	70,748	8,535	881,866
2021	500,743	146,643	124,459	71,470	8,512	851,827
Average	**519,313**	**142,467**	**120,967**	**68,499**	**8,380**	**859,626**

5 Riparian ET Losses

Riparian data produced by LCRAS were not available upstream of Hoover Dam, therefore this section only presents ET estimates from Reach 2 through Reach 5. The estimated riparian losses along the mainstream are presented in Table 12, as well as the associated acreage of riparian habitat within each reach. As shown in Figure 1 and the table below, Reach 4 contains the majority of the riparian habitats along the mainstream of the lower Colorado River resulting in increased riparian ET losses within that reach. The monthly and annual data for each riparian type that was described in Table 3 are provided in Appendix 4, including the associated acreage for each reach on an annual basis.

Table 12. LCRAS riparian ET losses and the average riparian acreage from Reach 2 through Reach 5.

Year	Riparian Loss (AF)				
	Reach 2	Reach 3	Reach 4	Reach 5	Total
2017	4,213	117,772	258,496	55,688	436,169
2018	4,438	123,876	256,681	54,799	439,794
2019	4,220	117,704	258,133	53,837	433,894
2020	4,490	125,177	271,644	55,561	456,872
2021	4,457	124,306	273,295	54,116	456,174
Average Loss	**4,364**	**121,767**	**263,650**	**54,800**	**444,581**
Average Riparian Acreage	**1,354**	**35,843**	**79,308**	**15,173**	**131,679**

6 Total Mainstream Evaporation and Riparian ET Losses

Estimates of the total system losses from both mainstream evaporation and riparian ET are presented in Table 13.

Reach 1 only includes Lake Mead evaporation estimates from HDB data that were presented in Section 4.2. LCRAS data are not available upstream of Hoover Dam and riparian ET data for Reach 1 are not available from current Reclamation datasets. As described in Section 3.2, HDB evaporation estimates use standard monthly evaporation coefficients, so any variation from year to year is dependent on reservoir elevations. Variation in the Reach 1 data from year to year is due to changes in Lake Mead's elevation, resulting in changes to the surface area.

Data in Table 13 for Reach 2 through Reach 5 are the combined annual LCRAS evaporative losses, presented in Section 4.1, and the annual riparian ET losses for Reach 2 through Reach 5 as presented in Chapter 5. Where LCRAS and HDB evaporation data overlap at Lake Mohave and Lake Havasu, the LCRAS evaporation data are used to ensure consistency in the methodology applied for the whole reach. As described in Section 3.1, LCRAS evaporation and riparian ET estimates are based on open-water and riparian acreages, and daily evaporation and ET rates that incorporate weather data. Variation in the Reach 2 through Reach 5 estimates from year to year is due to changes in the acreages and weather conditions.

Table 13. Total losses (evaporation and riparian ET) from Reach 1 through Reach 5.

Year	Mainstream Evaporation and Riparian ET Losses (AF)					
	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Total
2017	521,725	142,718	235,196	325,576	64,103	1,289,318
2018	518,023	149,418	247,055	323,216	63,053	1,300,765
2019	523,928	140,216	233,251	324,797	62,019	1,284,211
2020	532,147	150,702	249,401	342,392	64,096	1,338,738
2021	500,743	151,100	248,765	344,765	62,628	1,308,001
Average	**519,313**	**146,831**	**242,734**	**332,149**	**63,180**	**1,304,207**

7 Summary

The LCRAS and HDB datasets available for the lower Colorado River mainstream were used in this study to estimate the total annual evaporation and riparian ET losses from the mainstream of the lower Colorado River, including mainstream reservoirs, between Lake Mead and the NIB. This study showed that over the 5-year period from 2017 to 2021, the average annual total losses from open-water evaporation and riparian ET exceeded 1.3 million acre feet. As can be seen in Table 14 and Figure 2, below, the majority of those estimated system losses come from the major reservoirs in Reach 1, Reach 2, and Reach 3, contributing almost 760 kAF of total evaporative loss. Furthermore, most of the reservoir evaporation occurs from Lake Mead, Reach 1, with an average loss of almost 520 kAF annually, although this value varies significantly as the reservoir elevation and surface area fluctuates. Average mainstream evaporation from the Colorado River accounts for less than 8% of the total estimated average system losses. More than half of the estimated riparian ET occurs in Reach 4, between Parker and Imperial Dam.

Table 14. Summary of 2017-2021 average annual losses, in AF, for the lower Colorado River, major reservoirs and riparian ET by reach and in total.

Type of Loss	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Total
Mainstream Evaporation (2017-2021 Avg)	N/A	1,732	22,721	68,499	8,380	101,332
Major Reservoir Evaporation (2017-2021 Avg)	519,313	140,735	98,246	N/A	N/A	758,294
Riparian ET (2017-2021 Avg)	N/A	4,364	121,767	263,650	54,800	444,581
Total Losses (2017-2021 Avg)	**519,313**	**146,831**	**242,734**	**332,149**	**63,180**	**1,304,207**

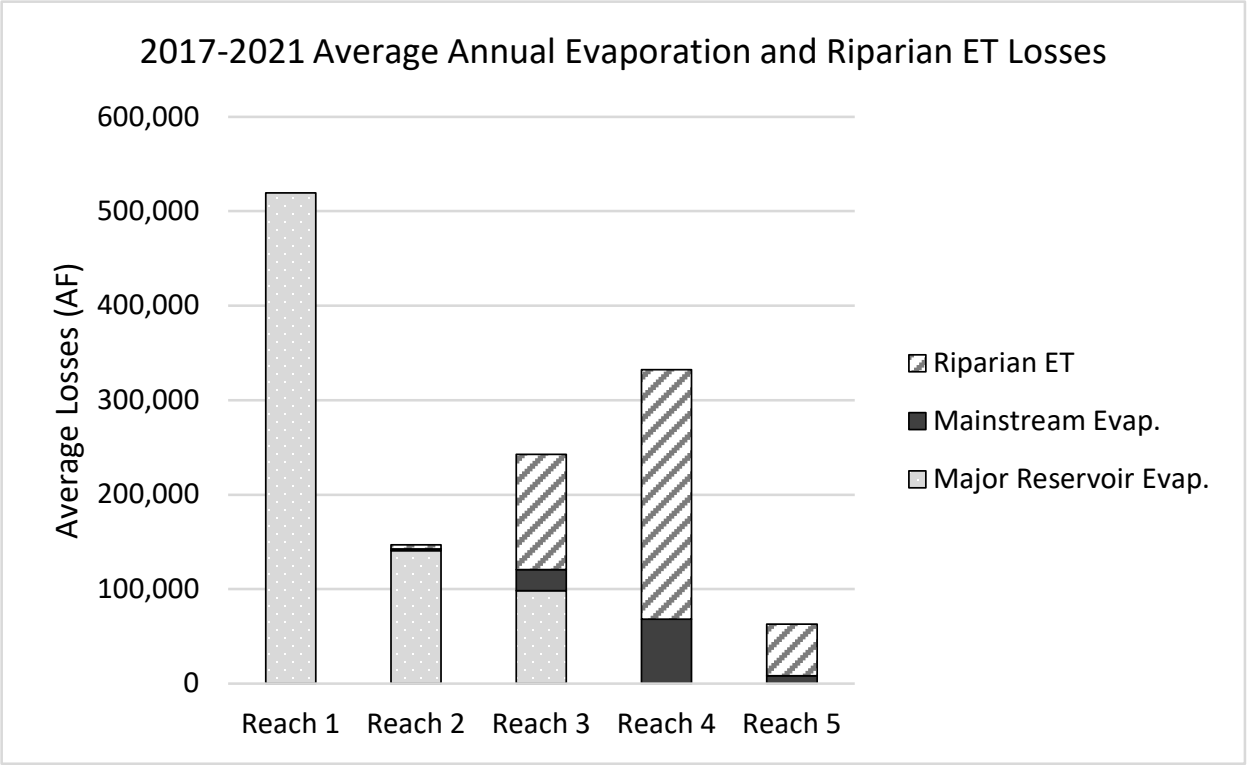

Figure 2. Chart of 2017-2021 average annual losses, in AF, for the lower Colorado River major reservoirs, mainstream evaporation, and riparian ET by reach.

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Appendix 1 – Reaches Identified in the Lower Colorado River Mainstream Evaporation and Riparian Evapotranspiration Losses Report

Introduction

This Appendix to the Lower Colorado River Mainstream Evaporation and Riparian Evapotranspiration Losses Report provides maps showing the extent of the area under examination. Figure A1-1 shows the full extent of the area, while indicating how the individual reaches were defined. Figure A1-2 through Figure A1-6 provide more detail about the extents of each individual reach, as defined in the Lower Colorado River Mainstream Evaporation and Riparian Evapotranspiration Losses Report.

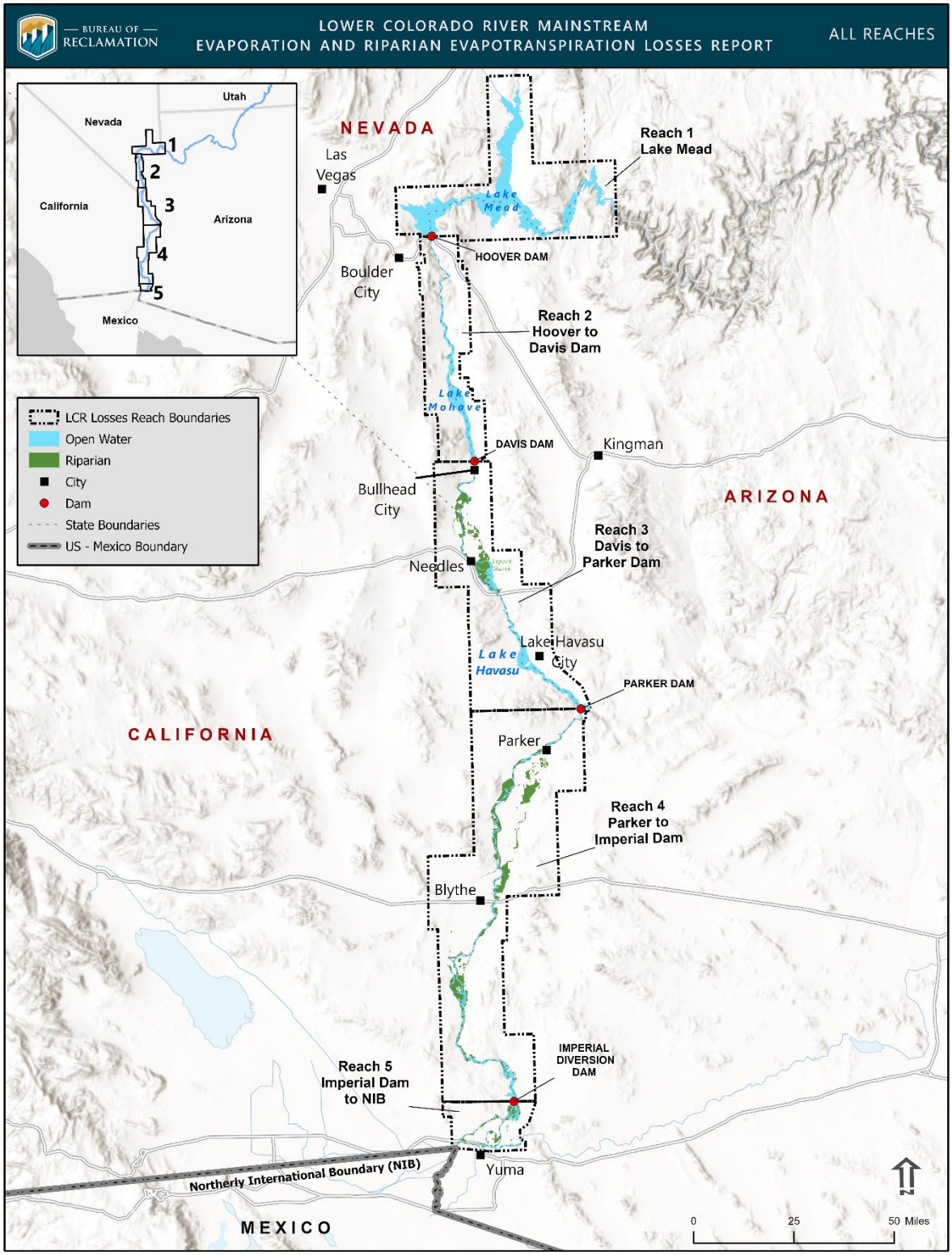


Figure A1-1 - Map of reaches identified in the Lower Colorado River Mainstream Evaporation and Riparian Evapotranspiration Losses Report

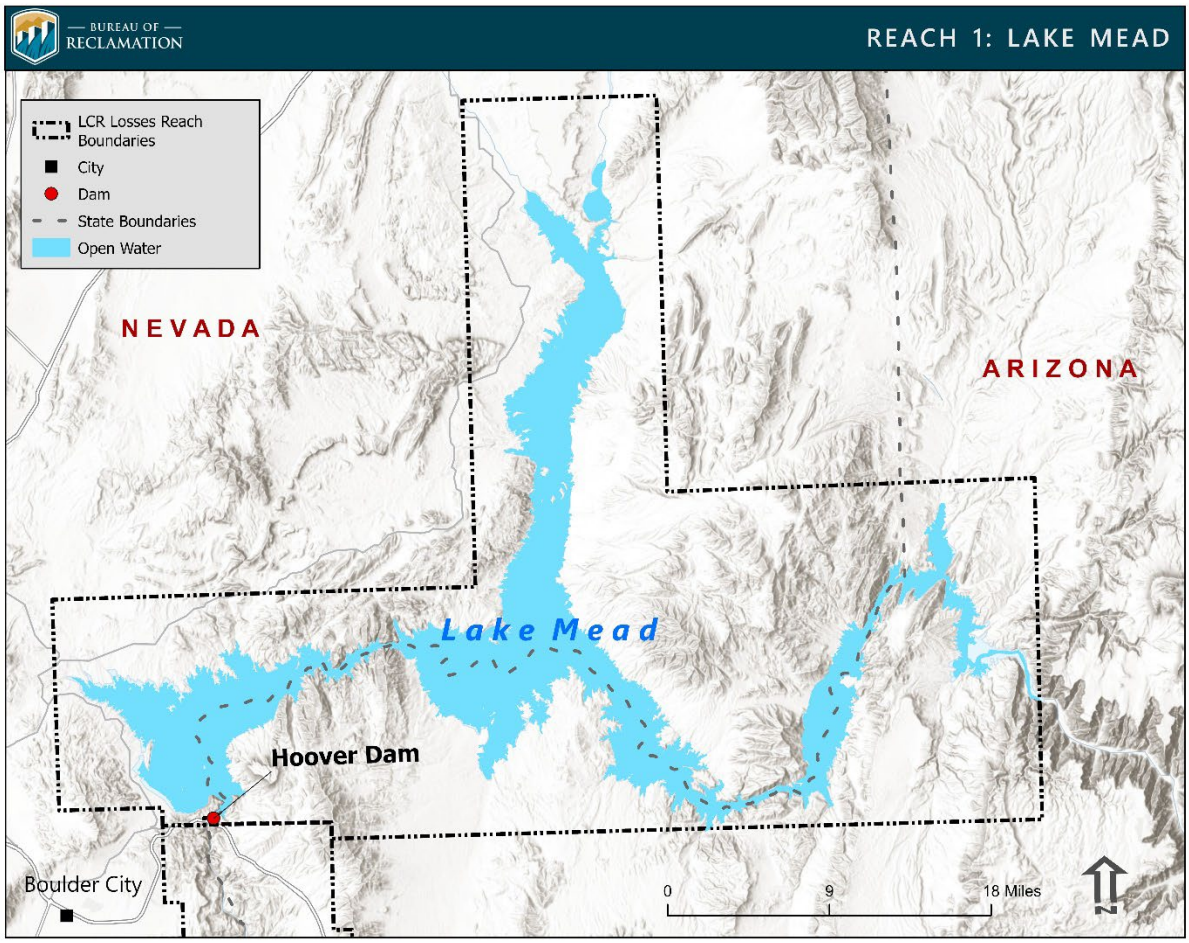


Figure A1-2 - Area included for Reach 1, Lake Mead

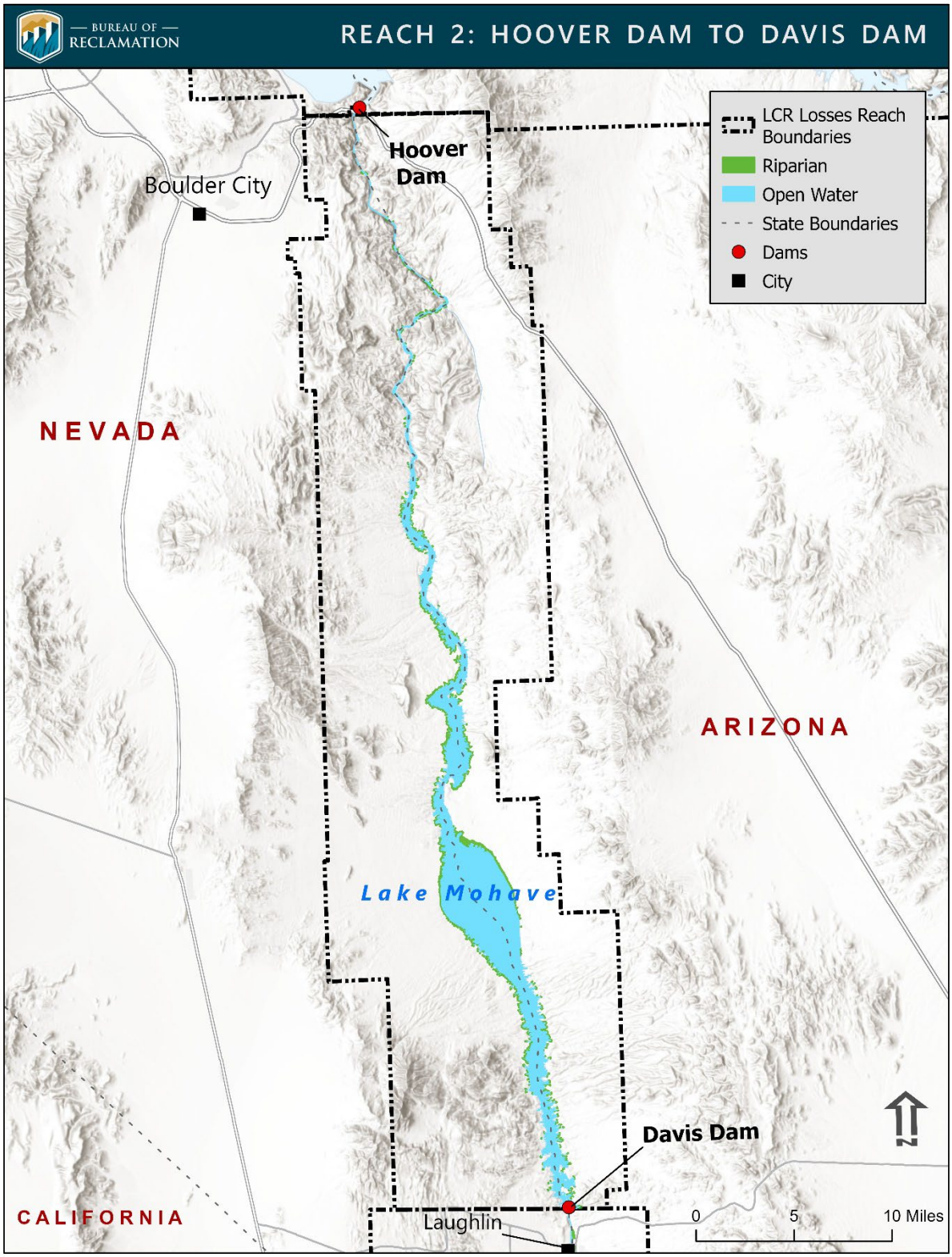


Figure A1-3 – Area included for Reach 2, Hoover Dam to Davis Dam

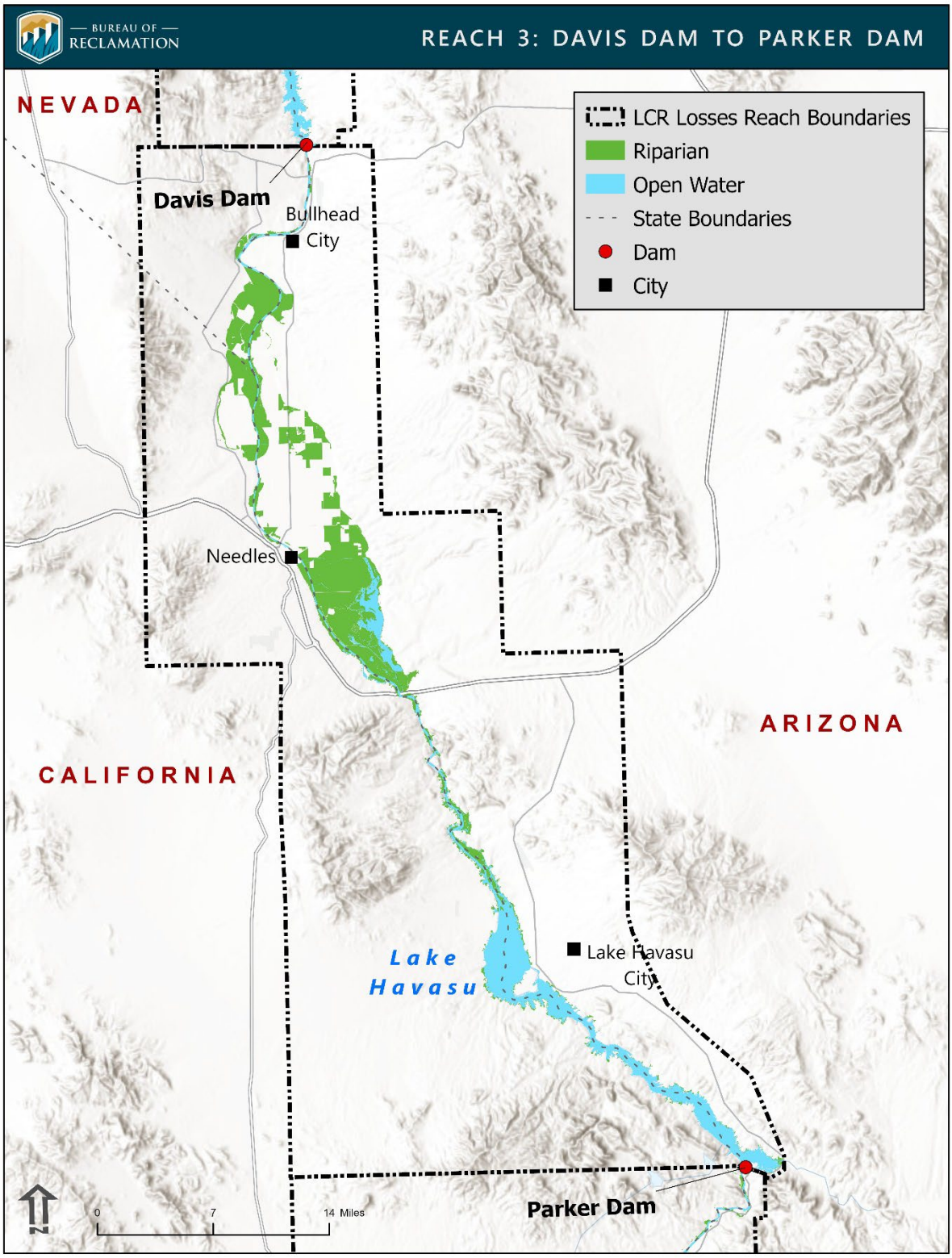


Figure A1-4 – Area included for Reach 3, Davis Dam to Parker Dam

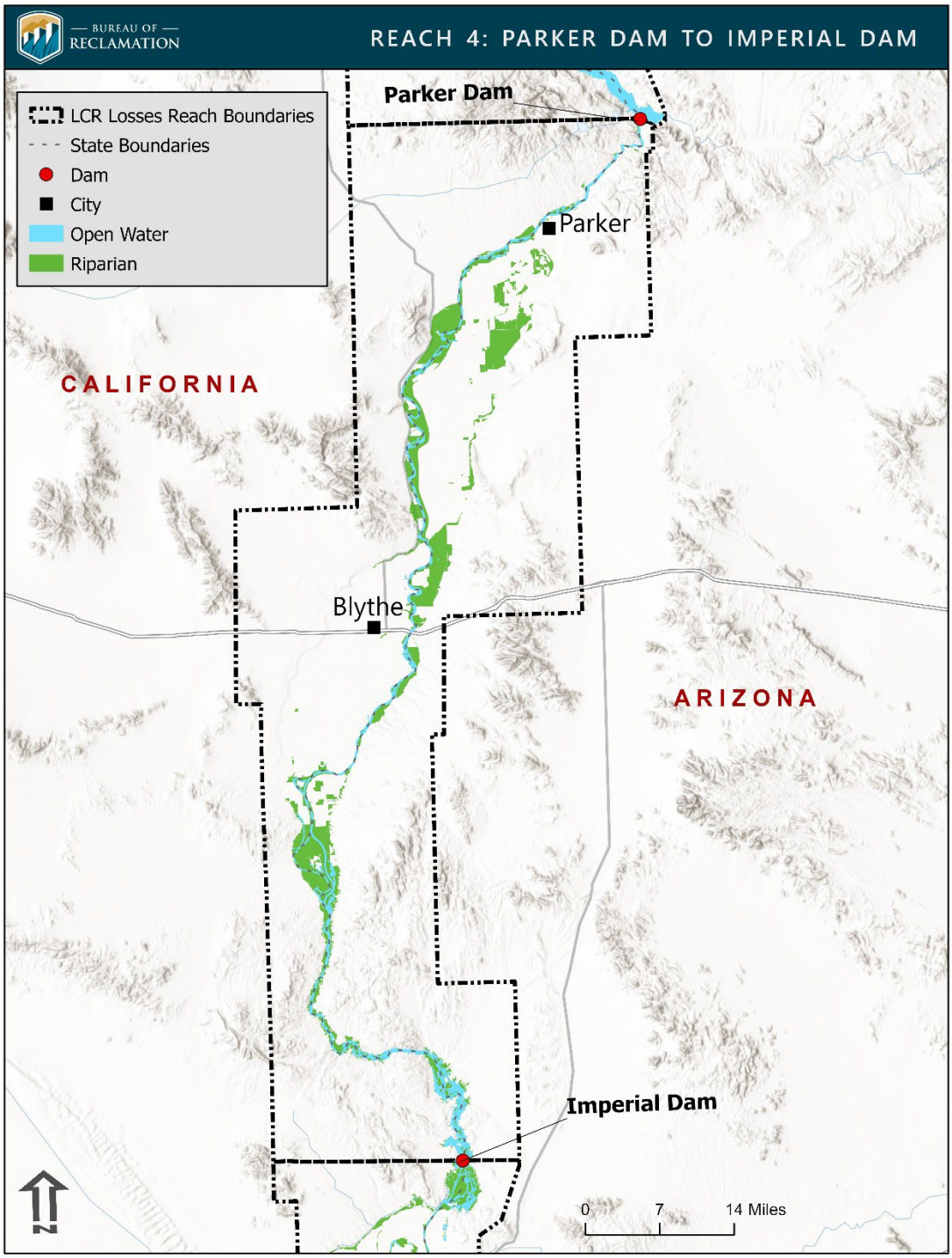


Figure A1-5 – Area included for Reach 4, Parker Dam to Imperial Dam

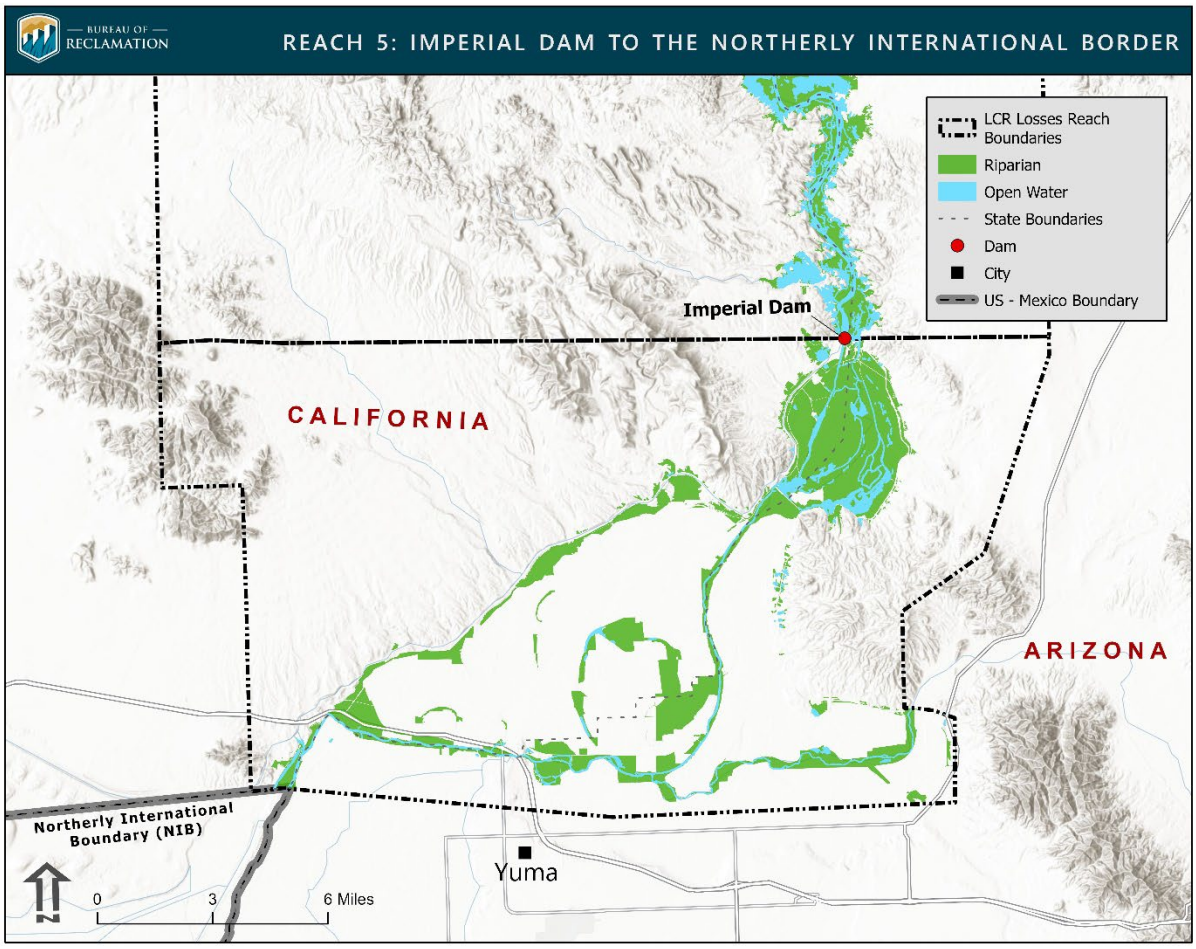


Figure A1-6 – Area included for Reach 5, Imperial Dam to Northerly International Boundary

Appendix 2 – LCRAS Open Water Monthly Evaporative Losses

Foreword

Data regarding the monthly and total evaporation are all provided in acre-feet. Due to rounding to the nearest acre-foot, the total value shown in a row may differ from the sum of the monthly values.

Introduction

This Appendix to the Lower Colorado River Mainstream Evaporation and Riparian Evapotranspiration Losses Report provides the monthly and annual evaporation losses from the LCRAS dataset between 2017 and 2021. Table A2-1 through Table A2-4 provide the losses estimated by the LCRAS report for Reach 2 through Reach 5. Table A2-5 provides the sum of the estimated losses between Hoover Dam, the start point of Reach 2, to the Northerly International Boundary, the end point of Reach 5. Table A2-6 provides the annual open water acreages for each reach, and the total acreage, that was used to estimate LCRAS evaporative losses for each reach.

Table A2-1. Reach 2, Hoover Dam to Davis Dam – Monthly and Annual LCRAS Evaporation in Acre-Feet

Year	Total	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2017	138,505	4,833	5,494	11,170	15,022	18,122	18,145	17,279	14,361	11,352	10,463	6,360	5,904
2018	144,980	6,406	6,793	10,304	16,185	18,852	19,445	17,666	16,800	12,059	9,164	6,884	4,422
2019	135,996	5,380	5,015	9,939	15,341	16,663	18,829	17,872	15,569	11,648	9,870	6,451	3,419
2020	146,212	5,790	7,181	9,141	14,407	20,562	19,103	19,262	16,504	12,196	9,118	7,249	5,699
2021	146,643	6,793	7,181	10,645	16,595	19,239	18,920	18,647	16,276	11,603	8,890	7,568	4,286
Average	**142,467**	**5,840**	**6,333**	**10,240**	**15,510**	**18,688**	**18,888**	**18,145**	**15,902**	**11,772**	**9,501**	**6,902**	**4,746**

Table A2-2. Reach 3, Davis Dam to Parker Dam – Monthly and Annual LCRAS Evaporation in Acre-Feet

Year	Total	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2017	117,424	4,097	4,658	9,470	12,736	15,364	15,383	14,649	12,175	9,624	8,871	5,392	5,005
2018	123,179	5,442	5,772	8,754	13,751	16,017	16,521	15,010	14,274	10,246	7,786	5,849	3,757
2019	115,547	4,571	4,261	8,444	13,034	14,158	15,998	15,184	13,228	9,897	8,386	5,481	2,905
2020	124,224	4,919	6,101	7,766	12,240	17,470	16,230	16,366	14,022	10,362	7,747	6,159	4,842
2021	124,459	5,765	6,094	9,035	14,085	16,329	16,058	15,826	13,814	9,848	7,545	6,423	3,637
Average	**120,967**	**4,959**	**5,377**	**8,694**	**13,169**	**15,868**	**16,038**	**15,407**	**13,503**	**9,995**	**8,067**	**5,861**	**4,029**

Table A2-3. Reach 4, Parker Dam to Imperial Dam – Monthly and Annual LCRAS Evaporation in Acre-Feet

Year	Total	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2017	67,080	1,611	2,203	4,732	6,965	7,842	9,473	9,259	8,199	6,292	5,415	2,835	2,254
2018	66,535	1,991	2,451	4,523	7,209	8,210	9,047	8,700	8,710	6,617	4,421	3,094	1,562
2019	66,664	1,624	2,023	4,424	6,968	7,540	9,134	9,348	9,001	6,682	5,445	3,024	1,451
2020	70,748	2,014	2,791	3,782	6,440	8,607	9,251	10,141	9,200	7,421	5,602	3,455	2,044
2021	71,470	1,983	2,739	4,528	7,113	8,626	9,842	9,648	8,912	6,991	5,294	3,638	2,156
Average	**68,499**	**1,845**	**2,441**	**4,398**	**6,939**	**8,165**	**9,349**	**9,419**	**8,804**	**6,801**	**5,235**	**3,209**	**1,893**

Table A2-4. Reach 5, Imperial Dam to Northerly International Boundary – Monthly and Annual LCRAS Evaporation in Acre-Feet

Year	Total	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2017	8,415	252	333	664	829	927	1,112	1,201	1,099	803	640	288	267
2018	8,254	317	350	616	822	961	1,016	1,117	1,102	882	570	313	188
2019	8,182	236	314	632	833	922	1,089	1,129	1,102	819	622	299	185
2020	8,535	288	386	520	779	1,025	1,111	1,221	1,176	879	582	331	237
2021	8,512	276	396	653	868	975	1,077	1,137	1,110	835	610	365	210
Average	**8,380**	**274**	**356**	**617**	**826**	**962**	**1,081**	**1,161**	**1,118**	**844**	**605**	**319**	**217**

Table A2-5. Sum of Evaporative Losses for Reaches 2 to 5, Hoover Dam to Northerly International Boundary – Monthly and Annual LCRAS Evaporation in Acre-Feet

Year	Total	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2017	331,424	10,793	12,688	26,036	35,552	42,255	44,113	42,388	35,834	28,071	25,389	14,875	13,430
2018	342,948	14,156	15,366	24,197	37,967	44,040	46,029	42,493	40,886	29,804	21,941	16,140	9,929
2019	326,389	11,811	11,613	23,439	36,176	39,283	45,050	43,533	38,900	29,046	24,323	15,255	7,960
2020	349,719	13,011	16,459	21,209	33,866	47,664	45,695	46,990	40,902	30,858	23,049	17,194	12,822
2021	351,084	14,817	16,410	24,861	38,661	45,169	45,897	45,258	40,112	29,277	22,339	17,994	10,289
Average	**340,313**	**12,918**	**14,507**	**23,948**	**36,444**	**43,682**	**45,357**	**44,132**	**39,327**	**29,411**	**23,408**	**16,292**	**10,886**

Table A2-6. Sum of open water acreages for Reaches 2 to 5, Hoover Dam to Northerly International Boundary

Year	Total	Reach 2	Reach 3	Reach 4	Reach 5
2017	64,123	27,355	23,191	12,237	1,341
2018	64,185	27,355	23,241	12,253	1,336
2019	64,196	27,355	23,241	12,260	1,341
2020	64,216	27,355	23,241	12,267	1,353
2021	64,200	27,355	23,216	12,264	1,365
Average	**64,184**	**27,355**	**23,226**	**12,256**	**1,347**

Appendix 3 – Lake Mead, Lake Mohave, and Lake Havasu Evaporation from Reclamation's Hydrologic Database (HDB)

Introduction

This Appendix to the Lower Colorado River Mainstream Evaporation and Riparian Evapotranspiration Losses Report provides monthly and annual evaporation losses from the HDB dataset. Table A3-1 provides Lake Mead data between 2001 and 2021, including the annual high and low water surface elevations, the average surface area, and the monthly and annual evaporative loss estimates. Figure A3-1 graphically shows the high and low elevations and the total estimated evaporation for Lake Mead that are provided in Table A3-1.

Tables A3-2 and A3-3 provide the annual high and low elevation water surface elevations, the average surface area, and the monthly and annual evaporative loss estimates for Lake Mohave and Lake Havasu, respectively, between 2017 and 2021.

The data provided in Tables A3-1 and A3-2 used updated Lake Mead and Lake Mohave coefficients based on a 2021 USGS evaporation study. The USGS study did not include an update for the Lake Havasu coefficients used in Table A3-3. The coefficients used are listed in Appendix 5, Table A5-2.

An online data query tool is available to access data from Reclamation's HDB at https://www.usbr.gov/lc/region/g4000/riverops/_HdbWebQuery.html. To query data found in this report, users would select the "Lower Colorado Regional Office" as the desired HDB. A list of site-database ID (SDI) numbers relevant to this report is provided in Table A3-1 below. The user can then specify a data frequency and date range, selected "Observed" as the desired data type, then specify the desired output and click "Build Request". A web link to the specified data query will be available below the "Build Request" button, and the user can either click the link or copy and paste it into a new web browser to view the data.

The new USGS coefficients were implemented in the official HDB record starting in October 2021. For this report, the new USGS evaporation coefficients were applied to the entire Lake Mead 2001 – 2021 dataset and the Lake Mohave 2017 – 2021 dataset since they provide a more accurate temporal distribution and evaporation magnitude at Lake Mead and Lake Mohave. Therefore, data from online HDB query tool prior to October 2021 will not match the data provided in this report.

Table A3-1. SDI numbers for Lake Mead, Lake Mohave, and Lake Havasu data to use in the HDB online data query.

Data type	Lake Mead SDIs	Lake Mohave SDIs	Lake Havasu SDIs
Elevation	1930	2100	2101
Surface Area	23096	2168	2148
Evaporation	1776	1777	1778

Table A3-2. Lake Mead data (2001 – 2021) from HDB with the updated 2021 USGS coefficients applied to the historic dataset.

Lake Mead Evaporation (AF)																
Year	Low Elev (ft)	High Elev (ft)	Average Surface Area[1] (acres)	Total Evap (AF)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2001	1178	1197	136,049	842,089	44,307	41,493	45,531	60,408	74,634	90,954	85,490	92,771	89,482	83,806	73,193	60,022
2002	1152	1178	120,874	744,923	40,524	37,825	41,112	53,944	65,944	79,873	75,217	81,590	78,747	73,772	64,135	52,238
2003	1139	1155	109,477	678,240	35,207	33,168	36,573	48,254	59,179	72,455	68,710	75,168	73,056	68,376	59,462	48,631
2004	1126	1141	102,485	635,472	32,828	30,770	33,843	45,005	55,473	67,668	64,092	70,061	68,078	64,178	56,670	46,806
2005	1130	1148	106,124	661,620	32,028	30,835	34,883	47,021	58,162	71,405	67,766	74,007	71,798	67,217	58,443	48,057
2006	1125	1141	102,458	635,222	32,665	30,794	33,981	45,166	55,752	68,067	64,370	70,145	67,986	63,931	56,092	46,273
2007	1110	1130	96,616	598,044	31,378	29,431	32,216	42,490	52,239	63,847	60,448	65,888	63,936	60,064	52,573	43,533
2008	1104	1118	93,325	577,847	29,670	27,879	30,709	40,721	50,143	61,353	58,249	63,731	62,095	58,839	51,675	42,782
2009	1093	1113	89,460	553,559	29,149	27,293	29,793	39,108	48,045	58,928	56,017	61,101	59,299	55,763	48,778	40,286
2010	1082	1103	86,409	537,015	27,484	26,062	28,792	38,290	47,511	58,021	54,678	59,538	57,496	53,651	46,778	38,713
2011	1086	1133	91,971	577,495	26,571	25,292	28,142	37,815	47,624	59,848	58,287	65,404	64,841	61,908	55,223	46,538
2012	1115	1135	98,216	608,277	31,926	29,882	32,645	42,999	52,872	64,601	61,317	67,167	65,144	61,304	53,869	44,553
2013	1104	1123	93,649	580,228	30,300	28,440	31,171	41,157	50,561	61,695	58,584	64,100	62,421	58,474	51,095	42,231
2014	1080	1109	86,447	533,534	28,630	26,860	29,167	38,130	46,676	56,599	53,339	58,132	56,620	53,433	47,001	38,949
2015	1075	1089	83,054	515,859	26,534	24,844	27,226	35,907	44,272	54,478	52,177	57,574	55,887	52,718	46,175	38,067
2016	1072	1084	81,895	508,910	25,911	24,408	26,763	35,382	43,797	53,828	51,295	56,563	55,166	52,101	45,875	37,822
2017	1079	1090	83,826	521,725	25,982	24,750	27,420	36,521	45,311	55,652	52,869	58,042	56,680	53,477	46,662	38,360
2018	1076	1088	83,340	518,023	26,161	24,750	27,338	36,494	45,152	55,149	52,356	57,569	56,035	52,784	46,171	38,063
2019	1081	1090	84,587	523,928	26,041	24,606	27,455	36,920	46,089	56,665	53,823	58,695	57,035	53,655	43,816	39,129
2020	1081	1099	85,646	532,147	26,926	25,444	28,233	38,016	47,142	57,454	54,194	58,893	57,152	53,579	46,634	38,481
2021	1065	1087	80,771	500,743	26,161	24,668	27,104	35,928	44,076	53,426	50,379	55,059	53,455	50,500	43,951	36,036
Average	**1103**	**1122**	**95,080**	**589,757**	**30,304**	**28,547**	**31,433**	**41,699**	**51,460**	**62,951**	**59,698**	**65,295**	**63,448**	**59,692**	**52,108**	**43,122**
Average 2017-2021	**1077**	**1091**	**83,634**	**519,313**	**26,254**	**24,844**	**27,510**	**36,776**	**45,554**	**55,669**	**52,724**	**57,651**	**56,071**	**52,799**	**45,447**	**38,014**

[1] This is the annual average, calculated by utilizing the average daily surface area to obtain a monthly average surface area, which was subsequently averaged to provide the annual average surface area. A dynamic surface area is used for evaporation calculations in Reclamation's HDB, which is based on Lake Mead's elevation and the area and capacity tables: https://www.usbr.gov/lc/region/g4000/LM_AreaCapacityTables2009.pdf.

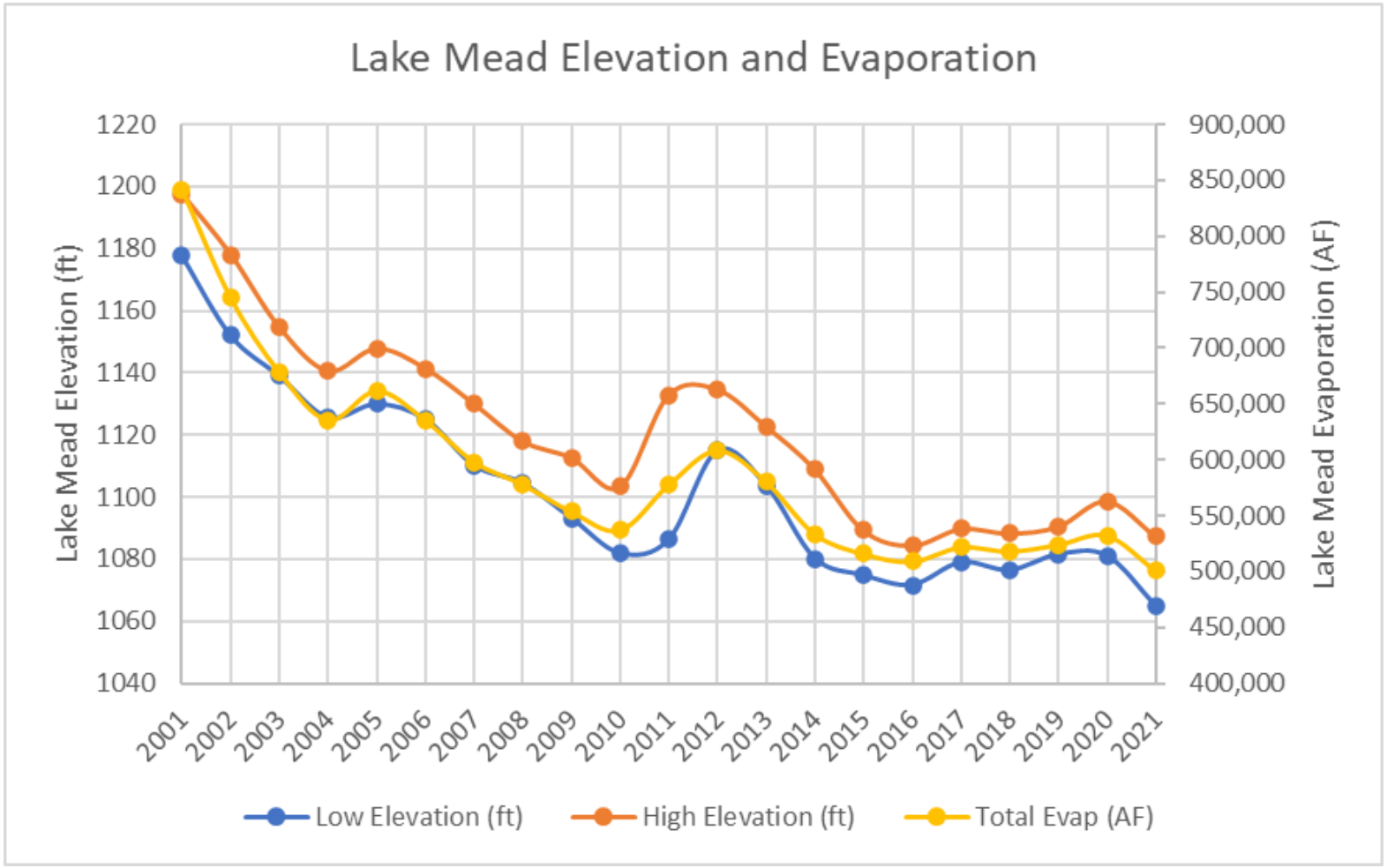


Figure A3-1. Lake Mead Elevation and Evaporation from 2001 to 2021

Table A3-3. Lake Mohave data (2017 – 2021) from HDB with the updated 2021 USGS coefficients applied to the historic dataset.

Lake Mohave Evaporation (AF)																
Year	Low Elev (ft)	High Elev (ft)	Average Surface Area[2] (acres)	Total Evap (AF)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2017	636	645	27,115	152,350	9,045	7,642	10,119	12,628	14,238	13,944	12,281	15,684	16,553	14,378	12,932	12,905
2018	635	645	27,007	151,592	8,963	7,592	10,100	12,520	14,166	13,972	12,362	15,493	16,324	14,323	12,912	12,865
2019	637	644	27,095	152,094	8,857	7,655	10,118	12,553	14,180	14,006	12,254	15,563	16,281	14,472	13,031	13,123
2020	634	646	26,955	151,489	8,914	7,601	10,141	12,644	14,191	13,956	12,300	15,583	16,232	14,228	12,898	12,800
2021	634	644	26,939	151,085	8,801	7,602	10,032	12,484	14,150	13,890	12,337	15,640	16,491	14,226	12,725	12,707
Average	**635**	**645**	**27,022**	**151,722**	**8,916**	**7,619**	**10,102**	**12,566**	**14,185**	**13,954**	**12,307**	**15,593**	**16,376**	**14,325**	**12,900**	**12,880**

Table A3-4. Lake Havasu data (2017 – 2021) from HDB.

Lake Havasu Evaporation (AF)																
Year	Low Elev (ft)	High Elev (ft)	Average Surface Area[3] (acres)	Total Evap (AF)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2017	446	449	18,890	140,019	6,446	7,709	9,113	11,179	13,386	15,409	17,122	16,942	15,320	12,245	8,614	6,535
2018	446	449	18,865	139,506	6,270	7,559	9,028	11,003	13,191	15,433	17,179	16,710	15,292	12,410	8,736	6,695
2019	446	450	18,941	139,880	6,369	7,673	9,036	11,080	13,309	15,424	16,987	16,796	15,320	12,368	8,717	6,801
2020	446	449	18,711	139,047	6,345	7,593	9,104	11,058	13,105	15,363	16,974	16,806	15,206	12,276	8,662	6,555
2021	446	449	18,915	139,677	6,322	7,593	8,978	11,019	13,364	15,474	17,098	16,884	15,325	12,396	8,633	6,592
Average	**446**	**449**	**18,864**	**139,626**	**6,350**	**7,625**	**9,052**	**11,068**	**13,271**	**15,421**	**17,072**	**16,828**	**15,293**	**12,339**	**8,672**	**6,636**

[2] This is the annual average, calculated by utilizing the average daily surface area to obtain a monthly average surface area, which was subsequently averaged to provide the annual average surface area. A dynamic surface area is used for evaporation calculations in Reclamation's HDB, which is based on each reservoir's elevation and the area and capacity tables.

[3] This is the annual average, calculated by utilizing the average daily surface area to obtain a monthly average surface area, which was subsequently averaged to provide the annual average surface area. A dynamic surface area is used for evaporation calculations in Reclamation's HDB, which is based on each reservoir's elevation and the area and capacity tables.

Appendix 4 – LCRAS Riparian Monthly Evapotranspiration Losses by Vegetation

Foreword

Data regarding the monthly and total riparian evapotranspiration (ET) losses are all provided in Acre-Feet. Due to rounding to the nearest acre-foot, the total value shown in a row may differ from the sum of the monthly values.

Introduction

This Appendix to the Lower Colorado River Mainstream Evaporation and Riparian Evapotranspiration Losses Report provides the monthly and annual riparian evapotranspiration losses by vegetation type from the LCRAS dataset between 2017 and 2021. Table A4-1 through Table A4-4 provide the losses estimated by the LCRAS report for Reach 2 through Reach 5. Table A4-5 provides the sum of the estimated riparian evapotranspiration losses by vegetation type between Hoover Dam, the start point of Reach 2, to the Northerly International Boundary, the end point of Reach 5. Table A4-6 provides the annual acreages by vegetation type for each reach, and the total acreage, that was used to estimate LCRAS riparian evapotranspiration losses for each reach.

Table A4-1. Reach 2, Hoover Dam to Davis Dam – Monthly and Annual Riparian ET Losses by Vegetation Type in Acre-Feet

Year	Vegetation Type	Total	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2017	Cottonwood/Willow	93	1	1	4	8	13	15	15	13	11	8	3	1
2017	Marsh	34	0	0	2	4	5	6	6	5	4	2	0	0
2017	Mixed Veg Low	846	13	15	47	84	124	137	137	119	81	53	19	17
2017	Mixed Veg Medium	1,175	26	31	77	119	167	184	184	146	100	71	35	35
2017	Salt Cedar Dense	2,065	25	30	77	168	292	338	338	300	245	166	52	34
2017	USGS barren	0	0	0	0	0	0	0	0	0	0	0	0	0
2017	**Sum**	**4,213**	**65**	**77**	**207**	**383**	**601**	**680**	**680**	**583**	**441**	**300**	**109**	**87**
2018	Cottonwood/Willow	101	2	2	4	9	14	16	15	16	12	7	3	1
2018	Marsh	34	0	0	2	4	5	6	6	6	4	1	0	0
2018	Mixed Veg Low	892	17	19	44	90	130	147	140	139	86	46	21	13
2018	Mixed Veg Medium	1,237	35	39	72	128	174	198	187	170	107	62	38	27
2018	Salt Cedar Dense	2,174	34	37	71	180	305	362	345	350	261	145	58	26
2018	USGS barren	0	0	0	0	0	0	0	0	0	0	0	0	0
2018	**Sum**	**4,438**	**88**	**97**	**193**	**411**	**628**	**729**	**693**	**681**	**470**	**261**	**120**	**67**
2019	Cottonwood/Willow	97	1	1	4	9	12	16	16	15	11	8	3	1
2019	Marsh	34	0	0	2	4	5	6	6	5	4	2	0	0
2019	Mixed Veg Low	846	14	14	42	86	115	142	142	129	83	49	20	10
2019	Mixed Veg Medium	1,170	30	29	69	122	154	191	190	157	104	67	36	21
2019	Salt Cedar Dense	2,073	28	27	69	172	268	351	350	325	252	156	55	20
2019	USGS barren	0	0	0	0	0	0	0	0	0	0	0	0	0
2019	**Sum**	**4,220**	**73**	**71**	**186**	**393**	**554**	**706**	**704**	**631**	**454**	**282**	**114**	**52**
2020	Cottonwood/Willow	100	1	2	3	8	15	16	17	15	12	7	3	1
2020	Marsh	35	0	0	2	4	6	6	6	6	4	1	0	0
2020	Mixed Veg Low	901	15	20	38	82	142	145	153	136	86	46	22	16
2020	Mixed Veg Medium	1,248	32	41	63	115	190	194	204	166	107	62	40	34
2020	Salt Cedar Dense	2,206	31	39	63	165	334	356	377	344	262	144	58	33
2020	USGS barren	0	0	0	0	0	0	0	0	0	0	0	0	0
2020	**Sum**	**4,490**	**79**	**102**	**169**	**374**	**687**	**717**	**757**	**667**	**471**	**260**	**123**	**84**

Year	Vegetation Type	Total	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2021	Cottonwood/Willow	100	2	2	4	9	14	16	16	15	11	7	3	1
2021	Marsh	35	0	0	2	5	5	6	6	6	4	1	0	0
2021	Mixed Veg Low	896	18	20	46	92	132	143	148	135	82	44	23	13
2021	Mixed Veg Medium	1,248	37	41	74	131	178	193	198	165	103	60	42	26
2021	Salt Cedar Dense	2,178	36	39	75	184	310	353	365	339	250	140	62	25
2021	USGS barren	0	0	0	0	0	0	0	0	0	0	0	0	0
2021	**Sum**	**4,457**	**93**	**102**	**201**	**421**	**639**	**711**	**733**	**660**	**450**	**252**	**130**	**65**
Average	Cottonwood/Willow	99	1	2	4	9	14	16	16	15	11	7	3	1
Average	Marsh	34	0	0	2	4	5	6	6	6	4	1	0	0
Average	Mixed Veg Low	878	15	18	43	87	129	143	144	132	84	48	21	14
Average	Mixed Veg Medium	1,216	32	36	71	123	173	192	193	161	104	64	38	29
Average	Salt Cedar Dense	2,140	31	34	71	174	302	352	355	332	254	150	57	28
Average	USGS barren	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	**Sum**	**4,367**	**79**	**90**	**191**	**397**	**623**	**709**	**714**	**646**	**457**	**270**	**119**	**72**

Table A4-2. Reach 3, Davis Dam to Parker Dam – Monthly and Annual LCRAS Riparian ET Losses by Vegetation Type in Acre-Feet

Year	Vegetation Type	Total	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2017	Cottonwood/Willow	923	12	14	41	80	129	146	146	129	106	82	26	12
2017	Marsh	27,680	247	291	1,772	3,292	4,059	4,446	4,442	3,935	3,209	1,353	315	319
2017	Mixed Veg Low	29,068	440	529	1,624	2,889	4,271	4,710	4,701	4,082	2,763	1,803	664	592
2017	Mixed Veg Medium	18,000	401	479	1,185	1,822	2,561	2,820	2,809	2,228	1,534	1,083	536	542
2017	Salt Cedar Dense	40,153	491	584	1,501	3,271	5,681	6,570	6,570	5,820	4,763	3,225	1,010	667
2017	USGS barren	1,948	89	93	146	174	215	235	235	209	172	157	105	118
2017	**Sum**	**117,772**	**1,680**	**1,990**	**6,269**	**11,528**	**16,916**	**18,927**	**18,903**	**16,403**	**12,547**	**7,703**	**2,656**	**2,250**
2018	Cottonwood/Willow	971	16	18	38	86	135	156	149	151	113	71	29	9
2018	Marsh	29,130	327	359	1,616	3,544	4,218	4,761	4,541	4,601	3,408	1,173	343	239
2018	Mixed Veg Low	30,612	583	655	1,498	3,095	4,450	5,042	4,809	4,773	2,952	1,579	736	440
2018	Mixed Veg Medium	18,903	536	592	1,094	1,957	2,663	3,024	2,866	2,600	1,636	948	581	406
2018	Salt Cedar Dense	42,221	658	723	1,381	3,503	5,922	7,034	6,709	6,802	5,060	2,808	1,121	500
2018	USGS barren	2,039	117	115	135	189	224	252	241	244	183	137	113	89
2018	**Sum**	**123,876**	**2,237**	**2,462**	**5,762**	**12,374**	**17,612**	**20,269**	**19,315**	**19,171**	**13,352**	**6,716**	**2,923**	**1,683**
2019	Cottonwood/Willow	924	13	13	37	82	118	151	151	140	109	76	28	6
2019	Marsh	27,717	275	267	1,568	3,360	3,731	4,613	4,593	4,266	3,296	1,245	319	184
2019	Mixed Veg Low	29,054	485	485	1,445	2,952	3,930	4,881	4,863	4,423	2,862	1,696	691	341
2019	Mixed Veg Medium	17,871	451	440	1,055	1,862	2,352	2,928	2,899	2,409	1,591	1,021	547	316
2019	Salt Cedar Dense	40,238	547	528	1,334	3,345	5,199	6,821	6,793	6,311	4,893	3,021	1,066	380
2019	USGS barren	1,900	98	85	130	178	198	244	244	226	176	148	105	68
2019	**Sum**	**117,704**	**1,869**	**1,818**	**5,569**	**11,779**	**15,528**	**19,638**	**19,543**	**17,775**	**12,927**	**7,207**	**2,756**	**1,295**
2020	Cottonwood/Willow	982	14	19	33	78	147	154	163	148	114	71	30	11
2020	Marsh	29,298	295	383	1,425	3,161	4,613	4,685	4,960	4,525	3,416	1,169	359	307
2020	Mixed Veg Low	30,918	520	700	1,319	2,807	4,862	4,960	5,247	4,673	2,942	1,570	753	565
2020	Mixed Veg Medium	19,103	485	626	964	1,759	2,909	2,971	3,124	2,543	1,641	942	615	524
2020	Salt Cedar Dense	42,812	593	759	1,222	3,195	6,473	6,918	7,325	6,686	5,084	2,797	1,121	639
2020	USGS barren	2,064	105	120	120	168	244	248	263	241	183	135	122	115

Year	Vegetation Type	Total	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2020	**Sum**	**125,177**	**2,012**	**2,607**	**5,083**	**11,168**	**19,248**	**19,936**	**21,082**	**18,816**	**13,380**	**6,684**	**3,000**	**2,161**
2021	Cottonwood/Willow	973	17	19	40	88	137	152	157	146	108	69	31	9
2021	Marsh	29,303	347	379	1,728	3,636	4,310	4,637	4,793	4,454	3,276	1,137	375	231
2021	Mixed Veg Low	30,740	619	699	1,560	3,164	4,536	4,904	5,074	4,617	2,824	1,524	789	430
2021	Mixed Veg Medium	19,038	569	625	1,132	1,999	2,714	2,939	3,024	2,517	1,571	918	636	394
2021	Salt Cedar Dense	42,145	692	757	1,449	3,563	5,999	6,830	7,061	6,563	4,846	2,714	1,191	480
2021	USGS barren	2,107	127	123	142	197	233	252	259	242	180	136	129	87
2021	**Sum**	**124,306**	**2,371**	**2,602**	**6,051**	**12,647**	**17,929**	**19,714**	**20,368**	**18,539**	**12,805**	**6,498**	**3,151**	**1,631**
Average	Cottonwood/Willow	955	14	17	38	83	133	152	153	143	110	74	29	9
Average	Marsh	28,626	298	336	1,622	3,399	4,186	4,628	4,666	4,356	3,321	1,215	342	256
Average	Mixed Veg Low	30,078	529	614	1,489	2,981	4,410	4,899	4,939	4,514	2,869	1,634	727	474
Average	Mixed Veg Medium	18,583	488	552	1,086	1,880	2,640	2,936	2,944	2,459	1,595	982	583	436
Average	Salt Cedar Dense	41,514	596	670	1,377	3,375	5,855	6,835	6,892	6,436	4,929	2,913	1,102	533
Average	USGS barren	2,012	107	107	135	181	223	246	248	232	179	143	115	95
Average	**Sum**	**121,767**	**2,034**	**2,296**	**5,747**	**11,899**	**17,447**	**19,697**	**19,842**	**18,141**	**13,002**	**6,962**	**2,897**	**1,804**

Table A4-3. Reach 4, Parker Dam to Imperial Dam – Monthly and Annual LCRAS Riparian ET Losses by Vegetation Type in Acre-Feet

Year	Vegetation Type	Total	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2017	Cottonwood/Willow	191	2	3	8	17	26	32	31	28	21	16	5	2
2017	Marsh	53,718	460	588	3,408	6,582	7,577	8,957	8,851	7,833	5,896	2,488	535	543
2017	Mixed Veg Low	79,835	1,158	1,520	4,391	8,179	11,364	13,487	13,342	11,557	7,262	4,560	1,592	1,423
2017	Mixed Veg Medium	45,233	974	1,267	2,923	4,746	6,235	7,418	7,307	5,776	3,702	2,505	1,183	1,197
2017	Salt Cedar Dense	76,059	896	1,155	2,809	6,394	10,462	13,030	12,875	11,410	8,617	5,636	1,672	1,103
2017	USGS barren	3,460	153	176	255	327	376	444	438	389	294	255	167	186
2017	**Sum**	**258,496**	**3,643**	**4,709**	**13,794**	**26,245**	**36,040**	**43,368**	**42,844**	**36,993**	**25,792**	**15,460**	**5,154**	**4,454**
2018	Cottonwood/Willow	189	3	3	8	18	27	30	29	30	22	13	5	1
2018	Marsh	53,382	566	657	3,154	6,807	7,931	8,550	8,308	8,316	6,203	1,932	581	377
2018	Mixed Veg Low	79,337	1,424	1,689	4,150	8,445	11,896	12,885	12,523	12,258	7,649	3,668	1,761	989
2018	Mixed Veg Medium	44,929	1,197	1,406	2,770	4,899	6,528	7,085	6,848	6,138	3,897	2,032	1,294	835
2018	Salt Cedar Dense	75,410	1,103	1,293	2,637	6,602	10,928	12,427	12,083	12,100	9,049	4,533	1,879	776
2018	USGS barren	3,434	186	196	245	336	392	425	412	412	310	209	180	131
2018	**Sum**	**256,681**	**4,479**	**5,244**	**12,964**	**27,107**	**37,702**	**41,402**	**40,203**	**39,254**	**27,130**	**12,387**	**5,700**	**3,109**
2019	Cottonwood/Willow	192	2	3	8	17	25	31	32	30	22	16	5	1
2019	Marsh	53,652	460	535	3,085	6,577	7,270	8,620	8,922	8,590	6,260	2,413	573	347
2019	Mixed Veg Low	79,745	1,158	1,399	4,054	8,204	10,906	12,981	13,440	12,668	7,745	4,536	1,737	917
2019	Mixed Veg Medium	44,873	974	1,155	2,714	4,746	5,985	7,140	7,349	6,333	3,939	2,505	1,267	766
2019	Salt Cedar Dense	76,270	896	1,069	2,585	6,412	10,014	12,531	12,979	12,496	9,135	5,602	1,844	707
2019	USGS barren	3,401	154	160	238	327	359	428	441	425	314	258	176	121
2019	**Sum**	**258,133**	**3,644**	**4,321**	**12,684**	**26,283**	**34,559**	**41,731**	**43,163**	**40,542**	**27,415**	**15,330**	**5,602**	**2,859**
2020	Cottonwood/Willow	204	3	4	7	16	29	31	34	31	25	16	6	2
2020	Marsh	55,948	565	739	2,646	6,077	8,293	8,723	9,665	8,768	6,906	2,420	656	490
2020	Mixed Veg Low	83,734	1,420	1,925	3,442	7,678	12,419	13,117	14,537	12,877	8,472	4,621	1,950	1,276
2020	Mixed Veg Medium	47,420	1,210	1,585	2,308	4,422	6,842	7,231	7,954	6,439	4,339	2,559	1,446	1,085
2020	Salt Cedar Dense	80,688	1,120	1,447	2,205	6,065	11,493	12,699	14,060	12,750	10,114	5,720	2,016	999
2020	USGS barren	3,650	189	216	202	300	411	431	480	434	346	265	206	170

Year	Vegetation Type	Total	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2020	**Sum**	**271,644**	**4,507**	**5,916**	**10,810**	**24,558**	**39,487**	**42,232**	**46,730**	**41,299**	**30,202**	**15,601**	**6,280**	**4,022**
2021	Cottonwood/Willow	204	3	4	8	18	29	33	33	30	23	15	6	2
2021	Marsh	56,526	558	732	3,160	6,705	8,319	9,284	9,201	8,500	6,546	2,315	686	520
2021	Mixed Veg Low	84,335	1,396	1,901	4,140	8,304	12,443	13,960	13,839	12,515	8,063	4,380	2,046	1,348
2021	Mixed Veg Medium	47,962	1,196	1,571	2,767	4,825	6,842	7,690	7,593	6,286	4,116	2,420	1,516	1,140
2021	Salt Cedar Dense	80,569	1,103	1,430	2,636	6,496	11,441	13,491	13,388	12,371	9,563	5,428	2,171	1,051
2021	USGS barren	3,699	186	216	245	333	411	460	457	421	327	251	212	180
2021	**Sum**	**273,295**	**4,442**	**5,854**	**12,956**	**26,681**	**39,485**	**44,918**	**44,511**	**40,123**	**28,638**	**14,809**	**6,637**	**4,241**
Average	Cottonwood/Willow	196	3	3	8	17	27	31	32	30	23	15	5	2
Average	Marsh	54,645	522	650	3,091	6,550	7,878	8,827	8,989	8,401	6,362	2,314	606	455
Average	Mixed Veg Low	81,397	1,311	1,687	4,035	8,162	11,806	13,286	13,536	12,375	7,838	4,353	1,817	1,191
Average	Mixed Veg Medium	46,083	1,110	1,397	2,696	4,728	6,486	7,313	7,410	6,194	3,999	2,404	1,341	1,005
Average	Salt Cedar Dense	77,799	1,024	1,279	2,574	6,394	10,868	12,836	13,077	12,225	9,296	5,384	1,916	927
Average	USGS barren	3,529	174	193	237	325	390	438	446	416	318	248	188	158
Average	**Sum**	**263,650**	**4,143**	**5,209**	**12,642**	**26,175**	**37,455**	**42,730**	**43,490**	**39,642**	**27,835**	**14,717**	**5,875**	**3,737**

Table A4-4. Reach 5, Imperial Dam to Northerly International Boundary – Monthly and Annual LCRAS Riparian ET Losses by Vegetation Type in Acre-Feet

Year	Vegetation Type	Total	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2017	Cottonwood/Willow	1,286	18	21	57	110	163	201	216	197	147	108	33	15
2017	Marsh	18,985	181	212	1,201	2,223	2,511	3,012	3,222	2,949	2,181	889	194	210
2017	Mixed Veg Low	12,174	198	234	671	1,190	1,619	1,951	2,088	1,868	1,154	718	249	234
2017	Mixed Veg Medium	6,297	152	178	410	628	811	978	1,041	851	537	360	169	182
2017	Salt Cedar Dense	16,038	213	245	590	1,283	2,061	2,597	2,782	2,544	1,887	1,222	362	252
2017	USGS barren	908	44	46	67	81	91	109	117	107	80	69	44	53
2017	**Sum**	**55,688**	**806**	**936**	**2,996**	**5,515**	**7,256**	**8,848**	**9,466**	**8,516**	**5,986**	**3,366**	**1,051**	**946**
2018	Cottonwood/Willow	1,218	22	21	51	105	163	178	193	191	156	92	36	10
2018	Marsh	18,725	229	224	1,118	2,220	2,620	2,770	3,014	2,977	2,409	784	213	147
2018	Mixed Veg Low	11,967	249	249	624	1,183	1,685	1,789	1,948	1,883	1,274	639	278	166
2018	Mixed Veg Medium	6,195	192	188	382	627	846	899	973	861	593	321	184	129
2018	Salt Cedar Dense	15,773	267	259	551	1,276	2,136	2,385	2,594	2,562	2,079	1,084	402	178
2018	USGS barren	921	57	50	64	83	98	103	112	111	91	63	50	39
2018	**Sum**	**54,799**	**1,016**	**991**	**2,790**	**5,494**	**7,548**	**8,124**	**8,834**	**8,585**	**6,602**	**2,983**	**1,163**	**669**
2019	Cottonwood/Willow	1,261	17	20	54	110	162	198	203	198	150	104	35	10
2019	Marsh	18,402	166	197	1,116	2,215	2,472	2,923	3,001	2,926	2,202	839	200	145
2019	Mixed Veg Low	11,800	182	222	633	1,184	1,595	1,896	1,946	1,856	1,173	687	261	165
2019	Mixed Veg Medium	5,915	136	163	375	608	778	927	945	824	531	337	168	123
2019	Salt Cedar Dense	15,546	197	232	556	1,273	2,022	2,521	2,588	2,525	1,906	1,167	383	176
2019	USGS barren	913	43	45	67	85	94	112	114	112	85	70	48	38
2019	**Sum**	**53,837**	**741**	**879**	**2,801**	**5,475**	**7,123**	**8,577**	**8,797**	**8,441**	**6,047**	**3,204**	**1,095**	**657**
2020	Cottonwood/Willow	1,303	20	24	44	104	179	199	217	209	160	97	37	13
2020	Marsh	18,922	203	241	922	2,054	2,726	2,952	3,214	3,097	2,331	779	221	182
2020	Mixed Veg Low	12,146	217	271	516	1,111	1,755	1,904	2,075	1,951	1,228	634	281	203
2020	Mixed Veg Medium	6,129	165	198	306	571	859	936	1,011	870	559	313	187	154
2020	Salt Cedar Dense	16,080	235	280	456	1,206	2,229	2,537	2,762	2,660	2,015	1,079	400	221
2020	USGS barren	981	53	56	56	80	107	116	127	121	93	67	55	50

Year	Vegetation Type	Total	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2020	**Sum**	**55,561**	**893**	**1,070**	**2,300**	**5,126**	**7,855**	**8,644**	**9,406**	**8,908**	**6,386**	**2,969**	**1,181**	**823**
2021	Cottonwood/Willow	1,271	19	25	55	112	168	192	200	196	150	101	41	12
2021	Marsh	18,547	192	244	1,150	2,267	2,568	2,838	2,968	2,895	2,202	823	239	161
2021	Mixed Veg Low	11,917	211	275	643	1,205	1,655	1,841	1,923	1,841	1,172	665	307	179
2021	Mixed Veg Medium	6,014	157	201	381	621	808	899	936	819	529	324	203	136
2021	Salt Cedar Dense	15,368	221	280	556	1,271	2,059	2,405	2,512	2,453	1,873	1,109	439	190
2021	USGS barren	999	52	59	72	92	104	115	120	118	90	71	61	45
2021	**Sum**	**54,116**	**852**	**1,084**	**2,857**	**5,568**	**7,362**	**8,290**	**8,659**	**8,322**	**6,016**	**3,093**	**1,290**	**723**
Average	Cottonwood/Willow	1,268	19	22	52	108	167	194	206	198	153	100	36	12
Average	Marsh	18,716	194	224	1,101	2,196	2,579	2,899	3,084	2,969	2,265	823	213	169
Average	Mixed Veg Low	12,001	211	250	617	1,175	1,662	1,876	1,996	1,880	1,200	669	275	189
Average	Mixed Veg Medium	6,110	160	186	371	611	820	928	981	845	550	331	182	145
Average	Salt Cedar Dense	15,761	227	259	542	1,262	2,101	2,489	2,648	2,549	1,952	1,132	397	203
Average	USGS barren	944	50	51	65	84	99	111	118	114	88	68	52	45
Average	**Sum**	**54,800**	**862**	**992**	**2,749**	**5,436**	**7,429**	**8,497**	**9,032**	**8,554**	**6,207**	**3,123**	**1,156**	**764**

Table A4-5. Sum of LCRAS Riparian ET Losses for Reaches 2 to 5, Hoover Dam to Northerly International Boundary – Monthly and Annual LCRAS Riparian ET Losses by Vegetation Type in Acre-Feet

Year	Vegetation Type	Total	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2017	Cottonwood/Willow	2,493	33	39	110	215	331	394	408	367	285	214	67	30
2017	Marsh	100,417	888	1,091	6,383	12,101	14,152	16,421	16,521	14,722	11,290	4,732	1,044	1,072
2017	Mixed Veg Low	121,923	1,809	2,298	6,733	12,342	17,378	20,285	20,268	17,626	11,260	7,134	2,524	2,266
2017	Mixed Veg Medium	70,705	1,553	1,955	4,595	7,315	9,774	11,400	11,341	9,001	5,873	4,019	1,923	1,956
2017	Salt Cedar Dense	134,315	1,625	2,014	4,977	11,116	18,496	22,535	22,565	20,074	15,512	10,249	3,096	2,056
2017	USGS barren	6,316	286	315	468	582	682	788	790	705	546	481	316	357
2017	**Sum**	**436,169**	**6,194**	**7,712**	**23,266**	**43,671**	**60,813**	**71,823**	**71,893**	**62,495**	**44,766**	**26,829**	**8,970**	**7,737**
2018	Cottonwood/Willow	2,479	43	44	101	218	339	380	386	388	303	183	73	21
2018	Marsh	101,271	1,122	1,240	5,890	12,575	14,774	16,087	15,869	15,900	12,024	3,890	1,137	763
2018	Mixed Veg Low	122,808	2,273	2,612	6,316	12,813	18,161	19,863	19,420	19,053	11,961	5,932	2,796	1,608
2018	Mixed Veg Medium	71,264	1,960	2,225	4,318	7,611	10,211	11,206	10,874	9,769	6,233	3,363	2,097	1,397
2018	Salt Cedar Dense	135,578	2,062	2,312	4,640	11,561	19,291	22,208	21,731	21,814	16,449	8,570	3,460	1,480
2018	USGS barren	6,394	360	361	444	608	714	780	765	767	584	409	343	259
2018	**Sum**	**439,794**	**7,820**	**8,794**	**21,709**	**45,386**	**63,490**	**70,524**	**69,045**	**67,691**	**47,554**	**22,347**	**9,906**	**5,528**
2019	Cottonwood/Willow	2,474	33	37	103	218	317	396	402	383	292	204	71	18
2019	Marsh	99,805	901	999	5,771	12,156	13,478	16,162	16,522	15,787	11,762	4,499	1,092	676
2019	Mixed Veg Low	121,445	1,839	2,120	6,174	12,426	16,546	19,900	20,391	19,076	11,863	6,968	2,709	1,433
2019	Mixed Veg Medium	69,829	1,591	1,787	4,213	7,338	9,269	11,186	11,383	9,723	6,165	3,930	2,018	1,226
2019	Salt Cedar Dense	134,127	1,668	1,856	4,544	11,202	17,503	22,224	22,710	21,657	16,186	9,946	3,348	1,283
2019	USGS barren	6,214	295	290	435	590	651	784	799	763	575	476	329	227
2019	**Sum**	**433,894**	**6,327**	**7,089**	**21,240**	**43,930**	**57,764**	**70,652**	**72,207**	**67,389**	**46,843**	**26,023**	**9,567**	**4,863**
2020	Cottonwood/Willow	2,589	38	49	87	206	370	400	431	403	311	191	76	27
2020	Marsh	104,203	1,063	1,363	4,995	11,296	15,638	16,366	17,845	16,396	12,657	4,369	1,236	979
2020	Mixed Veg Low	127,699	2,172	2,916	5,315	11,678	19,178	20,126	22,012	19,637	12,728	6,871	3,006	2,060
2020	Mixed Veg Medium	73,900	1,892	2,450	3,641	6,867	10,800	11,332	12,293	10,018	6,646	3,876	2,288	1,797
2020	Salt Cedar Dense	141,786	1,979	2,525	3,946	10,631	20,529	22,510	24,524	22,440	17,475	9,740	3,595	1,892
2020	USGS barren	6,695	347	392	378	548	762	795	870	796	622	467	383	335

Year	Vegetation Type	Total	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2020	**Sum**	**456,872**	**7,491**	**9,695**	**18,362**	**41,226**	**67,277**	**71,529**	**77,975**	**69,690**	**50,439**	**25,514**	**10,584**	**7,090**
2021	Cottonwood/Willow	2,548	41	50	107	227	348	393	406	387	292	192	81	24
2021	Marsh	104,411	1,097	1,355	6,040	12,613	15,202	16,765	16,968	15,855	12,028	4,276	1,300	912
2021	Mixed Veg Low	127,888	2,244	2,895	6,389	12,765	18,766	20,848	20,984	19,108	12,141	6,613	3,165	1,970
2021	Mixed Veg Medium	74,262	1,959	2,438	4,354	7,576	10,542	11,721	11,751	9,787	6,319	3,722	2,397	1,696
2021	Salt Cedar Dense	140,260	2,052	2,506	4,716	11,514	19,809	23,079	23,326	21,726	16,532	9,391	3,863	1,746
2021	USGS barren	6,805	365	398	459	622	748	827	836	781	597	458	402	312
2021	**Sum**	**456,174**	**7,758**	**9,642**	**22,065**	**45,317**	**65,415**	**73,633**	**74,271**	**67,644**	**47,909**	**24,652**	**11,208**	**6,660**
Average	Cottonwood/Willow	2,517	38	44	102	217	341	393	407	386	297	197	74	24
Average	Marsh	102,021	1,014	1,210	5,816	12,148	14,649	16,360	16,745	15,732	11,952	4,353	1,162	880
Average	Mixed Veg Low	124,353	2,067	2,568	6,185	12,405	18,006	20,204	20,615	18,900	11,991	6,704	2,840	1,867
Average	Mixed Veg Medium	71,992	1,791	2,171	4,224	7,341	10,119	11,369	11,528	9,660	6,247	3,782	2,145	1,614
Average	Salt Cedar Dense	137,213	1,877	2,243	4,565	11,205	19,126	22,511	22,971	21,542	16,431	9,579	3,472	1,691
Average	USGS barren	6,485	331	351	437	590	711	795	812	762	585	458	355	298
Average	**Sum**	**444,581**	**7,118**	**8,586**	**21,328**	**43,906**	**62,952**	**71,632**	**73,078**	**66,982**	**47,502**	**25,073**	**10,047**	**6,376**

Table A4-6. Sum of LCRAS Riparian Acres for Reaches 2 to 5, Hoover Dam to Northerly International Boundary

Year	Vegetation Type	Total	Reach 2	Reach 3	Reach 4	Reach 5
2017	Cottonwood/Willow	486	19	184	38	246
2017	Marsh	16,987	6	4,789	9,047	3,146
2017	Mixed Veg Low	44,359	314	10,767	28,952	4,327
2017	Mixed Veg Medium	26,189	443	6,769	16,702	2,275
2017	Salt Cedar Dense	36,639	573	11,120	20,682	4,264
2017	USGS Barren	7,137	0	2,220	3,919	998
2017	**Sum**	**131,797**	**1,354**	**35,849**	**79,339**	**15,255**
2018	Cottonwood/Willow	477	19	184	38	237
2018	Marsh	17,006	6	4,789	9,055	3,156
2018	Mixed Veg Low	44,365	314	10,767	28,955	4,329
2018	Mixed Veg Medium	26,195	443	6,769	16,703	2,281
2018	Salt Cedar Dense	36,642	573	11,120	20,684	4,265
2018	USGS Barren	7,169	0	2,220	3,919	1,028
2018	**Sum**	**131,854**	**1,354**	**35,849**	**79,354**	**15,296**
2019	Cottonwood/Willow	486	19	184	38	246
2019	Marsh	16,961	6	4,789	9,050	3,116
2019	Mixed Veg Low	44,327	314	10,767	28,954	4,292
2019	Mixed Veg Medium	26,111	443	6,769	16,702	2,197
2019	Salt Cedar Dense	36,596	573	11,120	20,683	4,219
2019	USGS Barren	7,180	0	2,220	3,919	1,040
2019	**Sum**	**131,661**	**1,354**	**35,849**	**79,347**	**15,111**
2020	Cottonwood/Willow	486	19	184	38	246
2020	Marsh	16,958	6	4,789	9,047	3,116
2020	Mixed Veg Low	44,231	314	10,764	28,882	4,271
2020	Mixed Veg Medium	26,093	443	6,766	16,687	2,197
2020	Salt Cedar Dense	36,568	573	11,113	20,676	4,206
2020	USGS Barren	7,209	0	2,220	3,919	1,070
2020	**Sum**	**131,545**	**1,354**	**35,835**	**79,250**	**15,106**

2021	Cottonwood/Willow	486	19	184	38	246
2021	Marsh	16,961	6	4,789	9,050	3,116
2021	Mixed Veg Low	44,242	314	10,757	28,882	4,289
2021	Mixed Veg Medium	26,084	443	6,757	16,687	2,197
2021	Salt Cedar Dense	36,471	573	11,076	20,676	4,146
2021	USGS Barren	7,295	0	2,273	3,919	1,103
2021	**Sum**	**131,539**	**1,354**	**35,835**	**79,252**	**15,097**
Average	Cottonwood/Willow	484	19	184	38	244
Average	Marsh	16,974	6	4,789	9,050	3,130
Average	Mixed Veg Low	44,305	314	10,764	28,925	4,302
Average	Mixed Veg Medium	26,135	443	6,766	16,696	2,230
Average	Salt Cedar Dense	36,583	573	11,110	20,680	4,220
Average	USGS Barren	7,198	0	2,231	3,919	1,048
Average	**Sum**	**131,679**	**1,354**	**35,843**	**79,308**	**15,173**

Appendix 5 – Evaporation and Riparian Evapotranspiration (ET) Coefficients

Introduction

This Appendix to the Lower Colorado River Mainstream Evaporation and Riparian Evapotranspiration Losses Report provides evaporation and riparian ET coefficients used in LCRAS and HDB. Section A5.1 provides LCRAS open water evaporation coefficients, section A5.2 provides HDB evaporation coefficients, and section A5.3 provides the LCRAS riparian ET coefficients.

The evaporation coefficients for Lake Mead and Lake Mohave were updated in 2021 based on a Reclamation-funded USGS Study. The updated USGS coefficients were applied to the entire Lake Mead and Lake Mohave HDB evaporation dataset provided in this report, but not to the HDB record until it was introduced in October 2021. Both the updated coefficients and historically used coefficients are provided in Section A5.2.

A5.1. LCRAS Open Water Coefficients

Figure A5-1. Annual variation in LCRAS open water evaporation coefficients (Kc) by reach

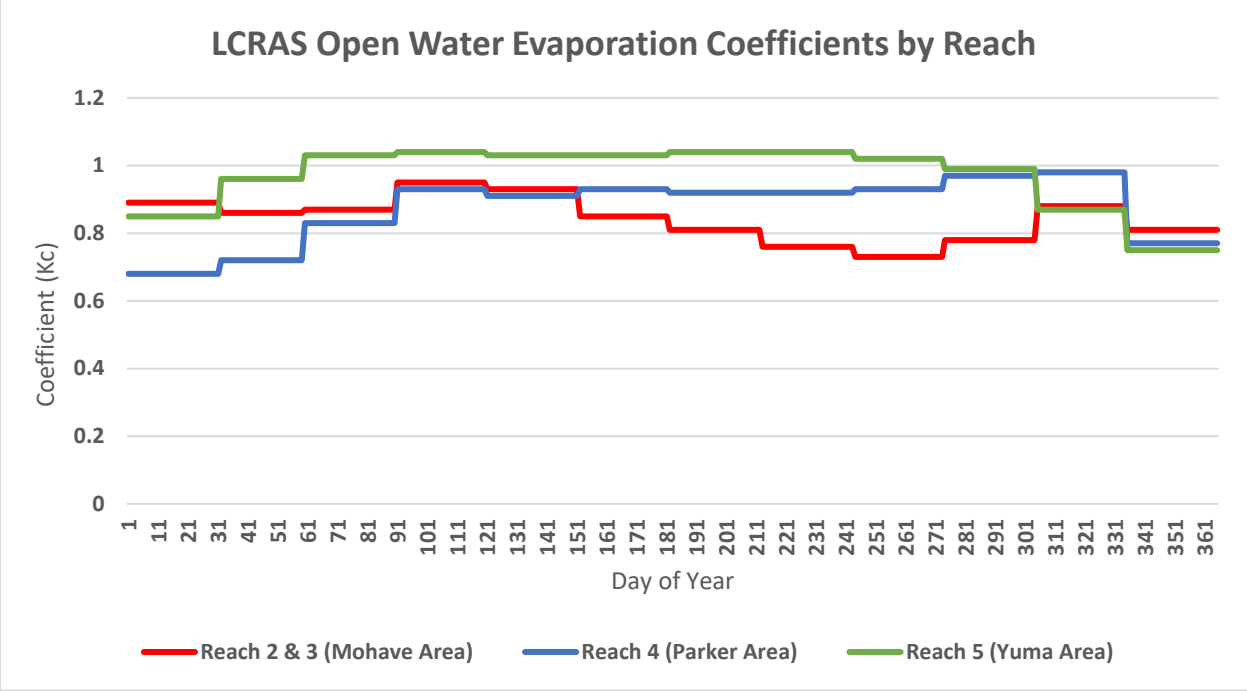


Table A5-1. LCRAS Open Water Evaporation Coefficients by Reach

Reach 2 & 3 (Mohave Area)	
Day of Year	Coefficient
1 - 30	0.89
31 - 58	0.86
59 - 89	0.87
90 - 119	0.95
120 - 150	0.93
151 - 180	0.85
181 - 211	0.81
212 - 242	0.76
243 - 272	0.73
273 - 303	0.78
304 - 333	0.88
334 - 365	0.81

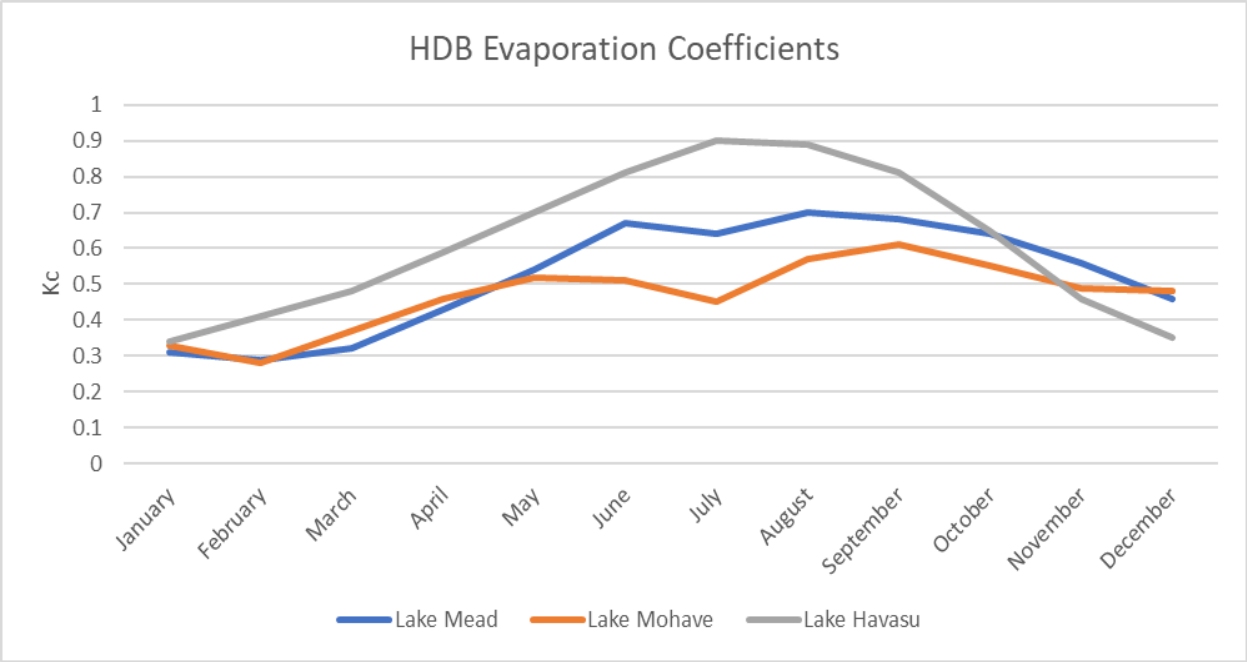
Reach 4 (Parker Area)	
Day of Year	Coefficient
1 - 30	0.68
31 - 58	0.72
59 - 89	0.83
90 - 119	0.93
120 - 150	0.91
151 - 180	0.93
191 - 242	0.92
243 - 272	0.93
273 - 303	0.97
304 - 333	0.98
334 - 365	0.77

Reach 5 (Yuma Area)	
Day of Year	Coefficient
1 - 31	0.85
32 - 59	0.96
60 - 90	1.03
91 - 120	1.04
121 - 181	1.03
182 - 243	1.04
242 - 273	1.02
274 - 304	0.99
305 - 334	0.87
335 - 365	0.75

A5.2. HDB Evaporation Coefficients

The original evaporation coefficients used to calculate evaporative losses at Lake Mead, Lake Mohave, and Lake Havasu were based on pan evaporation studies. Those coefficients are still used to estimate evaporation at Lake Havasu and are shown for Lake Havasu in Figure A5-2 and Table A5-2. The evaporation coefficients for Lake Mead and Lake Mohave were recently updated based on a Reclamation-funded USGS Study[1]. The new USGS coefficients were applied to the entire Lake Mead and Lake Mohave HDB evaporation dataset provided in this report, but not to the HDB record until October 2021[2]. All of the coefficients are shown in Table A5-2.

Figure A5-2. Annual variation in HDB evaporation coefficients (Kc) by reservoir



The new USGS coefficients at Lake Mead and Lake Mohave, shown above in Figure A5-2, follow a different monthly pattern, with evaporation peaking in the fall. Lake Mead's depth and cooler waters kept the water surface cooler than air temperature in the spring and summer, causing peak evaporation to lag peak net radiation by about two months. Lake Mohave's evaporation decrease in the summer is associated with the slightly shallower reservoir having an inflow of cold water originating from deep in Lake Mead while releasing its higher temperature water out of Davis Dam, resulting in less energy being available for evaporation.

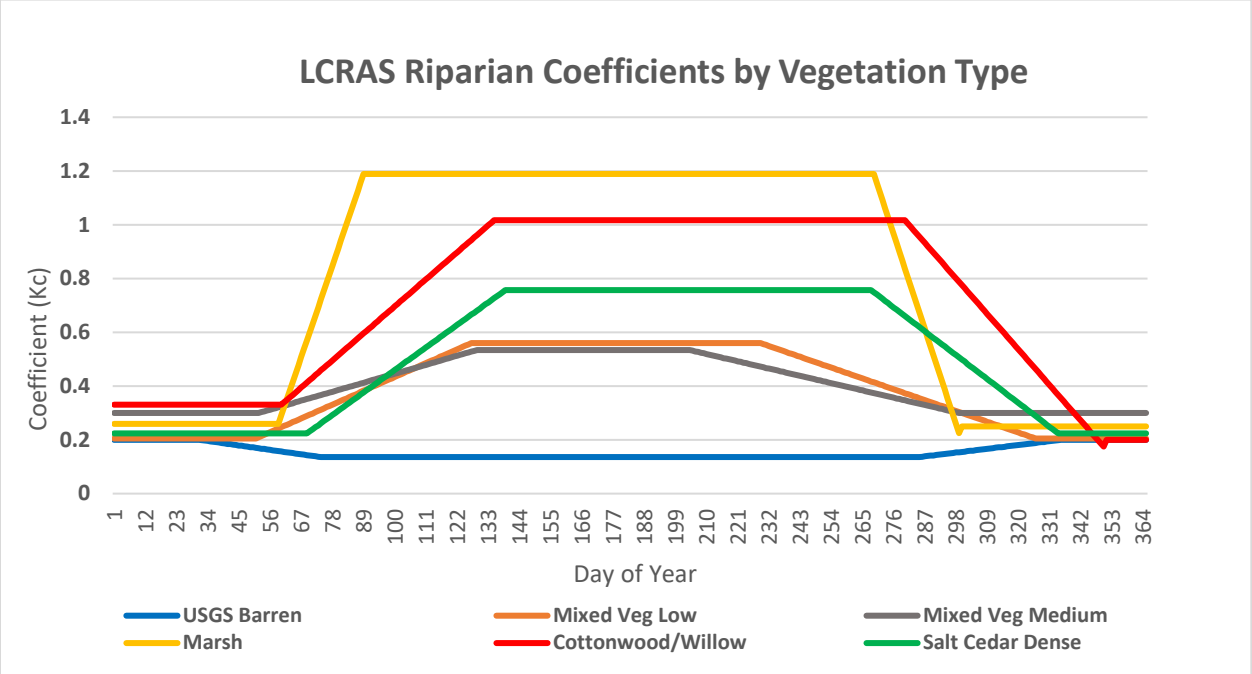
[1]The USGS report is available at: https://pubs.usgs.gov/publication/sir20135229.
[2]Reclamation completed a sensitivity analysis showing implementation effects of the new USGS coefficients, which is available at: https://www.usbr.gov/lc/riverops/evaporation/Mead-Mohave%20Evap%20Study.pdf.

Table A5-2. Evaporation Coefficients for Lakes Mead, Mohave, and Havasu used in HDB. For Lake Mead and Lake Mohave, the USGS coefficients were applied to the entire dataset in this report, though they were not implemented in HDB until October 2021.

Month	Lake Mead USGS Coefficients (ft/month)	Lake Mead Old Coefficients (ft/month)	Lake Mohave USGS Coefficients (ft/month)	Lake Mohave Old Coefficients (ft/month)	Lake Havasu Coefficients (ft/month)
January	0.31	0.36	0.33	0.36	0.34
February	0.29	0.33	0.28	0.36	0.41
March	0.32	0.37	0.37	0.48	0.48
April	0.43	0.46	0.46	0.61	0.59
May	0.54	0.53	0.52	0.81	0.70
June	0.67	0.64	0.51	0.93	0.81
July	0.64	0.80	0.45	0.93	0.90
August	0.70	0.85	0.57	0.84	0.89
September	0.68	0.70	0.61	0.68	0.81
October	0.64	0.51	0.55	0.56	0.65
November	0.56	0.51	0.49	0.40	0.46
December	0.46	0.44	0.48	0.35	0.35

A5.3. LCRAS Riparian ET Coefficients

Figure A5-3. Annual variation in LCRAS riparian ET coefficients (Kc) by vegetation type



Tables A5-33. LCRAS Riparian ET Coefficients by Vegetation Type

Day of Year	USGS Barren	Mixed Veg Low	Mixed Veg Medium	Marsh	Cottonwood/ Willow	Salt Cedar Dense
1	0.200	0.205	0.300	0.260	0.331	0.224
2	0.200	0.205	0.300	0.260	0.331	0.224
3	0.200	0.205	0.300	0.260	0.331	0.224
4	0.200	0.205	0.300	0.260	0.331	0.224
5	0.200	0.205	0.300	0.260	0.331	0.224
6	0.200	0.205	0.300	0.260	0.331	0.224
7	0.200	0.205	0.300	0.260	0.331	0.224
8	0.200	0.205	0.300	0.260	0.331	0.224
9	0.200	0.205	0.300	0.260	0.331	0.224
10	0.200	0.205	0.300	0.260	0.331	0.224
11	0.200	0.205	0.300	0.260	0.331	0.224
12	0.200	0.205	0.300	0.260	0.331	0.224
13	0.200	0.205	0.300	0.260	0.331	0.224
14	0.200	0.205	0.300	0.260	0.331	0.224
15	0.200	0.205	0.300	0.260	0.331	0.224
16	0.200	0.205	0.300	0.260	0.331	0.224
17	0.200	0.205	0.300	0.260	0.331	0.224
18	0.200	0.205	0.300	0.260	0.331	0.224
19	0.200	0.205	0.300	0.260	0.331	0.224
20	0.200	0.205	0.300	0.260	0.331	0.224
21	0.200	0.205	0.300	0.260	0.331	0.224
22	0.200	0.205	0.300	0.260	0.331	0.224
23	0.200	0.205	0.300	0.260	0.331	0.224
24	0.200	0.205	0.300	0.260	0.331	0.224
25	0.200	0.205	0.300	0.260	0.331	0.224
26	0.200	0.205	0.300	0.260	0.331	0.224
27	0.200	0.205	0.300	0.260	0.331	0.224
28	0.200	0.205	0.300	0.260	0.331	0.224
29	0.200	0.205	0.300	0.260	0.331	0.224
30	0.200	0.205	0.300	0.260	0.331	0.224
31	0.200	0.205	0.300	0.260	0.331	0.224
32	0.199	0.205	0.300	0.260	0.331	0.224
33	0.197	0.205	0.300	0.260	0.331	0.224
34	0.196	0.205	0.300	0.260	0.331	0.224
35	0.194	0.205	0.300	0.260	0.331	0.224
36	0.193	0.205	0.300	0.260	0.331	0.224
37	0.191	0.205	0.300	0.260	0.331	0.224
38	0.190	0.205	0.300	0.260	0.331	0.224
39	0.188	0.205	0.300	0.260	0.331	0.224
40	0.187	0.205	0.300	0.260	0.331	0.224

Day of Year	USGS Barren	Mixed Veg Low	Mixed Veg Medium	Marsh	Cottonwood/ Willow	Salt Cedar Dense
41	0.185	0.205	0.300	0.260	0.331	0.224
42	0.184	0.205	0.300	0.260	0.331	0.224
43	0.182	0.205	0.300	0.260	0.331	0.224
44	0.181	0.205	0.300	0.260	0.331	0.224
45	0.179	0.205	0.300	0.260	0.331	0.224
46	0.178	0.205	0.300	0.260	0.331	0.224
47	0.176	0.205	0.300	0.260	0.331	0.224
48	0.175	0.205	0.300	0.260	0.331	0.224
49	0.173	0.205	0.300	0.260	0.331	0.224
50	0.172	0.205	0.300	0.260	0.331	0.224
51	0.170	0.205	0.300	0.260	0.331	0.224
52	0.169	0.210	0.300	0.260	0.331	0.224
53	0.167	0.214	0.303	0.260	0.331	0.224
54	0.166	0.219	0.306	0.260	0.331	0.224
55	0.164	0.224	0.309	0.260	0.331	0.224
56	0.163	0.228	0.312	0.260	0.331	0.224
57	0.161	0.233	0.315	0.260	0.331	0.224
58	0.160	0.238	0.318	0.260	0.331	0.224
59	0.158	0.242	0.321	0.260	0.331	0.224
60	0.157	0.247	0.324	0.291	0.331	0.224
61	0.155	0.252	0.327	0.322	0.340	0.224
62	0.154	0.256	0.330	0.353	0.349	0.224
63	0.152	0.261	0.333	0.384	0.358	0.224
64	0.151	0.266	0.336	0.415	0.367	0.224
65	0.149	0.270	0.340	0.446	0.376	0.224
66	0.148	0.275	0.343	0.477	0.386	0.224
67	0.146	0.280	0.346	0.508	0.395	0.224
68	0.145	0.284	0.349	0.539	0.404	0.224
69	0.143	0.289	0.352	0.569	0.413	0.224
70	0.142	0.294	0.355	0.600	0.422	0.232
71	0.140	0.298	0.358	0.631	0.431	0.239
72	0.139	0.303	0.361	0.662	0.441	0.247
73	0.137	0.308	0.364	0.693	0.450	0.254
74	0.136	0.312	0.367	0.724	0.459	0.262
75	0.136	0.317	0.370	0.755	0.468	0.270
76	0.136	0.322	0.373	0.786	0.477	0.277
77	0.136	0.326	0.376	0.817	0.486	0.285
78	0.136	0.331	0.379	0.848	0.495	0.293
79	0.136	0.336	0.382	0.879	0.505	0.300
80	0.136	0.340	0.385	0.910	0.514	0.308
81	0.136	0.345	0.388	0.941	0.523	0.315

Day of Year	USGS Barren	Mixed Veg Low	Mixed Veg Medium	Marsh	Cottonwood/ Willow	Salt Cedar Dense
82	0.136	0.350	0.391	0.972	0.532	0.323
83	0.136	0.354	0.394	1.003	0.541	0.331
84	0.136	0.359	0.397	1.034	0.550	0.338
85	0.136	0.364	0.400	1.065	0.559	0.346
86	0.136	0.368	0.403	1.096	0.569	0.353
87	0.136	0.373	0.406	1.127	0.578	0.361
88	0.136	0.378	0.409	1.158	0.587	0.369
89	0.136	0.383	0.412	1.189	0.596	0.376
90	0.136	0.387	0.415	1.189	0.605	0.384
91	0.136	0.392	0.419	1.189	0.614	0.392
92	0.136	0.397	0.422	1.189	0.623	0.399
93	0.136	0.401	0.425	1.189	0.633	0.407
94	0.136	0.406	0.428	1.189	0.642	0.414
95	0.136	0.411	0.431	1.189	0.651	0.422
96	0.136	0.415	0.434	1.189	0.660	0.430
97	0.136	0.420	0.437	1.189	0.669	0.437
98	0.136	0.425	0.440	1.189	0.678	0.445
99	0.136	0.429	0.443	1.189	0.687	0.452
100	0.136	0.434	0.446	1.189	0.697	0.460
101	0.136	0.439	0.449	1.189	0.706	0.468
102	0.136	0.443	0.452	1.189	0.715	0.475
103	0.136	0.448	0.455	1.189	0.724	0.483
104	0.136	0.453	0.458	1.189	0.733	0.491
105	0.136	0.457	0.461	1.189	0.742	0.498
106	0.136	0.462	0.464	1.189	0.751	0.506
107	0.136	0.467	0.467	1.189	0.761	0.513
108	0.136	0.471	0.470	1.189	0.770	0.521
109	0.136	0.476	0.473	1.189	0.779	0.529
110	0.136	0.481	0.476	1.189	0.788	0.536
111	0.136	0.485	0.479	1.189	0.797	0.544
112	0.136	0.490	0.482	1.189	0.806	0.551
113	0.136	0.495	0.485	1.189	0.815	0.559
114	0.136	0.499	0.488	1.189	0.825	0.567
115	0.136	0.504	0.491	1.189	0.834	0.574
116	0.136	0.509	0.494	1.189	0.843	0.582
117	0.136	0.513	0.498	1.189	0.852	0.589
118	0.136	0.518	0.501	1.189	0.861	0.597
119	0.136	0.523	0.504	1.189	0.870	0.605
120	0.136	0.527	0.507	1.189	0.879	0.612
121	0.136	0.532	0.510	1.189	0.889	0.620
122	0.136	0.537	0.513	1.189	0.898	0.628

Day of Year	USGS Barren	Mixed Veg Low	Mixed Veg Medium	Marsh	Cottonwood/ Willow	Salt Cedar Dense
123	0.136	0.541	0.516	1.189	0.907	0.635
124	0.136	0.546	0.519	1.189	0.916	0.643
125	0.136	0.551	0.522	1.189	0.925	0.650
126	0.136	0.555	0.525	1.189	0.934	0.658
127	0.136	0.560	0.528	1.189	0.943	0.666
128	0.136	0.560	0.531	1.189	0.953	0.673
129	0.136	0.560	0.534	1.189	0.962	0.681
130	0.136	0.560	0.534	1.189	0.971	0.688
131	0.136	0.560	0.534	1.189	0.980	0.696
132	0.136	0.560	0.534	1.189	0.989	0.704
133	0.136	0.560	0.534	1.189	0.998	0.711
134	0.136	0.560	0.534	1.189	1.007	0.719
135	0.136	0.560	0.534	1.189	1.017	0.727
136	0.136	0.560	0.534	1.189	1.017	0.734
137	0.136	0.560	0.534	1.189	1.017	0.742
138	0.136	0.560	0.534	1.189	1.017	0.749
139	0.136	0.560	0.534	1.189	1.017	0.757
140	0.136	0.560	0.534	1.189	1.017	0.757
141	0.136	0.560	0.534	1.189	1.017	0.757
142	0.136	0.560	0.534	1.189	1.017	0.757
143	0.136	0.560	0.534	1.189	1.017	0.757
144	0.136	0.560	0.534	1.189	1.017	0.757
145	0.136	0.560	0.534	1.189	1.017	0.757
146	0.136	0.560	0.534	1.189	1.017	0.757
147	0.136	0.560	0.534	1.189	1.017	0.757
148	0.136	0.560	0.534	1.189	1.017	0.757
149	0.136	0.560	0.534	1.189	1.017	0.757
150	0.136	0.560	0.534	1.189	1.017	0.757
151	0.136	0.560	0.534	1.189	1.017	0.757
152	0.136	0.560	0.534	1.189	1.017	0.757
153	0.136	0.560	0.534	1.189	1.017	0.757
154	0.136	0.560	0.534	1.189	1.017	0.757
155	0.136	0.560	0.534	1.189	1.017	0.757
156	0.136	0.560	0.534	1.189	1.017	0.757
157	0.136	0.560	0.534	1.189	1.017	0.757
158	0.136	0.560	0.534	1.189	1.017	0.757
159	0.136	0.560	0.534	1.189	1.017	0.757
160	0.136	0.560	0.534	1.189	1.017	0.757
161	0.136	0.560	0.534	1.189	1.017	0.757
162	0.136	0.560	0.534	1.189	1.017	0.757
163	0.136	0.560	0.534	1.189	1.017	0.757

Day of Year	USGS Barren	Mixed Veg Low	Mixed Veg Medium	Marsh	Cottonwood/ Willow	Salt Cedar Dense
164	0.136	0.560	0.534	1.189	1.017	0.757
165	0.136	0.560	0.534	1.189	1.017	0.757
166	0.136	0.560	0.534	1.189	1.017	0.757
167	0.136	0.560	0.534	1.189	1.017	0.757
168	0.136	0.560	0.534	1.189	1.017	0.757
169	0.136	0.560	0.534	1.189	1.017	0.757
170	0.136	0.560	0.534	1.189	1.017	0.757
171	0.136	0.560	0.534	1.189	1.017	0.757
172	0.136	0.560	0.534	1.189	1.017	0.757
173	0.136	0.560	0.534	1.189	1.017	0.757
174	0.136	0.560	0.534	1.189	1.017	0.757
175	0.136	0.560	0.534	1.189	1.017	0.757
176	0.136	0.560	0.534	1.189	1.017	0.757
177	0.136	0.560	0.534	1.189	1.017	0.757
178	0.136	0.560	0.534	1.189	1.017	0.757
179	0.136	0.560	0.534	1.189	1.017	0.757
180	0.136	0.560	0.534	1.189	1.017	0.757
181	0.136	0.560	0.534	1.189	1.017	0.757
182	0.136	0.560	0.534	1.189	1.017	0.757
183	0.136	0.560	0.534	1.189	1.017	0.757
184	0.136	0.560	0.534	1.189	1.017	0.757
185	0.136	0.560	0.534	1.189	1.017	0.757
186	0.136	0.560	0.534	1.189	1.017	0.757
187	0.136	0.560	0.534	1.189	1.017	0.757
188	0.136	0.560	0.534	1.189	1.017	0.757
189	0.136	0.560	0.534	1.189	1.017	0.757
190	0.136	0.560	0.534	1.189	1.017	0.757
191	0.136	0.560	0.534	1.189	1.017	0.757
192	0.136	0.560	0.534	1.189	1.017	0.757
193	0.136	0.560	0.534	1.189	1.017	0.757
194	0.136	0.560	0.534	1.189	1.017	0.757
195	0.136	0.560	0.534	1.189	1.017	0.757
196	0.136	0.560	0.534	1.189	1.017	0.757
197	0.136	0.560	0.534	1.189	1.017	0.757
198	0.136	0.560	0.534	1.189	1.017	0.757
199	0.136	0.560	0.534	1.189	1.017	0.757
200	0.136	0.560	0.534	1.189	1.017	0.757
201	0.136	0.560	0.534	1.189	1.017	0.757
202	0.136	0.560	0.534	1.189	1.017	0.757
203	0.136	0.560	0.534	1.189	1.017	0.757
204	0.136	0.560	0.534	1.189	1.017	0.757

Day of Year	USGS Barren	Mixed Veg Low	Mixed Veg Medium	Marsh	Cottonwood/ Willow	Salt Cedar Dense
205	0.136	0.560	0.532	1.189	1.017	0.757
206	0.136	0.560	0.529	1.189	1.017	0.757
207	0.136	0.560	0.527	1.189	1.017	0.757
208	0.136	0.560	0.524	1.189	1.017	0.757
209	0.136	0.560	0.522	1.189	1.017	0.757
210	0.136	0.560	0.519	1.189	1.017	0.757
211	0.136	0.560	0.517	1.189	1.017	0.757
212	0.136	0.560	0.514	1.189	1.017	0.757
213	0.136	0.560	0.512	1.189	1.017	0.757
214	0.136	0.560	0.509	1.189	1.017	0.757
215	0.136	0.560	0.507	1.189	1.017	0.757
216	0.136	0.560	0.504	1.189	1.017	0.757
217	0.136	0.560	0.502	1.189	1.017	0.757
218	0.136	0.560	0.500	1.189	1.017	0.757
219	0.136	0.560	0.497	1.189	1.017	0.757
220	0.136	0.560	0.495	1.189	1.017	0.757
221	0.136	0.560	0.492	1.189	1.017	0.757
222	0.136	0.560	0.490	1.189	1.017	0.757
223	0.136	0.560	0.487	1.189	1.017	0.757
224	0.136	0.560	0.485	1.189	1.017	0.757
225	0.136	0.560	0.482	1.189	1.017	0.757
226	0.136	0.560	0.480	1.189	1.017	0.757
227	0.136	0.560	0.477	1.189	1.017	0.757
228	0.136	0.560	0.475	1.189	1.017	0.757
229	0.136	0.560	0.472	1.189	1.017	0.757
230	0.136	0.556	0.470	1.189	1.017	0.757
231	0.136	0.553	0.467	1.189	1.017	0.757
232	0.136	0.549	0.465	1.189	1.017	0.757
233	0.136	0.545	0.463	1.189	1.017	0.757
234	0.136	0.542	0.460	1.189	1.017	0.757
235	0.136	0.538	0.458	1.189	1.017	0.757
236	0.136	0.534	0.455	1.189	1.017	0.757
237	0.136	0.531	0.453	1.189	1.017	0.757
238	0.136	0.527	0.450	1.189	1.017	0.757
239	0.136	0.523	0.448	1.189	1.017	0.757
240	0.136	0.520	0.445	1.189	1.017	0.757
241	0.136	0.516	0.443	1.189	1.017	0.757
242	0.136	0.512	0.440	1.189	1.017	0.757
243	0.136	0.509	0.438	1.189	1.017	0.757
244	0.136	0.505	0.435	1.189	1.017	0.757
245	0.136	0.501	0.433	1.189	1.017	0.757

Day of Year	USGS Barren	Mixed Veg Low	Mixed Veg Medium	Marsh	Cottonwood/ Willow	Salt Cedar Dense
246	0.136	0.498	0.431	1.189	1.017	0.757
247	0.136	0.494	0.428	1.189	1.017	0.757
248	0.136	0.490	0.426	1.189	1.017	0.757
249	0.136	0.487	0.423	1.189	1.017	0.757
250	0.136	0.483	0.421	1.189	1.017	0.757
251	0.136	0.479	0.418	1.189	1.017	0.757
252	0.136	0.476	0.416	1.189	1.017	0.757
253	0.136	0.472	0.413	1.189	1.017	0.757
254	0.136	0.469	0.411	1.189	1.017	0.757
255	0.136	0.465	0.408	1.189	1.017	0.757
256	0.136	0.461	0.406	1.189	1.017	0.757
257	0.136	0.458	0.403	1.189	1.017	0.757
258	0.136	0.454	0.401	1.189	1.017	0.757
259	0.136	0.450	0.399	1.189	1.017	0.757
260	0.136	0.447	0.396	1.189	1.017	0.757
261	0.136	0.443	0.394	1.189	1.017	0.757
262	0.136	0.439	0.391	1.189	1.017	0.757
263	0.136	0.436	0.389	1.189	1.017	0.757
264	0.136	0.432	0.386	1.189	1.017	0.757
265	0.136	0.428	0.384	1.189	1.017	0.757
266	0.136	0.425	0.381	1.189	1.017	0.757
267	0.136	0.421	0.379	1.189	1.017	0.757
268	0.136	0.417	0.376	1.189	1.017	0.757
269	0.136	0.414	0.374	1.189	1.017	0.749
270	0.136	0.410	0.371	1.156	1.017	0.741
271	0.136	0.406	0.369	1.124	1.017	0.733
272	0.136	0.403	0.367	1.092	1.017	0.725
273	0.136	0.399	0.364	1.060	1.017	0.717
274	0.136	0.395	0.362	1.028	1.017	0.709
275	0.136	0.392	0.359	0.996	1.017	0.700
276	0.136	0.388	0.357	0.964	1.017	0.692
277	0.136	0.384	0.354	0.932	1.017	0.684
278	0.136	0.381	0.352	0.899	1.017	0.676
279	0.136	0.377	0.349	0.867	1.017	0.668
280	0.136	0.373	0.347	0.835	1.017	0.660
281	0.136	0.370	0.344	0.803	1.005	0.652
282	0.136	0.366	0.342	0.771	0.993	0.644
283	0.136	0.362	0.339	0.739	0.980	0.636
284	0.136	0.359	0.337	0.707	0.968	0.628
285	0.136	0.355	0.334	0.675	0.956	0.620
286	0.137	0.351	0.332	0.643	0.944	0.612

Day of Year	USGS Barren	Mixed Veg Low	Mixed Veg Medium	Marsh	Cottonwood/ Willow	Salt Cedar Dense
287	0.139	0.348	0.330	0.610	0.932	0.604
288	0.140	0.344	0.327	0.578	0.920	0.595
289	0.141	0.340	0.325	0.546	0.908	0.587
290	0.142	0.337	0.322	0.514	0.896	0.579
291	0.144	0.333	0.320	0.482	0.884	0.571
292	0.145	0.329	0.317	0.450	0.872	0.563
293	0.146	0.326	0.315	0.418	0.860	0.555
294	0.148	0.322	0.312	0.386	0.848	0.547
295	0.149	0.318	0.310	0.353	0.836	0.539
296	0.150	0.315	0.307	0.321	0.824	0.531
297	0.151	0.311	0.305	0.289	0.812	0.523
298	0.153	0.307	0.302	0.257	0.800	0.515
299	0.154	0.304	0.300	0.225	0.788	0.507
300	0.155	0.300	0.300	0.250	0.776	0.499
301	0.156	0.296	0.300	0.250	0.764	0.491
302	0.158	0.293	0.300	0.250	0.752	0.482
303	0.159	0.289	0.300	0.250	0.740	0.474
304	0.160	0.286	0.300	0.250	0.728	0.466
305	0.162	0.282	0.300	0.250	0.716	0.458
306	0.163	0.278	0.300	0.250	0.704	0.450
307	0.164	0.275	0.300	0.250	0.692	0.442
308	0.165	0.271	0.300	0.250	0.680	0.434
309	0.167	0.267	0.300	0.250	0.668	0.426
310	0.168	0.264	0.300	0.250	0.656	0.418
311	0.169	0.260	0.300	0.250	0.644	0.410
312	0.171	0.256	0.300	0.250	0.632	0.402
313	0.172	0.253	0.300	0.250	0.620	0.394
314	0.173	0.249	0.300	0.250	0.608	0.386
315	0.174	0.245	0.300	0.250	0.596	0.377
316	0.176	0.242	0.300	0.250	0.584	0.369
317	0.177	0.238	0.300	0.250	0.572	0.361
318	0.178	0.234	0.300	0.250	0.560	0.353
319	0.180	0.231	0.300	0.250	0.548	0.345
320	0.181	0.227	0.300	0.250	0.536	0.337
321	0.182	0.223	0.300	0.250	0.524	0.329
322	0.183	0.220	0.300	0.250	0.512	0.321
323	0.185	0.216	0.300	0.250	0.500	0.313
324	0.186	0.212	0.300	0.250	0.488	0.305
325	0.187	0.209	0.300	0.250	0.476	0.297
326	0.188	0.205	0.300	0.250	0.464	0.289
327	0.190	0.205	0.300	0.250	0.452	0.281

Day of Year	USGS Barren	Mixed Veg Low	Mixed Veg Medium	Marsh	Cottonwood/ Willow	Salt Cedar Dense
328	0.191	0.205	0.300	0.250	0.439	0.272
329	0.192	0.205	0.300	0.250	0.427	0.264
330	0.194	0.205	0.300	0.250	0.415	0.256
331	0.195	0.205	0.300	0.250	0.403	0.248
332	0.196	0.205	0.300	0.250	0.391	0.240
333	0.197	0.205	0.300	0.250	0.379	0.232
334	0.199	0.205	0.300	0.250	0.367	0.224
335	0.200	0.205	0.300	0.250	0.355	0.224
336	0.200	0.205	0.300	0.250	0.343	0.224
337	0.200	0.205	0.300	0.250	0.331	0.224
338	0.200	0.205	0.300	0.250	0.319	0.224
339	0.200	0.205	0.300	0.250	0.307	0.224
340	0.200	0.205	0.300	0.250	0.295	0.224
341	0.200	0.205	0.300	0.250	0.283	0.224
342	0.200	0.205	0.300	0.250	0.271	0.224
343	0.200	0.205	0.300	0.250	0.259	0.224
344	0.200	0.205	0.300	0.250	0.247	0.224
345	0.200	0.205	0.300	0.250	0.235	0.224
346	0.200	0.205	0.300	0.250	0.223	0.224
347	0.200	0.205	0.300	0.250	0.211	0.224
348	0.200	0.205	0.300	0.250	0.199	0.224
349	0.200	0.205	0.300	0.250	0.187	0.224
350	0.200	0.205	0.300	0.250	0.175	0.224
351	0.200	0.205	0.300	0.250	0.200	0.224
352	0.200	0.205	0.300	0.250	0.200	0.224
353	0.200	0.205	0.300	0.250	0.200	0.224
354	0.200	0.205	0.300	0.250	0.200	0.224
355	0.200	0.205	0.300	0.250	0.200	0.224
356	0.200	0.205	0.300	0.250	0.200	0.224
357	0.200	0.205	0.300	0.250	0.200	0.224
358	0.200	0.205	0.300	0.250	0.200	0.224
359	0.200	0.205	0.300	0.250	0.200	0.224
360	0.200	0.205	0.300	0.250	0.200	0.224
361	0.200	0.205	0.300	0.250	0.200	0.224
362	0.200	0.205	0.300	0.250	0.200	0.224
363	0.200	0.205	0.300	0.250	0.200	0.224
364	0.200	0.205	0.300	0.250	0.200	0.224
365	0.200	0.205	0.300	0.250	0.200	0.224

Appendix 6 – Evaporation and Riparian Evapotranspiration (ET) Rates

Introduction

This Appendix to the Lower Colorado River Mainstream Evaporation and Riparian Evapotranspiration Losses Report provides evaporation and riparian ET rates used in LCRAS. Section A6.1 provides monthly LCRAS open water evaporation rates, section A6.2 provides monthly LCRAS riparian evapotranspiration rates.

A6.1. LCRAS Open Water Evaporation Rates

Table A6-1. LCRAS Monthly Open Water Evaporation Rates by Reach and Year (inches)

Yr	Reach	Total	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2017	2	60.76	2.12	2.41	4.9	6.59	7.95	7.96	7.58	6.3	4.98	4.59	2.79	2.59
2017	3	60.76	2.12	2.41	4.9	6.59	7.95	7.96	7.58	6.3	4.98	4.59	2.79	2.59
2017	4	65.78	1.58	2.16	4.64	6.83	7.69	9.29	9.08	8.04	6.17	5.31	2.78	2.21
2017	5	75.33	2.26	2.98	5.94	7.42	8.3	9.95	10.75	9.84	7.19	5.73	2.58	2.39
2018	2	63.6	2.81	2.98	4.52	7.1	8.27	8.53	7.75	7.37	5.29	4.02	3.02	1.94
2018	3	63.6	2.81	2.98	4.52	7.1	8.27	8.53	7.75	7.37	5.29	4.02	3.02	1.94
2018	4	65.16	1.95	2.4	4.43	7.06	8.04	8.86	8.52	8.53	6.48	4.33	3.03	1.53
2018	5	74.13	2.85	3.14	5.53	7.38	8.63	9.13	10.03	9.9	7.92	5.12	2.81	1.69
2019	2	59.66	2.36	2.2	4.36	6.73	7.31	8.26	7.84	6.83	5.11	4.33	2.83	1.5
2019	3	59.66	2.36	2.2	4.36	6.73	7.31	8.26	7.84	6.83	5.11	4.33	2.83	1.5
2019	4	65.25	1.59	1.98	4.33	6.82	7.38	8.94	9.15	8.81	6.54	5.33	2.96	1.42
2019	5	73.25	2.11	2.81	5.66	7.46	8.25	9.75	10.11	9.86	7.33	5.57	2.68	1.66
2020	2	64.14	2.54	3.15	4.01	6.32	9.02	8.38	8.45	7.24	5.35	4	3.18	2.5
2020	3	64.14	2.54	3.15	4.01	6.32	9.02	8.38	8.45	7.24	5.35	4	3.18	2.5
2020	4	69.21	1.97	2.73	3.7	6.3	8.42	9.05	9.92	9	7.26	5.48	3.38	2
2020	5	75.69	2.55	3.42	4.61	6.91	9.09	9.85	10.83	10.43	7.8	5.16	2.94	2.1
2021	2	64.33	2.98	3.15	4.67	7.28	8.44	8.3	8.18	7.14	5.09	3.9	3.32	1.88
2021	3	64.33	2.98	3.15	4.67	7.28	8.44	8.3	8.18	7.14	5.09	3.9	3.32	1.88
2021	4	69.93	1.94	2.68	4.43	6.96	8.44	9.63	9.44	8.72	6.84	5.18	3.56	2.11
2021	5	74.83	2.43	3.48	5.74	7.63	8.57	9.47	9.99	9.76	7.34	5.36	3.21	1.85

A6.2. LCRAS Riparian ET Rates

Table A6-2. LCRAS Monthly Riparian ET rates by reach, year, and vegetation type

Year	Reach	Vegetation Type	Total	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2017	2	Cottonwood/Willow	60.32	0.79	0.93	2.69	5.24	8.44	9.53	9.52	8.43	6.94	5.33	1.73	0.76
2017	3	Cottonwood/Willow	60.32	0.79	0.93	2.69	5.24	8.44	9.53	9.52	8.43	6.94	5.33	1.73	0.76
2017	4	Cottonwood/Willow	61.4	0.77	0.99	2.71	5.51	8.35	10.16	10.04	8.89	6.74	5.01	1.55	0.68
2017	5	Cottonwood/Willow	62.78	0.88	1.03	2.77	5.37	7.97	9.82	10.52	9.62	7.17	5.26	1.62	0.75
2018	2	Cottonwood/Willow	63.38	1.05	1.15	2.47	5.61	8.8	10.2	9.73	9.86	7.37	4.65	1.92	0.57
2018	3	Cottonwood/Willow	63.38	1.05	1.15	2.47	5.61	8.8	10.2	9.73	9.86	7.37	4.65	1.92	0.57
2018	4	Cottonwood/Willow	60.87	0.95	1.11	2.55	5.69	8.74	9.69	9.42	9.43	7.09	4.02	1.72	0.47
2018	5	Cottonwood/Willow	61.77	1.11	1.08	2.57	5.34	8.28	9.01	9.8	9.68	7.89	4.68	1.8	0.52
2019	2	Cottonwood/Willow	60.43	0.88	0.85	2.39	5.35	7.74	9.89	9.84	9.14	7.12	4.99	1.82	0.42
2019	3	Cottonwood/Willow	60.43	0.88	0.85	2.39	5.35	7.74	9.89	9.84	9.14	7.12	4.99	1.82	0.42
2019	4	Cottonwood/Willow	61.59	0.77	0.91	2.49	5.53	8.01	9.77	10.12	9.74	7.15	4.98	1.7	0.42
2019	5	Cottonwood/Willow	61.5	0.82	0.97	2.62	5.38	7.92	9.63	9.89	9.64	7.31	5.09	1.73	0.51
2020	2	Cottonwood/Willow	64.14	0.94	1.21	2.18	5.1	9.62	10.04	10.63	9.7	7.43	4.63	1.93	0.73
2020	3	Cottonwood/Willow	64.14	0.94	1.21	2.18	5.1	9.62	10.04	10.63	9.7	7.43	4.63	1.93	0.73
2020	4	Cottonwood/Willow	65.01	0.96	1.24	2.13	5.21	9.17	9.9	10.96	9.95	7.93	5.1	1.87	0.61
2020	5	Cottonwood/Willow	63.64	0.99	1.18	2.15	5.09	8.75	9.72	10.59	10.2	7.78	4.73	1.82	0.65
2021	2	Cottonwood/Willow	63.58	1.11	1.21	2.6	5.74	8.96	9.94	10.27	9.55	7.09	4.51	2.05	0.56
2021	3	Cottonwood/Willow	63.58	1.11	1.21	2.6	5.74	8.96	9.94	10.27	9.55	7.09	4.51	2.05	0.56
2021	4	Cottonwood/Willow	65.03	0.94	1.23	2.55	5.6	9.15	10.53	10.43	9.64	7.49	4.82	2	0.65
2021	5	Cottonwood/Willow	61.99	0.95	1.2	2.67	5.48	8.21	9.35	9.77	9.54	7.32	4.91	2.01	0.58
2017	2	Marsh	69.35	0.62	0.73	4.44	8.25	10.17	11.14	11.13	9.86	8.04	3.39	0.79	0.8
2017	3	Marsh	69.35	0.62	0.73	4.44	8.25	10.17	11.14	11.13	9.86	8.04	3.39	0.79	0.8
2017	4	Marsh	71.23	0.61	0.78	4.52	8.73	10.05	11.88	11.74	10.39	7.82	3.3	0.71	0.72
2017	5	Marsh	72.41	0.69	0.81	4.58	8.48	9.58	11.49	12.29	11.25	8.32	3.39	0.74	0.8
2018	2	Marsh	73	0.82	0.9	4.05	8.88	10.57	11.93	11.38	11.53	8.54	2.94	0.86	0.6
2018	3	Marsh	73	0.82	0.9	4.05	8.88	10.57	11.93	11.38	11.53	8.54	2.94	0.86	0.6

Year	Reach	Vegetation Type	Total	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2018	4	Marsh	70.75	0.75	0.87	4.18	9.02	10.51	11.33	11.01	11.02	8.22	2.56	0.77	0.5
2018	5	Marsh	71.2	0.87	0.85	4.25	8.44	9.96	10.53	11.46	11.32	9.16	2.98	0.81	0.56
2019	2	Marsh	69.45	0.69	0.67	3.93	8.42	9.35	11.56	11.51	10.69	8.26	3.12	0.8	0.46
2019	3	Marsh	69.45	0.69	0.67	3.93	8.42	9.35	11.56	11.51	10.69	8.26	3.12	0.8	0.46
2019	4	Marsh	71.13	0.61	0.71	4.09	8.72	9.64	11.43	11.83	11.39	8.3	3.2	0.76	0.46
2019	5	Marsh	70.89	0.64	0.76	4.3	8.53	9.52	11.26	11.56	11.27	8.48	3.23	0.77	0.56
2020	2	Marsh	73.42	0.74	0.96	3.57	7.92	11.56	11.74	12.43	11.34	8.56	2.93	0.9	0.77
2020	3	Marsh	73.42	0.74	0.96	3.57	7.92	11.56	11.74	12.43	11.34	8.56	2.93	0.9	0.77
2020	4	Marsh	74.21	0.75	0.98	3.51	8.06	11	11.57	12.82	11.63	9.16	3.21	0.87	0.65
2020	5	Marsh	72.86	0.78	0.93	3.55	7.91	10.5	11.37	12.38	11.93	8.98	3	0.85	0.7
2021	2	Marsh	73.42	0.87	0.95	4.33	9.11	10.8	11.62	12.01	11.16	8.21	2.85	0.94	0.58
2021	3	Marsh	73.42	0.87	0.95	4.33	9.11	10.8	11.62	12.01	11.16	8.21	2.85	0.94	0.58
2021	4	Marsh	74.95	0.74	0.97	4.19	8.89	11.03	12.31	12.2	11.27	8.68	3.07	0.91	0.69
2021	5	Marsh	71.43	0.74	0.94	4.43	8.73	9.89	10.93	11.43	11.15	8.48	3.17	0.92	0.62
2017	2	Mixed Veg Low	32.39	0.49	0.59	1.81	3.22	4.76	5.25	5.24	4.55	3.08	2.01	0.74	0.66
2017	3	Mixed Veg Low	32.39	0.49	0.59	1.81	3.22	4.76	5.25	5.24	4.55	3.08	2.01	0.74	0.66
2017	4	Mixed Veg Low	33.09	0.48	0.63	1.82	3.39	4.71	5.59	5.53	4.79	3.01	1.89	0.66	0.59
2017	5	Mixed Veg Low	33.77	0.55	0.65	1.86	3.3	4.49	5.41	5.79	5.18	3.2	1.99	0.69	0.65
2018	2	Mixed Veg Low	34.09	0.65	0.73	1.67	3.45	4.96	5.62	5.36	5.32	3.29	1.76	0.82	0.49
2018	3	Mixed Veg Low	34.09	0.65	0.73	1.67	3.45	4.96	5.62	5.36	5.32	3.29	1.76	0.82	0.49
2018	4	Mixed Veg Low	32.87	0.59	0.7	1.72	3.5	4.93	5.34	5.19	5.08	3.17	1.52	0.73	0.41
2018	5	Mixed Veg Low	33.16	0.69	0.69	1.73	3.28	4.67	4.96	5.4	5.22	3.53	1.77	0.77	0.46
2019	2	Mixed Veg Low	32.38	0.54	0.54	1.61	3.29	4.38	5.44	5.42	4.93	3.19	1.89	0.77	0.38
2019	3	Mixed Veg Low	32.38	0.54	0.54	1.61	3.29	4.38	5.44	5.42	4.93	3.19	1.89	0.77	0.38
2019	4	Mixed Veg Low	33.04	0.48	0.58	1.68	3.4	4.52	5.38	5.57	5.25	3.21	1.88	0.72	0.38
2019	5	Mixed Veg Low	33	0.51	0.62	1.77	3.31	4.46	5.3	5.44	5.19	3.28	1.92	0.73	0.46
2020	2	Mixed Veg Low	34.47	0.58	0.78	1.47	3.13	5.42	5.53	5.85	5.21	3.28	1.75	0.84	0.63
2020	3	Mixed Veg Low	34.47	0.58	0.78	1.47	3.13	5.42	5.53	5.85	5.21	3.28	1.75	0.84	0.63
2020	4	Mixed Veg Low	34.8	0.59	0.8	1.43	3.19	5.16	5.45	6.04	5.35	3.52	1.92	0.81	0.53
2020	5	Mixed Veg Low	34.13	0.61	0.76	1.45	3.12	4.93	5.35	5.83	5.48	3.45	1.78	0.79	0.57

Year	Reach	Vegetation Type	Total	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2021	2	Mixed Veg Low	34.29	0.69	0.78	1.74	3.53	5.06	5.47	5.66	5.15	3.15	1.7	0.88	0.48
2021	3	Mixed Veg Low	34.29	0.69	0.78	1.74	3.53	5.06	5.47	5.66	5.15	3.15	1.7	0.88	0.48
2021	4	Mixed Veg Low	35.04	0.58	0.79	1.72	3.45	5.17	5.8	5.75	5.2	3.35	1.82	0.85	0.56
2021	5	Mixed Veg Low	33.33	0.59	0.77	1.8	3.37	4.63	5.15	5.38	5.15	3.28	1.86	0.86	0.5
2017	2	Mixed Veg Medium	31.91	0.71	0.85	2.1	3.23	4.54	5	4.98	3.95	2.72	1.92	0.95	0.96
2017	3	Mixed Veg Medium	31.91	0.71	0.85	2.1	3.23	4.54	5	4.98	3.95	2.72	1.92	0.95	0.96
2017	4	Mixed Veg Medium	32.5	0.7	0.91	2.1	3.41	4.48	5.33	5.25	4.15	2.66	1.8	0.85	0.86
2017	5	Mixed Veg Medium	33.2	0.8	0.94	2.16	3.31	4.28	5.16	5.49	4.49	2.83	1.9	0.89	0.96
2018	2	Mixed Veg Medium	33.51	0.95	1.05	1.94	3.47	4.72	5.36	5.08	4.61	2.9	1.68	1.03	0.72
2018	3	Mixed Veg Medium	33.51	0.95	1.05	1.94	3.47	4.72	5.36	5.08	4.61	2.9	1.68	1.03	0.72
2018	4	Mixed Veg Medium	32.27	0.86	1.01	1.99	3.52	4.69	5.09	4.92	4.41	2.8	1.46	0.93	0.6
2018	5	Mixed Veg Medium	32.58	1.01	0.99	2.01	3.3	4.45	4.73	5.12	4.53	3.12	1.69	0.97	0.68
2019	2	Mixed Veg Medium	31.65	0.8	0.78	1.87	3.3	4.17	5.19	5.14	4.27	2.82	1.81	0.97	0.56
2019	3	Mixed Veg Medium	31.65	0.8	0.78	1.87	3.3	4.17	5.19	5.14	4.27	2.82	1.81	0.97	0.56
2019	4	Mixed Veg Medium	32.25	0.7	0.83	1.95	3.41	4.3	5.13	5.28	4.55	2.83	1.8	0.91	0.55
2019	5	Mixed Veg Medium	32.3	0.74	0.89	2.05	3.32	4.25	5.06	5.16	4.5	2.9	1.84	0.92	0.67
2020	2	Mixed Veg Medium	33.89	0.86	1.11	1.71	3.12	5.16	5.27	5.54	4.51	2.91	1.67	1.09	0.93
2020	3	Mixed Veg Medium	33.89	0.86	1.11	1.71	3.12	5.16	5.27	5.54	4.51	2.91	1.67	1.09	0.93
2020	4	Mixed Veg Medium	34.1	0.87	1.14	1.66	3.18	4.92	5.2	5.72	4.63	3.12	1.84	1.04	0.78
2020	5	Mixed Veg Medium	33.46	0.9	1.08	1.67	3.12	4.69	5.11	5.52	4.75	3.05	1.71	1.02	0.84
2021	2	Mixed Veg Medium	33.8	1.01	1.11	2.01	3.55	4.82	5.22	5.37	4.47	2.79	1.63	1.13	0.7
2021	3	Mixed Veg Medium	33.8	1.01	1.11	2.01	3.55	4.82	5.22	5.37	4.47	2.79	1.63	1.13	0.7
2021	4	Mixed Veg Medium	34.48	0.86	1.13	1.99	3.47	4.92	5.53	5.46	4.52	2.96	1.74	1.09	0.82
2021	5	Mixed Veg Medium	32.84	0.86	1.1	2.08	3.39	4.41	4.91	5.11	4.47	2.89	1.77	1.11	0.74
2017	2	Salt Cedar Dense	43.32	0.53	0.63	1.62	3.53	6.13	7.09	7.09	6.28	5.14	3.48	1.09	0.72
2017	3	Salt Cedar Dense	43.32	0.53	0.63	1.62	3.53	6.13	7.09	7.09	6.28	5.14	3.48	1.09	0.72
2017	4	Salt Cedar Dense	44.14	0.52	0.67	1.63	3.71	6.07	7.56	7.47	6.62	5	3.27	0.97	0.64
2017	5	Salt Cedar Dense	45.16	0.6	0.69	1.66	3.61	5.8	7.31	7.83	7.16	5.31	3.44	1.02	0.71
2018	2	Salt Cedar Dense	45.57	0.71	0.78	1.49	3.78	6.39	7.59	7.24	7.34	5.46	3.03	1.21	0.54
2018	3	Salt Cedar Dense	45.57	0.71	0.78	1.49	3.78	6.39	7.59	7.24	7.34	5.46	3.03	1.21	0.54

Year	Reach	Vegetation Type	Total	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2018	4	Salt Cedar Dense	43.75	0.64	0.75	1.53	3.83	6.34	7.21	7.01	7.02	5.25	2.63	1.09	0.45
2018	5	Salt Cedar Dense	44.38	0.75	0.73	1.55	3.59	6.01	6.71	7.3	7.21	5.85	3.05	1.13	0.5
2019	2	Salt Cedar Dense	43.41	0.59	0.57	1.44	3.61	5.61	7.36	7.33	6.81	5.28	3.26	1.15	0.41
2019	3	Salt Cedar Dense	43.41	0.59	0.57	1.44	3.61	5.61	7.36	7.33	6.81	5.28	3.26	1.15	0.41
2019	4	Salt Cedar Dense	44.27	0.52	0.62	1.5	3.72	5.81	7.27	7.53	7.25	5.3	3.25	1.07	0.41
2019	5	Salt Cedar Dense	44.19	0.56	0.66	1.58	3.62	5.75	7.17	7.36	7.18	5.42	3.32	1.09	0.5
2020	2	Salt Cedar Dense	46.23	0.64	0.82	1.32	3.45	6.99	7.47	7.91	7.22	5.49	3.02	1.21	0.69
2020	3	Salt Cedar Dense	46.23	0.64	0.82	1.32	3.45	6.99	7.47	7.91	7.22	5.49	3.02	1.21	0.69
2020	4	Salt Cedar Dense	46.84	0.65	0.84	1.28	3.52	6.67	7.37	8.16	7.4	5.87	3.32	1.17	0.58
2020	5	Salt Cedar Dense	45.88	0.67	0.8	1.3	3.44	6.36	7.24	7.88	7.59	5.75	3.08	1.14	0.63
2021	2	Salt Cedar Dense	45.65	0.75	0.82	1.57	3.86	6.5	7.4	7.65	7.11	5.25	2.94	1.29	0.52
2021	3	Salt Cedar Dense	45.65	0.75	0.82	1.57	3.86	6.5	7.4	7.65	7.11	5.25	2.94	1.29	0.52
2021	4	Salt Cedar Dense	46.76	0.64	0.83	1.53	3.77	6.64	7.83	7.77	7.18	5.55	3.15	1.26	0.61
2021	5	Salt Cedar Dense	44.48	0.64	0.81	1.61	3.68	5.96	6.96	7.27	7.1	5.42	3.21	1.27	0.55
2017	2	USGS barren	10.53	0.48	0.5	0.79	0.94	1.16	1.27	1.27	1.13	0.93	0.85	0.57	0.64
2017	3	USGS barren	10.53	0.48	0.5	0.79	0.94	1.16	1.27	1.27	1.13	0.93	0.85	0.57	0.64
2017	4	USGS barren	10.59	0.47	0.54	0.78	1	1.15	1.36	1.34	1.19	0.9	0.78	0.51	0.57
2017	5	USGS barren	10.92	0.53	0.55	0.81	0.97	1.1	1.31	1.41	1.29	0.96	0.83	0.53	0.64
2018	2	USGS barren	11.01	0.63	0.62	0.73	1.02	1.21	1.36	1.3	1.32	0.99	0.74	0.61	0.48
2018	3	USGS barren	11.01	0.63	0.62	0.73	1.02	1.21	1.36	1.3	1.32	0.99	0.74	0.61	0.48
2018	4	USGS barren	10.51	0.57	0.6	0.75	1.03	1.2	1.3	1.26	1.26	0.95	0.64	0.55	0.4
2018	5	USGS barren	10.75	0.67	0.58	0.75	0.97	1.14	1.2	1.31	1.29	1.06	0.74	0.58	0.45
2019	2	USGS barren	10.27	0.53	0.46	0.7	0.96	1.07	1.32	1.32	1.22	0.95	0.8	0.57	0.37
2019	3	USGS barren	10.27	0.53	0.46	0.7	0.96	1.07	1.32	1.32	1.22	0.95	0.8	0.57	0.37
2019	4	USGS barren	10.4	0.47	0.49	0.73	1	1.1	1.31	1.35	1.3	0.96	0.79	0.54	0.37
2019	5	USGS barren	10.53	0.5	0.52	0.77	0.98	1.09	1.29	1.32	1.29	0.98	0.81	0.55	0.44
2020	2	USGS barren	11.16	0.57	0.65	0.65	0.91	1.32	1.34	1.42	1.3	0.99	0.73	0.66	0.62
2020	3	USGS barren	11.16	0.57	0.65	0.65	0.91	1.32	1.34	1.42	1.3	0.99	0.73	0.66	0.62
2020	4	USGS barren	11.19	0.58	0.66	0.62	0.92	1.26	1.32	1.47	1.33	1.06	0.81	0.63	0.52
2020	5	USGS barren	11.01	0.6	0.63	0.63	0.9	1.2	1.3	1.42	1.36	1.04	0.75	0.62	0.56

Year	Reach	Vegetation Type	Total	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2021	2	USGS barren	11.13	0.67	0.65	0.75	1.04	1.23	1.33	1.37	1.28	0.95	0.72	0.68	0.46
2021	3	USGS barren	11.13	0.67	0.65	0.75	1.04	1.23	1.33	1.37	1.28	0.95	0.72	0.68	0.46
2021	4	USGS barren	11.32	0.57	0.66	0.75	1.02	1.26	1.41	1.4	1.29	1	0.77	0.65	0.55
2021	5	USGS barren	10.87	0.57	0.64	0.78	1	1.13	1.25	1.31	1.28	0.98	0.77	0.66	0.49