APPENDIX P

Hydrology, Hydraulics, and Water Quality Technical Study

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Hydrology, Hydraulics, and Water Quality Technical Study

Sapphire Solar Project Riverside County, California

FEBRUARY 2023

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Acronyms and Abbreviations

Acronym/Abbreviation	Definition
AMC	antecedent moisture condition
amsl	above mean sea level
BLM	Bureau of Land Management
BMPs	Best management practices
BESS	battery energy storage system
CDFW	California Department of Fish and Wildlife
CEQA	California Environmental Quality Act
cfs	cubic feet per second
CRBR	Colorado River Basin Region
CWA	Clean Water Act
DWR	Department of Water Resources
EDFR	EDF Renewables Development, Inc.
Gen-tie	Generation tie line
FEMA	Federal Emergency Management Agency
fps	feet per second
HA	Hydrologic Area
HEC-HMS	Hydraulic Engineering Center Hydrologic Modeling System
HEC-RAS	Hydraulic Engineering Center River Analysis System
HSG	Hydrologic Soil Group
HU	Hydrologic Unit
HUC	Hydrologic Unit Code
kV	kilovolt
MW	megawatt
NEPA	National Environmental Policy Act
NHD	National Hydrography Dataset
NLCD	National Land Cover Database
NOAA	National Oceanic and Atmospheric Administrations
NWI	National Wetlands Inventory
O&M	Operations and Maintenance
PV	Photovoltaic
QSD	Qualified SWPPP Developer
QSP	Qualified SWPPP Practitioner
RCFCWCD	Riverside County Flood Control and Water Conservation District
RI	Runoff Index
RWQCB	Regional Water Quality Control Board
SCADA	Supervisory control and data acquisition
SCE	Southern California Edison
SCS	Soil Conservation Service
Sq. mi.	square-mile

SWPPP	Stormwater Pollution Prevention Plan
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USFWS	United States Fish and Wildlife Service
USGS	U.S. Geological Survey
WSA	Water Supply Assessment

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1 Introduction

1.1 Background

This report (Report) documents the methods and results of a hydrology, hydraulics, and water quality study for the Sapphire Solar Project (Project). EDF Renewables Development, Inc. (EDFR) on behalf of Sapphire Solar, LLC (Applicant) proposes to entitle, construct, operate, and maintain the Project, located in Riverside County, California. The Applicant is pursuing a Conditional Use Permit, Public Use Permit, and a Development Agreement from Riverside County for the private lands associated with the Project and a Right-of-Way grant from the BLM (Bureau of Land Management) for the BLM administered lands associated with the Project. As such, Riverside County will serve as the California Environmental Quality Act (CEQA) lead agency and the BLM as the National Environmental Policy Act (NEPA) lead agency.

The hydrological methods used in this Report are described in the Riverside County Flood Control and Water Conservation District (RCFCWCD) Hydrology Manual (Hydrology Manual; RCFCWCD 1978). The Synthetic Unit Hydrograph Method, which is outlined in Section E of the Hydrology Manual, was used to develop the rainfall-runoff relationship for the offsite drainage analysis for this Report. Hydraulic Engineering Center Hydrologic Modeling System (HEC-HMS) software developed by the U.S. Army Corps of Engineers (USACE) was used to calculate peak discharge and maximum flow volumes for the 10-year and 100-year rainfall events with storm durations of 3-, 6-, and 24-hours. A HEC-HMS Preprocessor User Manual and Guidance document was developed by the USACE in 2016 and was used in the development of the project hydrologic model (RCFCWCD 2016). Hydraulic Engineering Center River Analysis System (HEC-RAS) software was used to model the 100-year, 3-hour flood inundation depths and flow velocities at the Project Site.

The objective of this Report is to:

- Calculate discharge which flows onto the Project Site from contributing watersheds;
- Use discharge flows to assess the hydraulic conditions and scour potential within the Project Site;
- Assess impacts of the Project with respect to surface water hydrology and water quality.

The analyses in this Report are preliminary in nature and subject to change should the site plan, grading, or other components of the Project change. The proposed conditions are based on the 10% Site Plan design provided by Barr Engineering and dated September 28, 2022. Plans, specifications, and recommendations found within this Report are not approved and are not for construction purposes; contractors shall refer to the final approved construction documents for construction details. This Report does not address Project-specific requirements which are discussed in the RCFCWCD Design Handbook for Low Impact Development Best Management Practices or Riverside County Water Quality Management Plans.

1.2 Project Description and Location

The proposed Project site (Project Site) is located in Riverside County, California, approximately five miles north of Desert Center, approximately 40 miles west of the City of Blythe, and three and a half miles north of Interstate 10. The Project Site is bounded on the north, east and west sides by BLM lands and to the South by Belsby Avenue. Melon

Street runs along the West side of the Project Site and Jojoba Street on the east. The east side of the Project Site is adjacent to California State Route 177/Rice Road.

The Project would consist of 1,192 acres with 1,082 acres of private lands and 110 acres of Bureau of Land Management (BLM) administered lands. The Project would include up to 117 megawatts (MW) of photovoltaic (PV) solar generation and up to 117-MW of battery storage (Figure 1).

The Project would consist of PV panels, a single-axis tracker system, inverters, converters, transformers, electrical collection and communication lines, a 12- kilovolt (kV) distribution line for backup power, an on-site electrical substation, a battery energy storage system (BESS), security fence, an operations and maintenance (O&M) facility including a stand-alone storage building, up to three onsite groundwater wells, meteorological station and albedometer weather station, a microwave/communication tower, and a supervisory control and data acquisition (SCADA) system that are located on private lands. The current site plan displays two location options for the laydown yard, O&M facility, BESS facility, and substation, one in the northwest corner of the Project Site and one in the northern portion of the Project Site. The current site plan displays three additional location options for a temporary laydown yard and construction parking.

The Project would also include up to three 230-kV generation tie (gen-tie) line alignment options (only one of which would be constructed), access roads, and collector line routes, collectively referred to as "Linear Facility Routes," that are located on federal public lands administered by the BLM and designed to support the proposed Project, which is located on adjacent private lands. The Project would interconnect with the Southern California Edison (SCE) Red Bluff Substation via the existing Desert Harvest gen-tie line located on lands administered by BLM.

2 Environmental Setting

The Project Site is located in eastern Riverside County and in the southern Mojave Desert. The topography of the proposed solar field is characterized by an average 0.08% slope to the east with a maximum elevation of 660 feet above mean sea level (amsl) to the west and a minimum elevation of 580 feet amsl to the east. The proposed solar field is entirely within private land previously used for cultivating jojoba. The fallow agricultural land supported remnant jojoba shrubs and several nonnative plant species. Evidence of past farming disturbances were found throughout the proposed solar field, and agricultural practices have modified natural hydrology (Ironwood 2022).

2.1 Surface Water Hydrology

According to the Water Quality Control Plan for the Colorado River Basin Region (CRBR), the Project Site falls within the Palen Hydrologic Area (HA; 717.2) which is located within the Chuckwalla Hydrologic Unit (HU; 717) of the CRBR (SWRCB 2019). There are no hydrologic sub-areas defined within the Palen HA. These watersheds are used as a way to identify beneficial uses and associated water quality objectives in the Colorado River Basin Plan (SWRCB 2019). Table 1 and Figure 2 show the Project Site within the context of the Regional Water Quality Control Board (RWQCB) HU and HA. The Project Site encompasses approximately 0.28% of the Palen HA.

Table 1. RWQCB Hydrologic Setting

Number	Name	Analysis Scale	Area (Sq. Mi.)	Proposed Project Area (Sq. Mi.)	Project Contribution (Percent)
717	Chuckwalla	Hydrologic Unit	1,982	1.8	0.09%
717.2	Palen	Hydrologic Area	654	1.8	0.28%

Source: SWRCB 2019.
Note: RWQCB = Regional Water Quality Control Board; Sq. Mi. = Square Miles

The USGS Watershed Boundary Dataset indicates the Project Site is located within three subwatersheds and two watersheds within the South Mojave subbasin (USGS 2022). The subbasin, watersheds, and subwatersheds, which are identified by a Hydrologic Unit Code (HUC), are identified in Table 2 along with the project area within the drainage feature and the project area contribution to the drainage feature based on size. Figure 3 shows the Project Site within the context of the USGS Watershed Boundary Dataset.

Table 2. Project Contribution to Hydrologic Subarea

HUC Digit / HUC	Name	Analysis Scale	Area (Sq. Mi.)	Approximate Proposed Project Area (Sq. Mi.)	Estimated Project Contribution (Percent)
8/18100100	Southern Mojave	Subbasin	8,867	1.8	0.02%
10/1810010049	Big Wash	Watershed	212	0.6	0.28%

Table 2. Project Contribution to Hydrologic Subarea

HUC Digit / HUC	Name	Analysis Scale	Area (Sq. Mi.)	Approximate Proposed Project Area (Sq. Mi.)	Estimated Project Contribution (Percent)
10/1810010048	Hayfield Lake-Lake Tamarisk	Watershed	163	1.2	0.74%
12/181001004906	Lower Big Wash	Subwatershed	29	0.4	1.50%
12/181001004901	Dragon Wash	Subwatershed	30	0.2	0.54%
12/181001004805	Lake Tamarisk	Subwatershed	55	1.2	2.20%

Source: USGS 2022.
Note: Sq. Mi. = Square Miles

The Project Site is located within the Hayfield Planning Area of the CRBR and within the Chuckwalla Valley and is bordered by the Chuckwalla Mountains to the south, the Coxcomb Mountains to the north, Eagle Mountains to the west, and the Palen Valley followed by the Palen Mountains to the east. Average annual precipitation in the Hayfield Basin Planning Area ranges from less than three inches in the lower valley to eight inches in the higher elevations of the Little San Bernardino Mountains (SWRCB 2019). The average annual runoff for the Hayfield Basin Planning Area, which occurs principally during thunderstorms, is 5,00 acre-ft. Almost all the moisture from rain is lost through evaporation or evapotranspiration (SWRCB 2019). Much of the local landscape is shaped by alluvial fans and aeolian influence from wind patterns blowing west to east and occasional winds from the north to the south (East et al., 2021).

The Project Site is subject to storm flows due to its location on an active desert alluvial fan and near a concentrated flow path. Alluvial fans are gently sloping, fan-shaped deposits of sediment that form where steep, confined mountain streams flow out onto a piedmont plain. Alluvial fans are dynamic depositional systems and channel relocations are likely to occur within the larger flow zone (CADFG 2010).

The National Hydrography Dataset (NHD) is maintained by the United States Geological Service (USGS 2022) for the purpose of portraying surface waters on a national scale. The NHD is maintained at a broad nationwide level to represent features, such as rivers, streams, canals, lakes, ponds, coastlines, dams, and stream gages. Due to its scale, the NHD provides only an estimate of the waterbodies, is not comprehensive, and may not be accurate. The United States Fish and Wildlife Service (USFWS 2022) maintains the National Wetlands Inventory (NWI) and the NWI Wetlands Mapper, which provide access to wetland data on a national scale. The USFWS created NWI maps by analyzing remote-sensing data and aerial imagery and by drawing polygons around areas that appear to have wetland signatures. Similar to the NHD, the NWI maps are reconnaissance-level information and not a comprehensive database of wetlands. The USFWS NWI Mapper shows a series of riverine features flowing adjacent to the proposed solar field, but no riverine flow into the proposed solar field, while the NHD displays one ephemeral stream flowing through the proposed solar field (Figure 4). No additional surface hydrology features were presented within the proposed solar field for either database. Several hydrology features displayed by the NHD and the NWI Mapper are shown crossing the Linear Facility Routes.

2.2 Flood Zones

Federal Emergency Management Agency (FEMA) Flood insurance Rate Maps (FIRM) identify flood zones and areas that are susceptible to 100-year and 500-year floods. FEMA map numbers 06065C1800G and 06065C1825G (Appendix A) show that the Project Site is outside of the 100-year and 500-year floodplains and in an area of minimal hazard (FEMA 2022).

According to the Riverside County Flood Control Floodplain Map, the Project Site is not in an area identified as a Riverside County flood zone (RCFCD 2023).

The California Department of Water Resources (DWR) developed the Best Available Maps (BAM) which display floodplains and designated floodway data. According to the BAM, the Project Site is within the 100-year DWR "Awareness Floodplain," which means without specific depths and other flood hazard data, this area is possibly prone to flooding (DWR 2022; Appendix B).

2.3 Rainfall

Rainfall depths for various storm durations and recurrence intervals were obtained using NOAA Atlas 14 precipitation estimates. These depths are provided in Table 3 and shown in Appendix C.

Table 3. Rainfall Depths

Duration	Precipitation (inches)		Basin 1 Aerial Adjustment Factor (%)	Basin 2 Aerial Adjustment Factor (%)	Basin 3 Aerial Adjustment Factor (%)
	Average Recurrence Interval (years)				
	10	100			
1-hour	0.81	1.52	75%	86%	68%
3-hour	1.12	2.12	86%	93%	81%
6-hour	1.35	2.56	91%	95%	86%
24-hour	2.15	4.08	94%	97%	92%

Source: NOAA 2022; RCFCWCD Hydrology Manual 1978.

For use with the Synthetic Unit Hydrograph method, an area adjustment was applied to point rainfall values using curves in Plate E-5.8 of the Hydrology Manual. The aerial adjustment factors used for the three basins, which are discussed in Section 3, are shown in Table 3 (Appendix D).

2.4 Groundwater

The Project Site is located in the western part of the Chuckwalla Valley Groundwater Basin (CVGB) (California Department of Water Resources [DWR] Basin no. 7-005). The CVGB has an area of 940 square miles and is shown in Figure 5. Data show stable groundwater levels in the CVGB and contours for the basin indicate that groundwater

moves from the north and west toward the gap between the Mule and the McCoy Mountains at the southeastern end of the valley (DWR 2004).

Per the Colorado River Basin Plan, the Project Site is located in the Palen Hydrologic Area within the Chuckwalla Hydrologic Unit in the Hayfield Planning Area. Runoff from higher elevations is the main source of recharge of the groundwater basins within the Hayfield Planning Area. Small amounts of water percolate to the groundwater table from direct precipitation. Water in storage is generally unconfined in the sediments that fill the valleys (SWRCB 2019).

2.5 Beneficial Uses for Surface and Groundwater

California Water Code Section 13050(f) describes the beneficial uses of surface and ground waters that may be designated by the State Water Resources Control Board or Regional Water Quality Control Board for protection as follows:

> Beneficial uses of the waters of the state that may be protected against quality degradation include, but are not necessarily limited to, domestic, municipal, agricultural and industrial supply; power generation; recreation; aesthetic enjoyment; navigation; and preservation and enhancement of fish, wildlife, and other aquatic resources or preserves.

To comply with the California Water Code and the federal Clean Water Act, surface waters downstream of the Project Site have been assigned beneficial uses in the Water Quality Control Plan for the Colorado River Basin as shown in Table 4. While there are no defined surface water bodies downstream of the Project Site, there are unlisted intermittent streams and washes downstream of the Project Site.

Table 4. Downstream Surface Water Beneficial Uses

Stream	Beneficial Use						
	MUN	GWR	REC-1	REC-2	WARM	WILD	RARE
Unlisted Perennial and Intermittent Streams	+[a]	○ ●	○ ● +	○ ●	○ ●	○ ●	○ ●[c]
Washes (Ephemeral Streams)		○		○	[b]	○	

Source: SWRCB 2019

Notes:

- ● Existing beneficial uses.
- \+ Potential beneficial uses.
- ○ Intermittent beneficial uses.
- [a] Potential use designations will be determined on a case-by-case basis as necessary in accordance with the "Sources of Drinking Water Policy" in the CRBR Basin Plan
- [b] Use, if any, to be determined on a case-by-case basis.
- [c] Rare, endangered, or threatened wildlife exists in or utilizes some of these waterway(s). If the RARE beneficial use may be affected by a water quality control decision, responsibility for substantiation of the existence of rare, endangered, or threatened species on a case-by-case basis is upon the California Department of Fish and Wildlife on its own initiative and/or at the request of the Regional Water Board; and such substantiation must be provided within a reasonable time frame as approved by the Regional Water Board.

To comply with the California Water Code and the federal Clean Water Act, groundwater within the Project area has been assigned the following beneficial uses in the Water Quality Control Plan for the Colorado River Region as shown in Table 5.

Table 5. Beneficial Uses of Ground Waters in the Colorado River Basin

Hydrologic Unit	Area Code	Beneficial Use		
		MUN	AGR	IND
Chuckwalla	717	●	●	●

Source: SWRCB 2019
Notes:
- Existing beneficial uses.

Definitions of the beneficial uses mentioned in Tables 4 and 5 are as follows:

Municipal and Domestic Supply (MUN) –Uses of water for community, military, or individual water supply systems including, but not limited to, drinking water supply.

Agriculture Supply (AGR) – Uses of water for farming, horticulture, or ranching including, but not limited to, irrigation, stock watering, or support of vegetation for range grazing.

Industrial Service Supply (IND) –Uses of water for industrial activities that do not depend primarily on water quality including, but not limited to, mining, cooling water supply, hydraulic conveyance, gravel washing, fire protection, and oil well repressurization.

Groundwater Recharge (GWR) – Uses of water for natural or artificial recharge of ground water for purposes of future extraction, maintenance of water quality, or halting salt water intrusion into fresh aquifers.

Water Contact Recreation (REC-1) – Uses of water for recreational activities involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, swimming, wading, water-skiing, skin and scuba diving, surfing, white water activities, fishing, or use of natural hot springs.

Non-contact Water Recreation (REC-2) – Uses of water for recreational activities involving proximity to water, but not normally involving contact with water where ingestion of water is reasonably possible. These uses include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tidepool and marine life study, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities.

Warm Freshwater Habitat (WARM) – Uses of water that support warm water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.

Wildlife Habitat (WILD) – Uses of water that support terrestrial ecosystems including, but not limited to, the preservation and enhancement of terrestrial habitats, vegetation, fish, or wildlife, including invertebrates.

Preservation of Rare, Threatened, or Endangered Species (RARE) – Uses of water that support habitats necessary, at least in part, for the survival and successful maintenance of plant or animal species established under state or federal laws as rare, threatened, or endangered.

2.6 303(d) Listed Impaired Water Bodies

As discussed in Section 2.1, the Project Site is within the Palen Hydrologic Area within the Hayfield Planning Area. Almost all the moisture from rain is lost through evaporation and evapotranspiration within the Hayfield Planning Area. There are no water bodies listed as impaired according to the 2018 Integrated Report (Clean Water Act Sections 305(b) and 303(d)) published by the State Water Resources Control Board (SWRCB 2020) downstream of the Project Site.

3 Regulatory Setting

3.1 Federal

3.1.1 Clean Water Act

The Clean Water Act (CWA) (33 U.S. Code Section 1251 et seq.), formerly the Federal Water Pollution Control Act of 1972, was enacted with the intent of restoring and maintaining the chemical, physical, and biological integrity of waters of the United States. The CWA required states to set standards to protect, maintain, and restore water quality through the regulation of point-source and certain nonpoint-source discharges to surface water. Those discharges are regulated by the National Pollutant Discharge Elimination System (NPDES) permit process (CWA Section 402). In California, NPDES permitting authority is delegated to, and administered by, the nine Regional Water Quality Control Boards (RWQCBs).

Section 401, Water Quality Certification. Section 401 of the CWA requires that, prior to issuance of any federal permit or license, any activity, including river or stream crossings during road, pipeline, or transmission line construction, that may result in discharges into waters of the United States must be certified by the state, as administered by the RWQCB. This certification ensures that the proposed activity does not violate state and/or federal water quality standards.

Section 402, National Pollutant Discharge Elimination System. Section 402 of the CWA authorizes the State Water Resources Control Board (SWRCB) to issue a NPDES General Construction Storm Water Permit (Water Quality Order 2009-0009-DWQ), referred to as the "Construction General Permit." On September 8, 2022, the SWRCB adopted a new Construction General Permit (Water Quality Order 2022-0057-DWQ) which becomes effective on September 1, 2023. Coverage under the Construction General Permit is required for projects that will discharge stormwater to Waters of the United States unless the project will disturb less than one acre. Projects can obtain coverage under the Construction General Permit provided that they do the following:

1. Develop and implement a Stormwater Pollution Prevention Plan (SWPPP) that specifies best management practices (BMPs) that will prevent all construction pollutants from contacting stormwater and with the intent of keeping all products of erosion from moving off site into receiving waters.
2. Eliminate or reduce non-stormwater discharges to storm sewer systems and other waters of the United States.
3. Perform inspections of all BMPs.

Section 404, Discharge of Dredged or Fill Materials. Section 404 of the CWA establishes programs to regulate the discharge of dredged and fill material in waters of the United States, including wetlands. For purposes of Section 404 of the CWA, the limits of non-tidal waters extend to the ordinary high-water mark, defined as the line on the shore established by the fluctuation of water and indicated by physical characteristics, such as a natural line impressed on the bank, changes in the character of the soil, and presence of debris. When an application for a Section 404 permit is made, the applicant must show it has done the following:

- Taken steps to avoid impacts to wetlands or waters of the United States, where practicable

- Minimized unavoidable impacts to waters of the United States and wetlands
- Provided mitigation for unavoidable impacts

Section 404 of the CWA requires a permit for construction activities involving placement of any kind of fill material into waters of the United States or wetlands. A water quality certification pursuant to Section 401 of the CWA is required for Section 404 permit actions. Thus, if applicable, construction would require a request for water quality certification (or waiver thereof) from the Colorado River Basin RWQCB. Project activities would adhere to state and federal water quality standards and would comply with Sections 401 and 404 of the CWA.

3.1.2 National Flood Insurance Act

FEMA is responsible for managing the National Flood Insurance Program, which makes federally backed flood insurance available for communities that agree to adopt and enforce floodplain management ordinances to reduce future flood damage. The National Flood Insurance Program, established in 1968 under the National Flood Insurance Act, requires that participating communities adopt certain minimum floodplain management standards, including restrictions on new development in designated floodways, a requirement that new structures in the 100-year flood zone be elevated to or above the 100-year flood level (known as base flood elevation), and a requirement that subdivisions be designed to minimize exposure to flood hazards.

To facilitate identifying areas with flood potential, FEMA has developed Flood Insurance Rate Maps that can be used for planning purposes, including floodplain management, flood insurance, and enforcement of mandatory flood insurance purchase requirements.

3.2 State

3.2.2 Porter-Cologne Water Quality Control Act

The Porter-Cologne Water Quality Control Act (Porter-Cologne Act) established the principal California legal and regulatory framework for water quality control. The Porter-Cologne Act is embodied in the California Water Code, which authorizes California's nine Regional Water Quality Control Boards (RWQCB) to implement the provisions of the federal CWA (see Section 3.1.1) and the California Water Code. The Colorado River Basin RWQCB implements and enforces provisions of the California Water Code and CWA in the Colorado River Basin. The act requires a "report of water discharge" for any discharge of water (liquid, solid, or otherwise) to land, surface waters, or groundwaters that may impair a beneficial use of any groundwater or surface water in the state and authorizes the RWQCBs to impose waste discharge requirements (WDRs). The Porter-Cologne Act also provides for the development and periodic review of basin-specific water quality control plans (Basin Plans) that designate beneficial uses of California's major rivers and groundwater basins and establish water quality objectives for those waters.

3.2.3 Streambed Alteration Agreement (California Fish and Game Code)

Section 1602 of the California Fish and Game Code protects the natural flow, bed, channel, and bank of any river, stream, or lake designated by the California Department of Fish and Wildlife (CDFW) in which there is, at any time,

any existing fish or wildlife resources, or benefit for the resources. Section 1602 applies to all perennial, intermittent, and ephemeral rivers, streams, and lakes in the state, and requires any person, state or local governmental agency, or public utility to notify CDFW before beginning any activity that will do any of the following:

- Substantially divert or obstruct the natural flow of any river, stream or lake
- Substantially change or use any material from the bed, channel, or bank of, any river, stream, or lake
- Deposit or dispose of debris, waste, or other material containing crumbled, flaked, or ground pavement where it may pass into any river, stream, or lake

If it is determined that any project-related actions would have the potential to necessitate a Streambed Alteration Agreement, such an agreement would be prepared and implemented prior to construction of the project, thus maintaining compliance with Section 1602 of the California Fish and Game Code. A Streambed Alteration Agreement is required if CDFW determines that the activity could substantially adversely affect an existing fish and wildlife resource. The agreement includes measures to protect fish and wildlife resources while conducting the project.

3.3 Local

3.3.2 Water Quality Control Plan for the Colorado River Basin

The Colorado River Basin covers approximately 13 million acres (20,000 square miles) in the southeastern portion of California and includes all of imperial County and portions of San Bernardino, Riverside, and San Diego Counties. The Colorado River Basin Plan contains the water quality regulations for the Colorado River Basin Region and programs to implement those regulations. The Colorado River Basin Plan is designed to preserve and enhance water quality in the region and to protect the beneficial uses of all regional waters for the benefit of present and future generations (SWRCB 2019).

3.3.3 Riverside County Floodplain Management Ordinance (15.80)

The purpose of the ordinance is to promote the public health, safety, and welfare and minimize public and private costs caused by flooding by regulating development within the special flood hazard areas to be applied uniformly throughout the unincorporated areas of Riverside County to all publicly and privately owned land within flood prone, mudslide, or flood related erosion areas. Within special flood hazard areas, no structure, including flow obstructing structures, shall be constructed, located, or substantially improved and no land shall be graded, filled, or developed, and no permit or approval shall be granted therefor, unless it complies with all the applicable requirements of chapter 15.80 and all other applicable ordinances. Section 15.80.080 of the ordinances elaborates on the standards of construction allowed in the special flood hazard areas.

4 Hydrological Analysis

4.1 Methodology

Three watersheds totaling 274.1 square miles (sq. mi. [175,419 acres]) contribute flow to the Project Site and are analyzed in this Report. Because hydraulic modeling needs to account for offsite flows running onto the Project Site, the upstream areas of the Project Site and the contributing watersheds were analyzed in this Report. The three watersheds examined as part of this Report are within the Southern Mojave Subbasin and are referred to as Basin 1, Basin 2, and Basin 3. The peak flow discharge was calculated at the three watershed concentration points[1] (Figure 6).

The Synthetic Unit Hydrograph Method was used to determine peak runoff for these watersheds. An S-graph is a summation hydrograph modified to the extent that discharge is expressed in percent of ultimate discharge, and time is expressed in percent of lag time. Four S-graphs are used to represent the runoff characteristics of watersheds in Riverside County. Based on Google Earth aerial imagery, an equal percentage of all four S-graphs (Valley, Foothill, Mountain, and Desert) were used to characterize the contributing watersheds.

Lag time was computed using the HEC-HMS preprocessor tool available on the Riverside County Flood Control and Water Conservation District website. Lag for a drainage area is defined as the elapsed time from the beginning of unit effective rainfall to the instant that the summation hydrograph for the concentration point of an area reaches 50% of ultimate discharge. The preprocessor tool is used to calculate input parameters into HEC-HMS. Lag time calculations and other inputs into the HEC-HMS preprocessor tool can be found in Appendix D.

4.2 Topography

Northeasterly-flowing ephemeral streams and washes fan out from the Eagle Mountains in the west and flow through the Project Site. Although these drainages are not defined by the NHD or NWI datasets as described in Section 2.1, they are ephemeral flow paths on an active desert alluvial fan which are expected to drain water from higher ground in the west to lower ground in the east during and after rain events. Basin 1 is 81.9 sq. mi. and comprises the northern portion of the Big Wash Watershed. Basin 1 encompasses a northern piece of the Project Site and the flows from Basin 1 concentrate north of the Project Site and are analyzed due to the proximity to the northern Project boundary. Basin 2 is 29.6 sq. mi. and comprises the southern portion of the Big Wash Watershed. Basin 2 encompasses a western piece of the Project Site. Basin 3 is 162.6 sq. mi. and comprises the entire Hayfield Lake-Lake Tamarisk Watershed. Basin 3 encompasses the eastern portion of the Project Site.

Existing topography of the Project Site and watersheds is presented in Figure 6. The longest flow path of Basin 1 is 19.4-miles and starts at an elevation of 3,870-feet amsl and ends at an elevation of 540 feet amsl. The longest flow path of Basin 2 is 12.5-miles and starts at an elevation of 3,600-feet amsl and ends at an elevation of 600

[1] The concentration point is the point at which all flow from the Project Site discharges downstream. This point also includes upland flow from areas outside of the Project Site boundary.

feet amsl. The longest flow path of Basin 3 is 26.6-miles and starts at an elevation of 4,410-feet amsl and ends at an elevation of 540 feet amsl.

4.3 Infiltration and Surface Cover

Among the many factors affecting infiltration or loss rates, three of the most impactful are: soil surface and profile characteristics, soil cover or vegetation type, and antecedent moisture condition (AMC). The Soil Conservation Service (SCS) of the U.S. Department of Agriculture (USDA) has investigated the hydrologic characteristics of soils as related to runoff potential and has developed a system to classify soils into four hydrologic soil groups. The four Hydrologic Soil Groups (HSG) are A, B, C and D. Group A generally has the smallest runoff potential and Group D the greatest. The Hydrologic Soil Groups are defined as follows:

- **Group A.** Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well-drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.
- **Group B.** Soils having a moderate infiltration rate when thoroughly wet. These consist primarily of moderately deep or deep, moderately well-drained or well-drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.
- **Group C.** Soils having a slow infiltration rate when thoroughly wet. These consist mostly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.
- **Group D.** Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist largely of clays that have a high shrink–swell potential, soils that have a high-water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

The hydrologic soil groups of the Project Site and contributing watersheds were obtained using the Web Soil Survey application made available through the USDA Natural Resources Conservation Service website (Appendix E; USDA 2022). Hydrologic soil group data is presented in Figure 7 and Table 6.

Table 6. Hydrologic Soil Groups of Contributing Watersheds

Watershed	Hydrologic Soil Group	Size (Acres)	Percentage of Watershed
Basin 1	A	2,653	5.1%
	C	4,031	7.7%
	D	2,524	4.8%
	Not Rated	43,192	82.4%
Basin 2	A	3,866	20.4%
	C	677	3.6%
	D	-	0%
	Not Rated	14,414	76.0%
Basin 3	A	11,593	11.1%
	C	-	0%
	D	2,021	1.9%
	Not Rated	90,472	86.9%

Sources: USDA 2022.

As seen in Appendix E and Table 6, the majority of each basin consists of terrain which was not surveyed for hydrologic soil group data and does not have an HSG rating. Because the majority of the terrain not surveyed is mountainous with steep slopes which generally have lower infiltration rates, it is assumed for this Report that the un-surveyed area is made up of HSG D. This assumption is conservative because it likely results in a higher runoff rate than would otherwise be determined if the area had HSG ratings.

The type of vegetation or ground cover on a watershed, and the quality or density of that cover, has a major impact on the infiltration capacity of a given soil. Table 7 and Figure 8 presents the land cover types at the Project Site and the contributing watersheds as of 2019 (NLCD 2019). Shrub/scrub cover makes up the majority of the land cover type within the contributing watersheds. The Project Site consists primarily of shrub/scrub cover.

Table 7. Land Cover of Contributing Watersheds

	NLCD Code	Land Cover Type	Area (acres)	Percentage of Basin Area
Basin 1	11	Open Water	6	0%
	21	Developed, Open Space	445	1%
	22	Developed, Low Intensity	1047	2%
	23	Developed, Medium Intensity	1670	3%
	24	Developed, High Intensity	521	1%
	31	Barren Land	962	2%
	52	Shrub/Scrub	46955	90%
	71	Herbaceuous	788	2%
Basin 2	11	Open Water	1	0%
	21	Developed, Open Space	43	0%
	22	Developed, Low Intensity	36	0%
	23	Developed, Medium Intensity	1	0%
	31	Barren Land	7	0%
	52	Shrub/Scrub	18387	97%
	71	Herbaceuous	481	3%
Basin 3	11	Open Water	15	0%
	21	Developed, Open Space	337	0%
	22	Developed, Low Intensity	342	0%
	23	Developed, Medium Intensity	297	0%
	24	Developed, High Intensity	83	0%
	31	Barren Land	308	0%
	52	Shrub/Scrub	98967	95%
	71	Herbaceuous	2810	3%
	81	Hay/Pasture	4	0%
	90	Woody Wetlands	114	0%
	95	Emergent Herbaceuous Wetlands	770	1%

Source: NLCD 2019.

Land cover types obtained from NLCD must be converted to land cover types listed in Plate 5.5 of the Hydrology Manual in order to obtain Runoff Index (RI) values. Shrub/scrub, herbaceous, and hay/pasture cover was selected to be represented by the open brush cover type; barren land and developed areas are represented by barren land; and woody wetlands, emergent herbaceous wetlands, and open water are represented by meadows or cienegas. Open brush and meadow or cienega land types is graded as fair because based on Google Earth imagery between 50% and 75% of the ground surface is protected by plant cover or brush and tree canopy.

An impervious cover percentage must be selected from Plate 5.6 of the Hydrology Manual in order to obtain Runoff Index (RI) values. For developed land cover types, the commercial, downtown business, or industrial percentage was assigned. For all other land cover types, the natural land use percentage was assigned. The RI data for the existing condition are presented in Figure 9 and Table 8.

Table 8. Existing Condition Runoff Index Values of Contributing Watersheds

	Land Cover Type	Quality of Cover	HSG	RI Number	Land Use	Impervious Area (%)	Area (acres)	Percentage of Basin Area
Basin 1	Barren Land	-	A	78	Developed1	90	11	0%
	Barren Land	-	C	91	Developed[1]	90	48	0%
	Barren Land	-	D	93	Developed[1]	90	3621	7%
	Barren Land	-	D	93	Natural	0	955	2%
	Open Brush	Fair	A	46	Natural	0	2642	5%
	Open Brush	Fair	C	77	Natural	0	3982	8%
	Open Brush	Fair	D	83	Natural	0	41129	78%
	Meadow or Cienegas	Fair	D	84	Natural	0	6	0%
Basin 2	Barren Land	-	A	78	Developed[1]	90	26	0%
	Barren Land	-	C	91	Developed[1]	90	6	0%
	Barren Land	-	D	93	Developed[1]	90	48	0%
	Barren Land	-	A	78	Natural	0	7	0%
	Open Brush	Fair	A	46	Natural	0	3839	20%
	Open Brush	Fair	C	77	Natural	0	670	4%
	Open Brush	Fair	D	83	Natural	0	14356	76%
	Meadow or Cienegas	Fair	D	84	Natural	0	1	0%
Basin 3	Barren Land	-	A	78	Developed[1]	90	35	0%
	Barren Land	-	D	93	Developed[1]	90	1025	1%
	Barren Land	-	A	78	Natural	0	10	0%
	Barren Land	-	D	93	Natural	0	298	0%
	Open Brush	Fair	A	46	Natural	0	11545	11%
	Open Brush	Fair	D	83	Natural	0	90265	87%
	Meadow or Cienegas	Fair	D	84	Natural	0	899	1%

Source: RCFCWCD Hydrology Manual 1978.
Notes: HSG=Hydrologic Soil Group; RI=Runoff Index
[1]Commercial, Downtown Business or Industrial per RCFCWCD Hydrology Manual

Table 8 was input into the HEC-HMS Preprocessor tool on the RCFCWCD website along with lag time and other parameters (Appendix F).

AMC has a major effect on the runoff potential of a particular soil-cover complex. The Hydrology Manual defines AMC as the relative wetness of a watershed just prior to a flood producing storm event. For the purposes of design hydrology using RCFCWCD methods, AMC II should be assumed for both the 10-year and 100-year frequency storm (RCFCWCD 1978). For this study, AMC Level II, the intermediate condition with moderate runoff potential, has been selected because the 10-year and 100-year frequency storms were analyzed.

4.4 Hydrology Results

Peak flow rates and total discharge volume for various storms were modeled at each watershed's concentration point and are presented in Table 9 and 10, respectively. See Appendix G for HEC-HMS output reports and generation of peak flows and discharge volumes. The maximum peak flow rate occurs in Basin 3 during the 100-year, 3-hour storm with a flow rate of 24,444 cubic feet per second (cfs). The maximum total discharge volume occurs in in Basin 1 during the 100-year, 3-hour storm at 8,342 acre-feet.

Table 9. Peak Flow Rates

Watershed	Area (sq. mi.)	Peak Flow (cfs)					
		10-Year Storm Recurrence Interval			100-Year Storm Recurrence Interval		
		3-hour	6-hour	24-hour	3-hour	6-hour	24-hour
Basin 1	81.9	5972	5891	1700	17324	16843	9241
Basin 2	29.6	2328	1983	410	7656	6717	2842
Basin 3	162.6	7193	7129	2178	24444	23403	13791

Table 10. Discharge Volumes

Watershed	Area (sq. mi.)	Total Discharge Volume (acre-feet)					
		10-Year Storm Recurrence Interval			100-Year Storm Recurrence Interval		
		3-hour	6-hour	24-hour	3-hour	6-hour	24-hour
Basin 1	81.9	1555	1559	1092	4879	4787	5189
Basin 2	29.6	470	461	328	1727	1541	1400
Basin 3	162.6	2298	2394	1838	8342	7952	8273

4.5 Proposed Condition Hydrology

Hydrologic soil groups and antecedent moisture conditions in the proposed condition remain unchanged from the existing condition. Surface cover will be impacted due to the proposed Project. According to the 10% Site Plans, 96,000 linear feet of internal road with a 16-foot width is proposed. The proposed internal roads will encompass 35-acres and will be compacted native ground. Approximately 13,000 linear feet of primary access roads with a 24-foot width is proposed. This primary access road will encompass 7-acres and will consist of either a compacted 8-inch Class II Base with geotextile fabric or a compacted 10-inch Class II Base. Because both the primary access road and internal roads will be compacted, they will be considered impervious surfaces. The roads are spaced evenly throughout the Project Site and for calculation purposes the 42-acres of impervious surface area were distributed by area-weight amongst the three drainage basins. When calculating the RI number for the proposed roads, a "Barren Land" cover type was assigned along with a "Developed" land use.

The substation, battery storage area, and O&M facilities consist of proposed impervious areas totaling 16 acres. When calculating the RI number for the facilities, a "Barren Land" cover type will be assigned along with a "Developed" land use.

The RI data for the proposed condition are presented in Figure 9 and Table 11.

Table 11. Proposed Condition Runoff Index Values of Contributing Watersheds

	Land Cover Type	Quality of Cover	HSG	RI Number	Land Use	Impervious Area (%)	Area (acres)	Percentage of Basin Area
Basin 1	Barren Land	-	A	78	Developed[1]	90	11	0%
	Barren Land	-	C	91	Developed[1]	90	48	0%
	Barren Land	-	D	93	Developed[1]	90	3643	7%
	Barren Land	-	D	93	Natural	0	955	2%
	Open Brush	Fair	A	46	Natural	0	2642	5%
	Open Brush	Fair	C	77	Natural	0	3982	8%
	Open Brush	Fair	D	83	Natural	0	41107	78%
	Meadow or Cienegas	Fair	D	84	Natural	0	6	0%
Basin 2	Barren Land	-	A	78	Developed[1]	90	26	0%
	Barren Land	-	C	91	Developed[1]	90	6	0%
	Barren Land	-	D	93	Developed[1]	90	58	0%

Table 11. Proposed Condition Runoff Index Values of Contributing Watersheds

	Land Cover Type	Quality of Cover	HSG	RI Number	Land Use	Impervious Area (%)	Area (acres)	Percentage of Basin Area
	Barren Land	-	A	78	Natural	0	7	0%
	Open Brush	Fair	A	46	Natural	0	3839	20%
	Open Brush	Fair	C	77	Natural	0	670	4%
	Open Brush	Fair	D	83	Natural	0	14346	76%
	Meadow or Cienegas	Fair	D	84	Natural	0	1	0%
Basin 3	Barren Land	-	A	78	Developed[1]	90	35	0%
	Barren Land	-	D	93	Developed[1]	90	1051	1%
	Barren Land	-	A	78	Natural	0	10	0%
	Barren Land	-	D	93	Natural	0	298	0%
	Open Brush	Fair	A	46	Natural	0	11545	11%
	Open Brush	Fair	D	83	Natural	0	90239	87%
	Meadow or Cienegas	Fair	D	84	Natural	0	899	1%

Source: RCFCWCD Hydrology Manual 1978.
Notes: HSG=Hydrologic Soil Group; RI=Runoff Index
[1]Commercial, Downtown Business or Industrial per RCFCWCD Hydrology Manual

Table 11 was input into the HEC-HMS Preprocessor tool on the RCFCWCD website along with lag time and several other parameters in order to calculate peak flows and discharge volumes.

Peak flow rates and total discharge volume for various storms were modeled at each watershed's concentration point. Because the additional 0.09-square miles of impervious area consists of less than 0.001% of the 274.1-square miles of contributing drainage area, the peak runoff rates and discharge volumes remain unchanged from the existing condition.

5 Project Hydraulics

5.1 Methodology

Flow depth and velocity modeling for existing conditions was performed with an unsteady flow analysis using HEC-RAS software (version 6.2) for the 100-year, 3-hour storm to model hydraulics throughout the Project Site. A flow area computational mesh was generated using cells of 100 feet by 100 feet and a refinement region using cells of 50 feet by 50 feet was created around the Project Site. Manning's n-values were assigned to the computational mesh based on the NLCD Land Cover classification (NLCD 2019). The only hydrologic control included in the hydraulic analysis model is topography. Hydrographs generated in HEC-HMS, with peak flows shown in Table 9, were used in the model as inflow boundary conditions for the three watersheds.

5.2 Hydraulic Results

Flood inundation maps showing maximum flow depths and flow velocities for existing topographic conditions can be found in Figures 10 and 11, respectively.

Modeling results indicate that maximum water depths for the majority of the Project Site can reach an average height of 1- to 2-feet and velocities can reach an average speed of 2- to 3-feet per second (fps). The agricultural ditches in the Project Site fill up and reach depths up to 7-feet and velocities up to 4-fps. Based on the 10% Site Plan, these ditches will be filled in during grading, so these flow depths and velocities can be expected to be reduced. The southeastern portion of the of the Project Site may receive flow depths up to 4-feet and flow velocities up to 4-fps from Basin 3 discharge. Flows generated in Basin 1 concentrate in a braided drainage north of the Project Site and a small portion of this drainage may encroach onto the northern portion of the Project Site. Depths in this drainage can be expected to reach up to 7- to 8-feet and velocities can be expected to reach up to 4-fps.

5.3 Scour Analysis

A scour analysis was completed to evaluate erosion potential around proposed solar arrays. The scour analysis was conducted assuming the PV panels are mounted on piles which are placed directly on the existing surface without BMPs or implementation of grading modifications. The proposed PV panels have erosional potential because the posts they are mounted on have similar characteristics to simple piers exposed to flow. This scour analysis applies the same methodology as that of a round, single-column pier scour described in *Evaluating Scour at Bridges, Fifth Edition*, prepared by the Federal Highway Administration (FHA 2012). Scour potential of the PV panel posts was calculated for potential scenarios considering flow depth, velocity, flow angle, and post geometry and bed condition. Calculations can be found in Table H within Appendix H. Scour potential at the Project Site for the solar arrays can be expected to reach 1-foot in some locations for the 100-year, 3-hour storm.

Potential scour of the gen-tie poles can be found in a Preliminary Hydrology and Hydraulics Study prepared by West Consultants.

6 Design Considerations

1. The Project Site is located in an area of minimal flood hazard outside of the FEMA 500-year floodplain. However, the Project Site is within a DWR Awareness Floodplain and must comply with the Riverside County municipal code.

2. Both potential options shown on the 10% Site Plans for the O&M facility, substation, and BESS facilities are located in topographically high areas which are expected to receive minimal flow, which makes them feasible locations from a hydrology perspective.

3. The southern and southeastern portions of the Project Site are expected to receive flow depths up to 4-feet and flow velocities up to 4-fps from Basin 3 discharge during the 100-year, 3-hour storm event. The eastern-most location option for construction parking and a temporary laydown yard are shown in areas of potentially high flow. From a hydrology perspective, the other construction parking and temporary laydown yard locations are more viable. Solar arrays which are proposed in these areas should be designed with adequate freeboard.

4. Flow depths over 5-feet and flow velocities up to 4-fps can be expected in the braided drainage north of the Project Site emanating from Basin 1. Based on the 10% Site Plans a perimeter fence, access road, and solar array are adjacent to this drainage in three locations. Due to the proximity of potentially high flow depths and velocities, post-construction best management practices (BMPs) should be considered in these locations. Riprap is a potential BMP which could be applied to these locations to protect proposed infrastructure and armor it against erosion.

7 Impact Analysis

Methods of Analysis

Impacts with respect to hydrology and water quality are assessed by comparing conditions expected under the proposed Project to the existing environmental setting described in Section 2. The analysis considers impacts on hydrology, water quality, flooding, and groundwater resources in the context of broader issues and concerns affecting the region.

Thresholds of Significance

The significance criteria used to evaluate the Project impacts to hydrology and water quality are based on Appendix G of the CEQA Guidelines. According to Appendix G, a significant impact would occur if development of the proposed Project would do any of the following:

- Violate any water quality standards or waste discharge requirements or otherwise substantially degrade surface or ground water quality.
- Substantially decrease groundwater supplies or interfere substantially with groundwater recharge such that the project may impede sustainable groundwater management of the basin.
- Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river or through the addition of impervious surfaces, in a manner which would:
    - result in substantial erosion or siltation on or off site;
    - substantially increase the rate or amount of surface runoff in a manner which would result in flooding on- or offsite;
    - create or contribute runoff water which would exceed the capacity of existing or planned stormwater drainage systems or provide substantial additional sources of polluted runoff; or
    - impede or redirect flood flows.
- In flood hazard, tsunami, or seiche zones, risk release of pollutants due to project inundation.
- Conflict with or obstruct implementation of a water quality control plan or sustainable groundwater management plan.

Impacts and Applicant Proposed Measures

Impact HYD-1: Would the Project violate water quality standards or waste discharge requirements or degrade surface or ground water quality?

Construction and Decommissioning

The proposed Project would involve up to approximately 1,192 acres of soil disturbance. Per the 10% Site Plans, approximately 25,000 cubic yards of both cut and fill will be required to grade the Project Site. While Project Site preparation and grading is taking place, soil erosion may result in discharges of sediment-laden stormwater runoff downstream of the Project Site. Construction could temporarily concentrate flows from storms and construction water usage, thus resulting in increased sedimentation and erosion of existing soils. Ground disturbance in drainage areas has a higher likelihood of resulting in erosion and sedimentation because water flow is more concentrated in these areas and has greater erosive potential.

BMPs such as fiber rolls and gravel bag barriers will limit the increase in sedimentation/siltation from construction activities on the Project Site which could otherwise temporarily violate Colorado River Basin Plan objectives for sediment. Excessive sedimentation could impair the protection of the beneficial uses of downstream ephemeral washes discussed in Section 2.5. In addition to sediment, other pollutants associated with construction activity could include heavy metals, oil/grease, fuels, trash, and other pollutants from accidental spills or releases of refuse, paints, solvents, sanitary wastes, and concrete curing compounds. BMPs such as drip pans and proper waste management would be used during construction activities to reduce pollutant and/or t sediment mobilization to ensure compliance with Colorado River Basin Plan objectives and protection of beneficial uses.

A Stormwater Pollution Prevention Plan (SWPPP) or substantive equivalent would be prepared to address potential construction-related impacts on water quality. It will specify the location, type, and maintenance requirements for BMPs necessary to prevent stormwater runoff from carrying construction-related pollutants into downstream ephemeral washes. Minimum standard BMPs include erosion and sediment controls; site management/housekeeping/waste management; management of non-stormwater discharges; run-on and runoff controls; and BMP inspection, maintenance, and repair activities. The plan will also include a construction site monitoring program that identifies specific requirements for dry weather visual observations of pollutants at all discharge locations, and any additional measures, as appropriate.

SWPPPs prepared for the purpose of obtaining coverage under California's Construction Stormwater General Permit must be developed and implemented by a Construction General Permit Qualified SWPPP Developer (QSD)/Qualified SWPPP Practitioner (QSP). If a substantive equivalent is utilized it would be prepared by a qualified engineer or erosion control specialist.

The following list includes examples of treatment control BMPs which could be employed during construction of the Project (these features would appear as notes on any final design plans):

- Silt fences installed along limits of work and/or the construction site
- Stockpile containment (e.g., visqueen, fiber rolls, gravel bags)
- Street sweeping
- Runoff control devices (e.g., drainage swales, gravel bag barriers/chevrons, velocity check dams) and slope protection
- Wind erosion (dust) controls
- Tracking controls
- Prevention of fluid leaks (inspections and drip pans) from vehicles
- Materials pollution management

- Proper waste management (e.g., concrete waste management)
- Regular inspections and maintenance of BMPs

The applicant's erosion control plan should include the placement of fiber rolls around the perimeter of disturbed areas to filter out sediment, debris, and floatable material; use of hazardous material spill kits; and stabilized construction zone ingress/egress. These plans are to be further developed through preparation of a SWPPP or substantive equivalent.

The BMPs described above are sufficient to address the project's potential to violate water quality standards or waste discharge requirements. The construction-related impact of the Project on water quality would be less than significant because existing permitting requirements and conditions of approval are sufficient to avoid water quality degradation, meet water quality standards and Colorado River Basin Plan objectives, and prevent adverse effects on beneficial uses.

Operation

According to the Plan of Development, operation of the Project would require up to eight employees, the use of a 3,600-square-foot O&M building, and annual panel washing. If a septic system is needed, water quality should not be affected as long as the septic system is installed according to the County of Riverside Department of Environmental Health guidelines. Under these guidelines an onsite wastewater treatment system application must be filed which requires a soils percolation report and a detailed contour plot plan, among other documents. Operation of the facility is not anticipated to impact water quality.

Applicant Proposed Measures

- BMPs installed during SWPPP or substantive equivalent implementation

Impact HYD-2: Would the Project substantially decrease groundwater supplies or interfere substantially with groundwater recharge such that the Project may impede sustainable groundwater management of the basin?

This impact criterion is outside the scope of this report and is addressed in the project's Water Supply Assessment.

Impact HYD-3: Would the Project substantially alter the existing drainage pattern of the site or area through the addition of impervious surfaces resulting in erosion or siltation on- or off-site; increasing the rate or amount of surface runoff resulting in flooding on- or off-site; contributing runoff water which would exceed the capacity of existing or planned stormwater drainage systems or provide polluted runoff; or impede or redirect flood flows?

Construction could temporarily concentrate flows from storms and construction water usage, thus resulting in increased sedimentation and erosion of existing soils. Ground disturbance in drainage areas has a higher likelihood of resulting in erosion and sedimentation because water flow is more concentrated in these areas and has greater erosive potential. BMPs such as fiber rolls and silt fence should mitigate the temporary effects of erosion and sedimentation during construction.

In general, modeling has shown that solar panels themselves do not have a significant impact on runoff volumes, peaks, or time to peak if ground cover or imperviousness is not impacted (Cook and McCuen 2013). However, the energy of the flow that drains from the panels may be greater than that of rainfall, which could increase erosion at the base of the panels (Cook and McCuen 2013), though this impact is expected to be minimal.

Much of the existing underlying soil will be undisturbed because the solar arrays and gen-tie lines are elevated from the surface. No proposed drainage structures, channels, or underground piping infrastructure will be constructed as part of the Project. The cut and fill proposed in the 10% Site Plan is intended to smooth the topography and not significantly alter the drainage course. Road crowns will follow existing ground grades, but grading may locally alter the drainage patterns. Depressions and natural channels that may pose a risk of concentrated flows will be graded to mitigate scour within the solar array. As it does in the existing condition, drainage paths will continue to flow generally from west to east in the proposed condition. As discussed in Section 4, the additional impervious area comprises a small fraction of the contributing watershed and downstream peak flows will not increase. The Project's impact to surface hydrology (as it would affect erosion, siltation, runoff, or flooding) would be less-than-significant.

Applicant Proposed Measures

- BMPs installed during SWPPP or substantive equivalent implementation

Impact HYD-4: Would the Project release pollutants during flooding?

During the construction and decommissioning phase pollutants will be disposed of properly in accordance with the Waste Management Plan. During Project operation several hazardous materials are anticipated to be used, including petroleum, hydraulic fluid, water treatment chemicals, oily rags, and spent batteries. These materials are to be handled and disposed of in accordance with the Hazardous Materials Business Plan.

The Project Site is within a DWR Awareness Floodplain but is located in an area of minimal flood hazard outside of the FEMA 500-year floodplain and unlikely to be subject to catastrophic flooding as described in section 2.2. The Project Site is located well inland and far from the ocean and any enclosed or semi-enclosed water body such that there would be no potential threat from tsunami or seiche hazards.

Prior to mitigation, the potential for release of pollutants due to Project inundation would be less than significant and is further reduced with implementation of a Waste Management Plan and Hazardous Materials Business plan,

Applicant Proposed Measures

- Waste Management Plan
- Hazardous Materials Business Plan

Impact HYD-5: Would the Project conflict with or obstruct implementation of a water quality control plan or sustainable groundwater management plan?

This impact criterion is outside the scope of this report and is addressed in the project's Water Supply Assessment.

8 References

Cook, Lauren M. and McCune, Richard H. 2013. Hydrologic Response of Solar Farms. September 2022.

CADFG (California Department of Fish and Game). 2010. A Review of Stream Processes and Forms in Dryland Watersheds. December 2010.

DWR (Department of Water Resources). 2004. Chuckwalla Valley Groundwater Basin. California's Groundwater Bulletin 118. Last updated February 27, 2004.

DWR (Department of Water Resources). 2022. Best Available Map Online Viewer. https://gis.bam.water.ca.gov/bam/. Accessed September 2022.

East, A.E., Gray, H.J., Redsteer, M.H., and Ballmer, M., 2021, Landscape evolution in eastern Chuckwalla Valley, Riverside County, California: U.S. Geological Survey Scientific Investigations Report 2021–5017, 46 p., https://doi.org/10.3133/sir20215017.

FEMA (Federal Emergency Management Agency). 2022. FEMA Flood Map Service Center. https://msc.fema.gov/portal/search. Accessed September 2022.

Ironwood Consulting. 2022. Biological Resources Technical Report. September 2022.

National Land Cover Database (NCLD). 2019. MRLC NLCD Viewer, 2019 CONUS Land Cover. Accessed September 2022. https://www.mrlc.gov/viewer/

NOAA. 2022. NOAA Atlas 14 Point Precipitation Frequency Estimates: CA. Accessed September 13, 2022. https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html

Riverside County. 2015. General Plan. Revised December 8, 2015.

Riverside County Flood Control and Water Conservation District (RCFCWCD). 1978. Hydrology Manual. April 1978.

Riverside County Flood Control and Water Conservation District (RCFCWCD). 2016. HEC-HMS Preprocessor User Manual and HEC-HMS Guidance Document. Version 1.0; July 2016.

Riverside County Flood Control and Water Conservation District (RCFCWCD). 2023. Floodplain Map Application. Accessed February 2023. https://content.rcflood.org/floodplainmap/

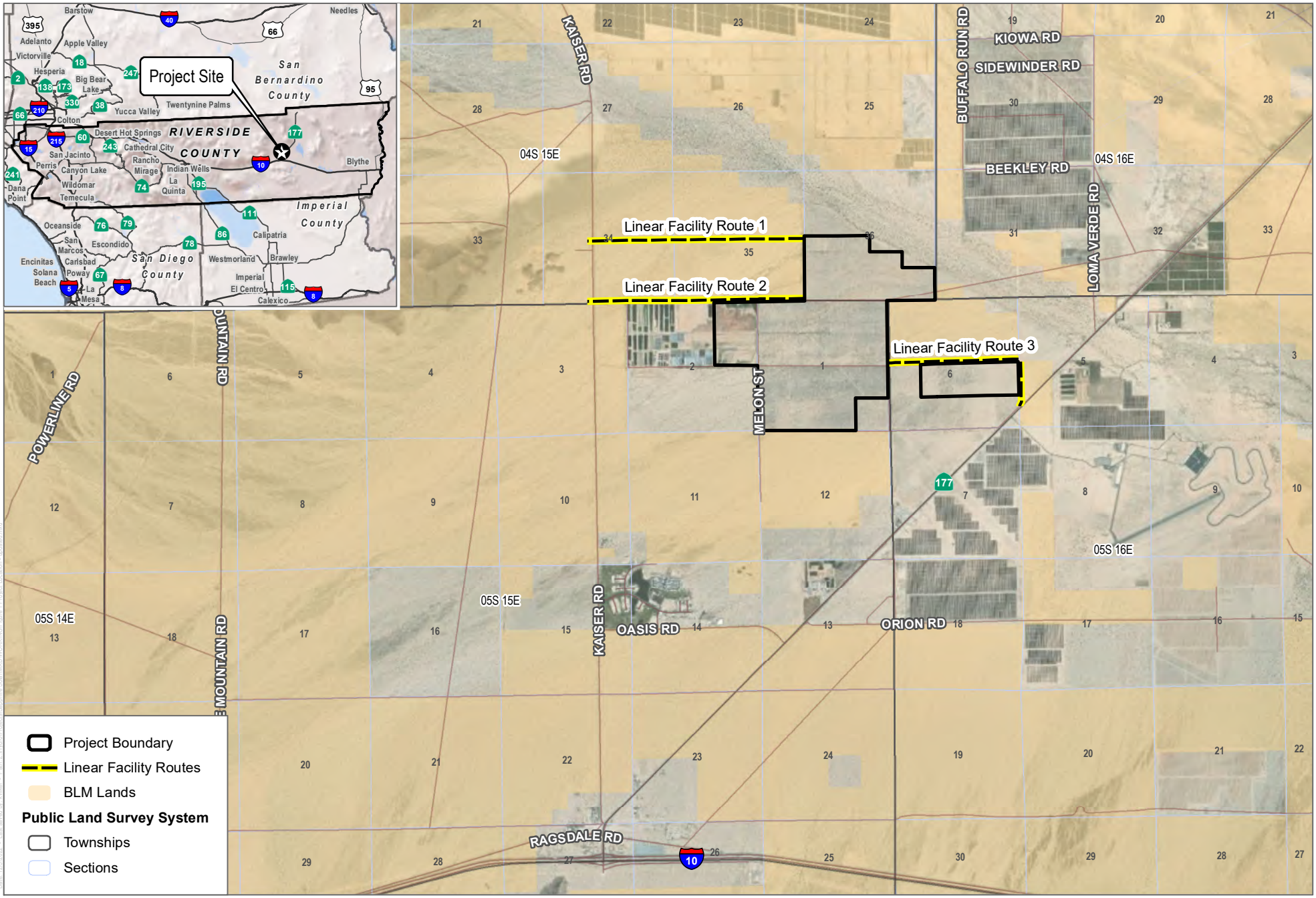
SWRCB (State Water Resources Control Board). 2019. Water Quality Control Plan for the Colorado River Basin Region. Amended on January 8, 2019.

United States Department of Agriculture (USDA). 2022. Natural Resources Conservation Service, Web Soil Survey. Accessed September 2022. https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx

USGS. 2022. "National Hydrography Dataset: GIS Online viewer." Accessed September 2022. https://www.usgs.gov/core-science-systems/ngp/national-hydrography.

USFWS. 2022. "The National Wetlands Inventory." Accessed September 2022. fws.gov/wetlands/NWI/index.html.

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SOURCE: Esri World Imagery Basemap (accessed 2022); County of Riverside 2022; CALFIRE 2022

DUDEK

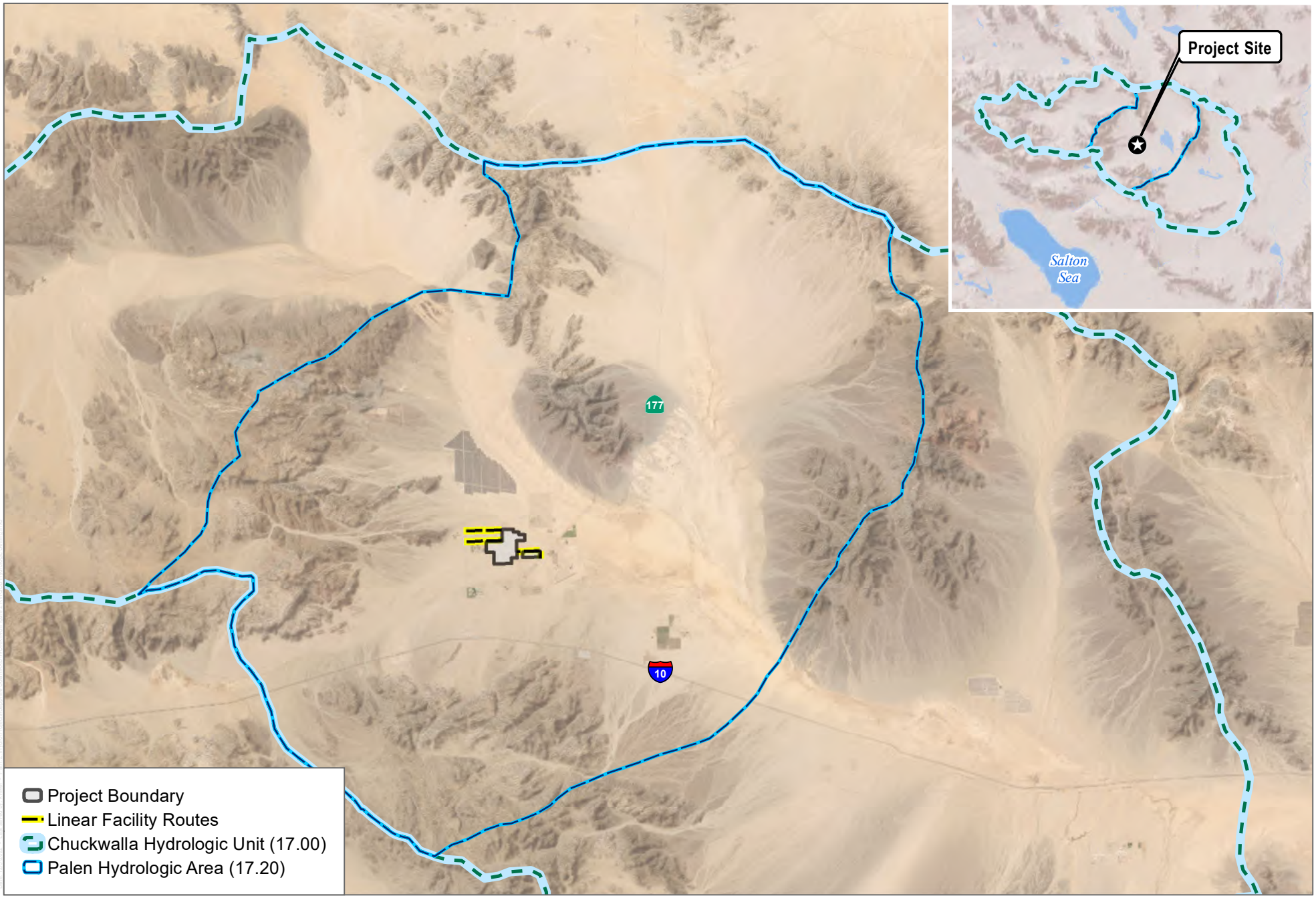
0 0.5 1 Miles

FIGURE 1

Project Location

Sapphire Solar Project

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SOURCE: Esri World Imagery Basemap; SWRQCB

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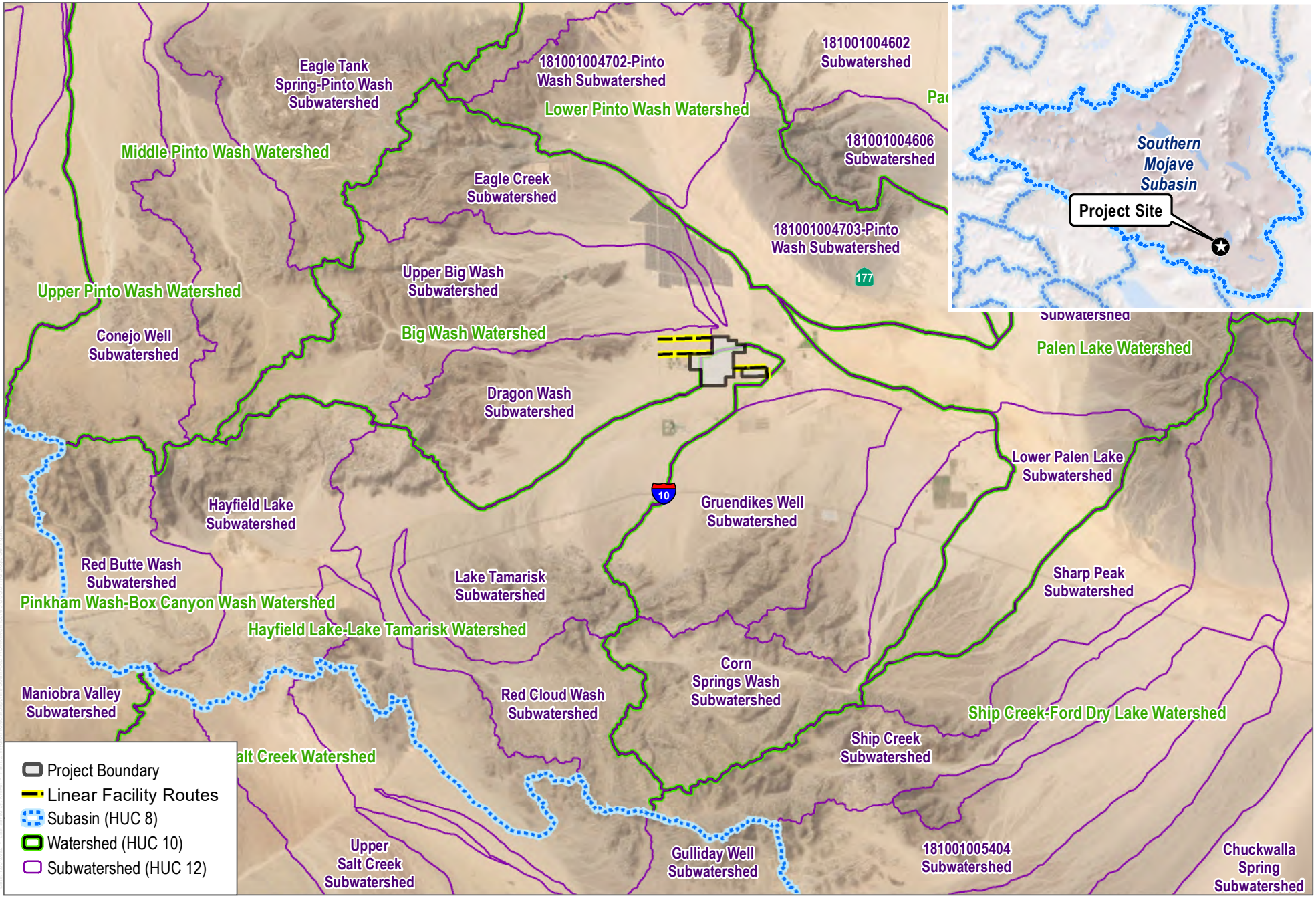
0 2.5 5 Miles

FIGURE 2

RWQCB Hydrologic Setting

Sapphire Solar Project

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SOURCE: Esri World Imagery Basemap; USGS NHD 2022

DUDEK

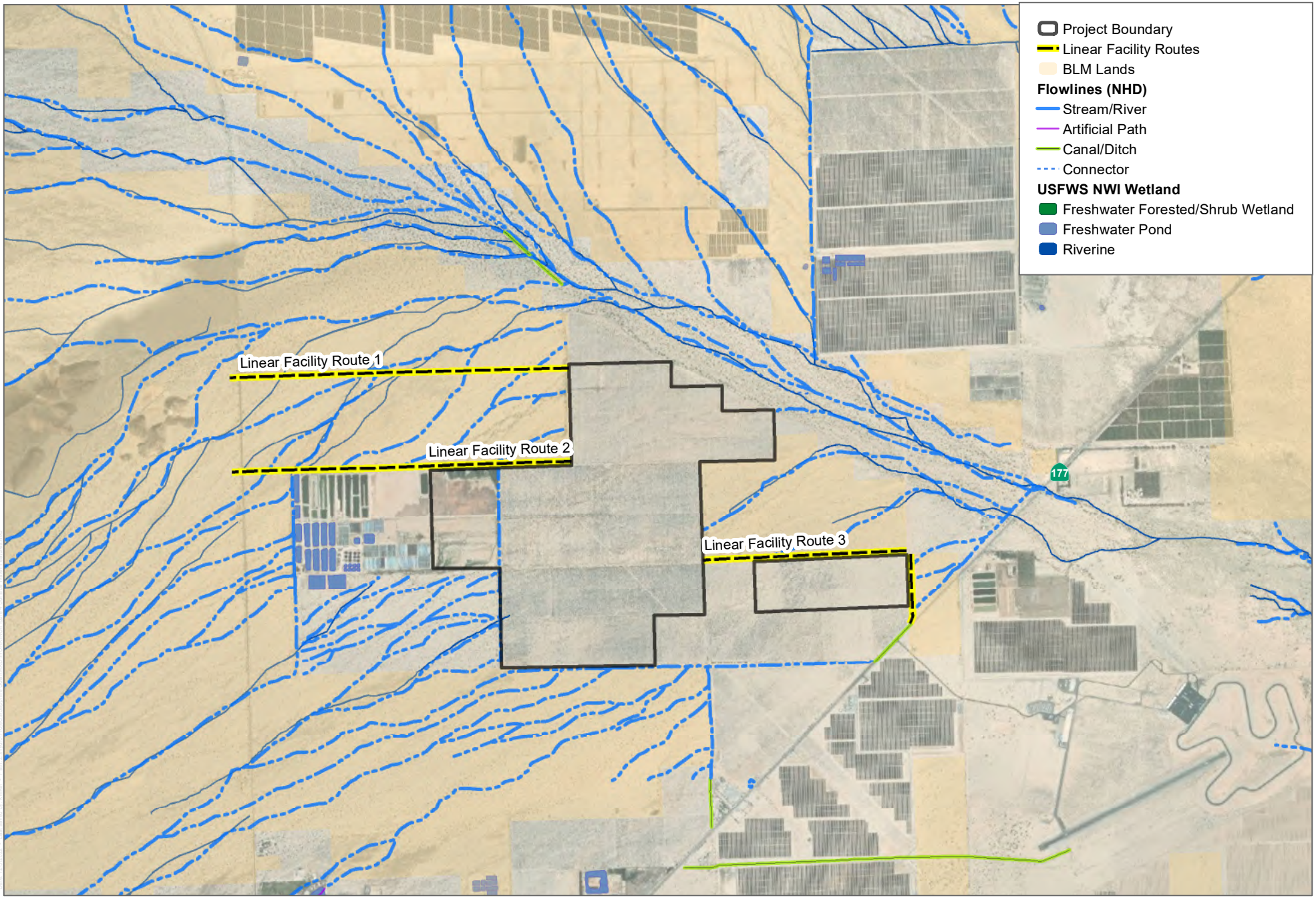
0 1.75 3.5 Miles

FIGURE 3

USGS Hydrologic Setting

Sapphire Solar Project

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SOURCE: Esri World Imagery Basemap; USGS NHD 2022; USFWS 2022

DUDEK

0 0.5 1 Miles

FIGURE 4

Surface Water Features

Sapphire Solar Project

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SOURCE: Esri World Imagery Basemap; SWRQCB

DUDEK

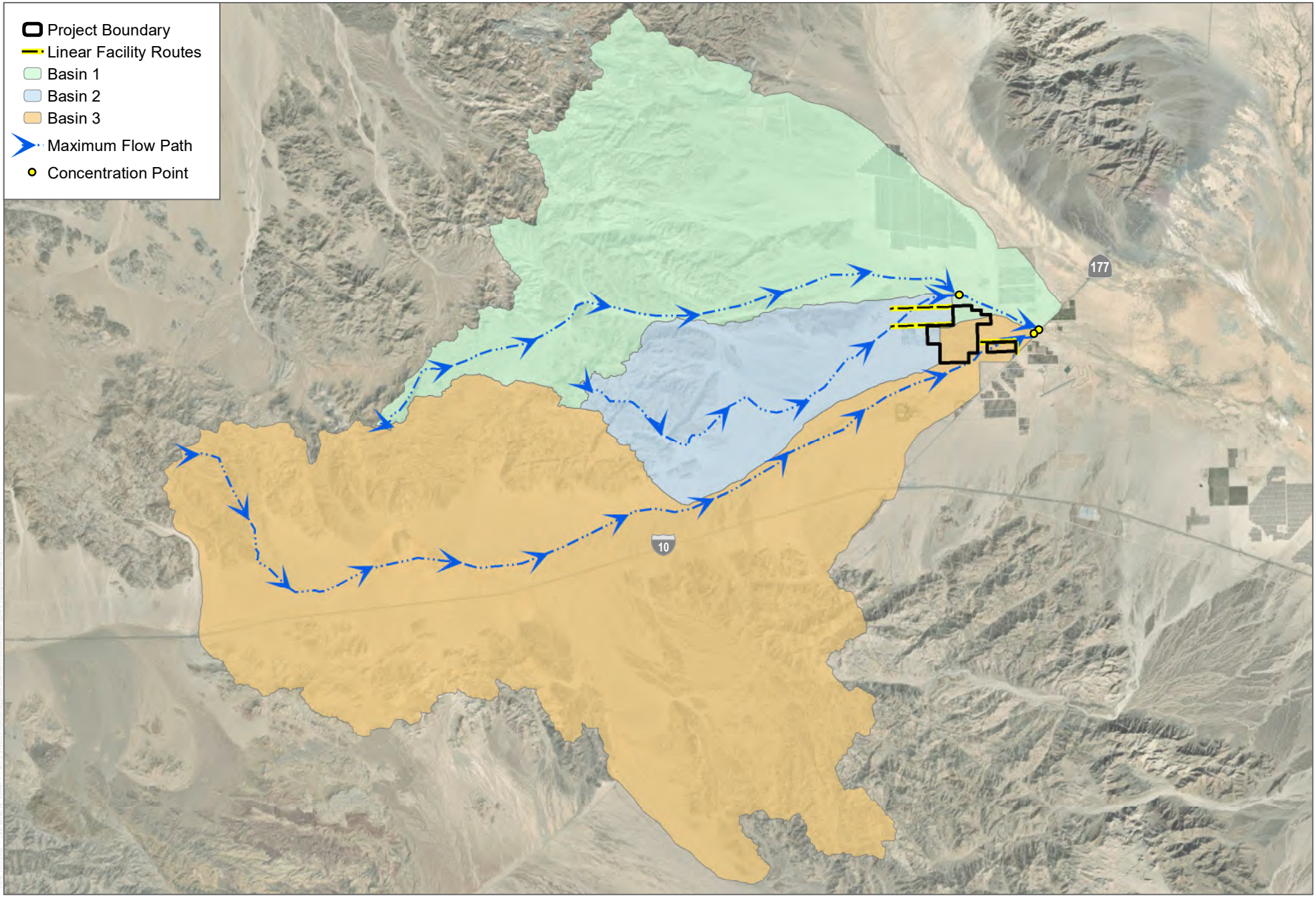
0 3 6 Miles

FIGURE 5

Groundwater Basin Setting

Sapphire Solar Project

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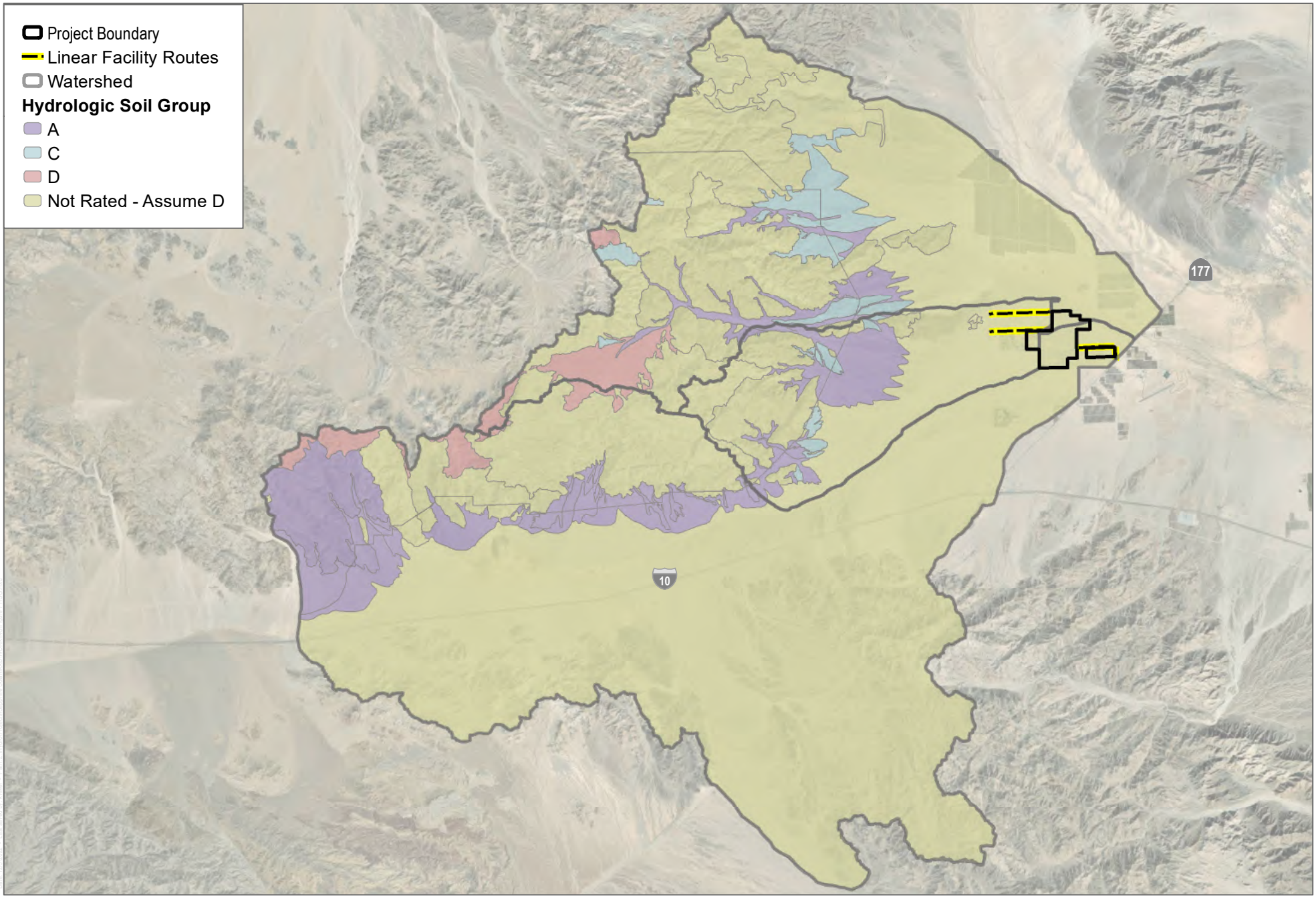
SOURCE: Esri World Imagery Basemap; Riverside County

DUDEK

0 1.5 3 Miles

FIGURE 6
Topographic Setting
Sapphire Solar Project

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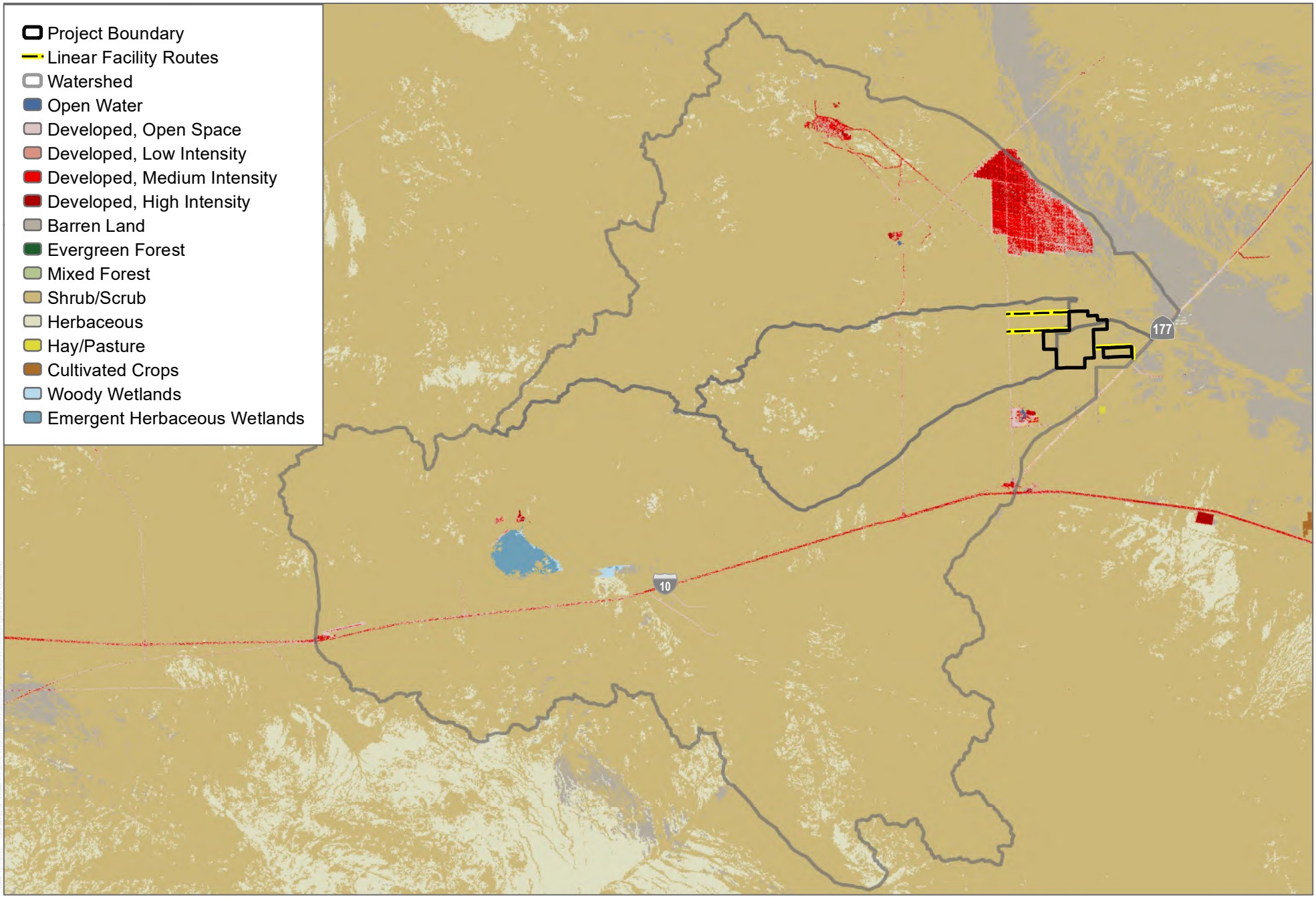
SOURCE: Esri World Imagery Basemap; USGS 2022

DUDEK

0 1.5 3 Miles

FIGURE 7
Hydrologic Soil Group
Sapphire Solar Project

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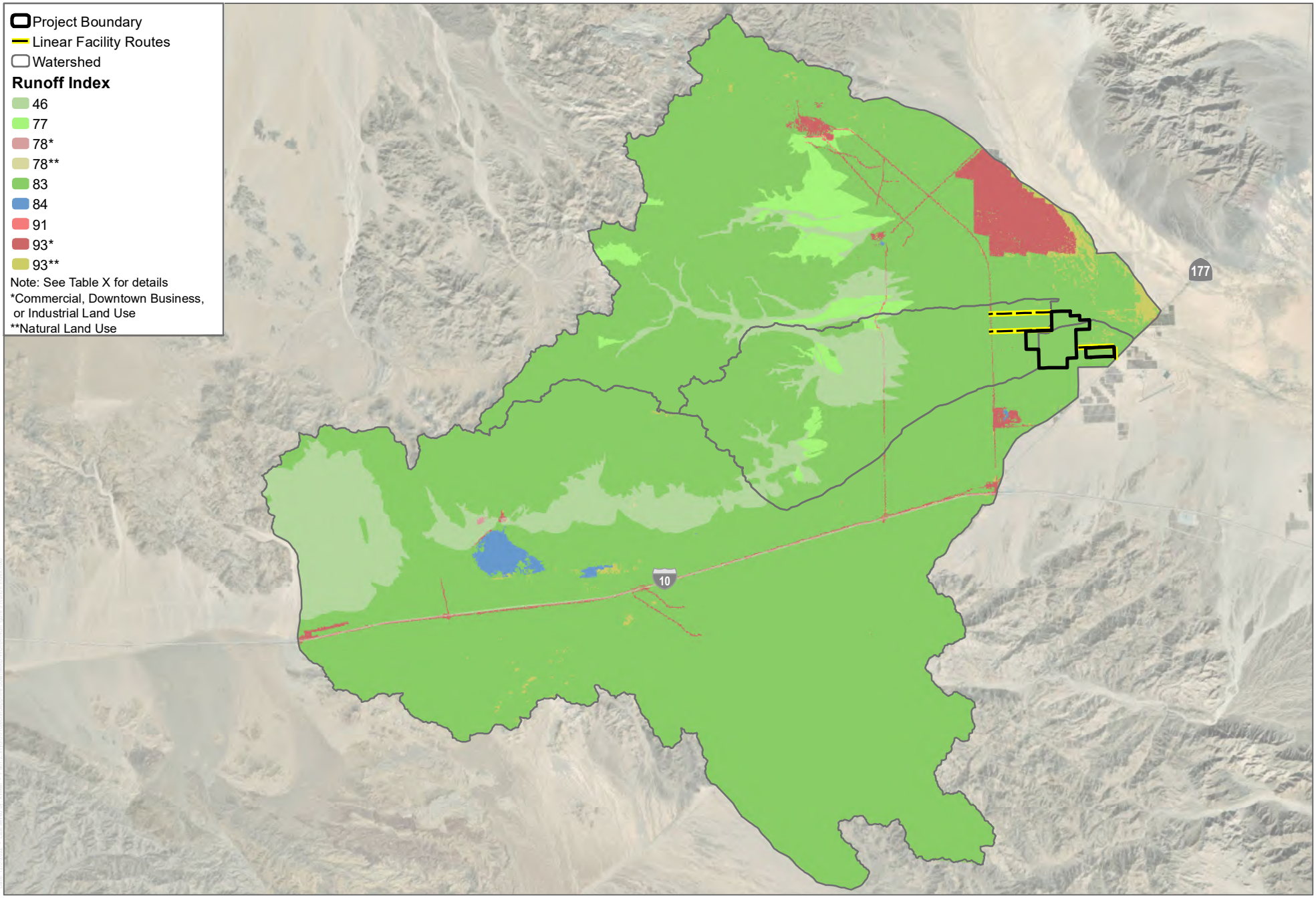
SOURCE: Esri World Imagery Basemap; NLCD 2022

DUDEK

0 1.5 3 Miles

FIGURE 8
Land Cover
Sapphire Solar Project

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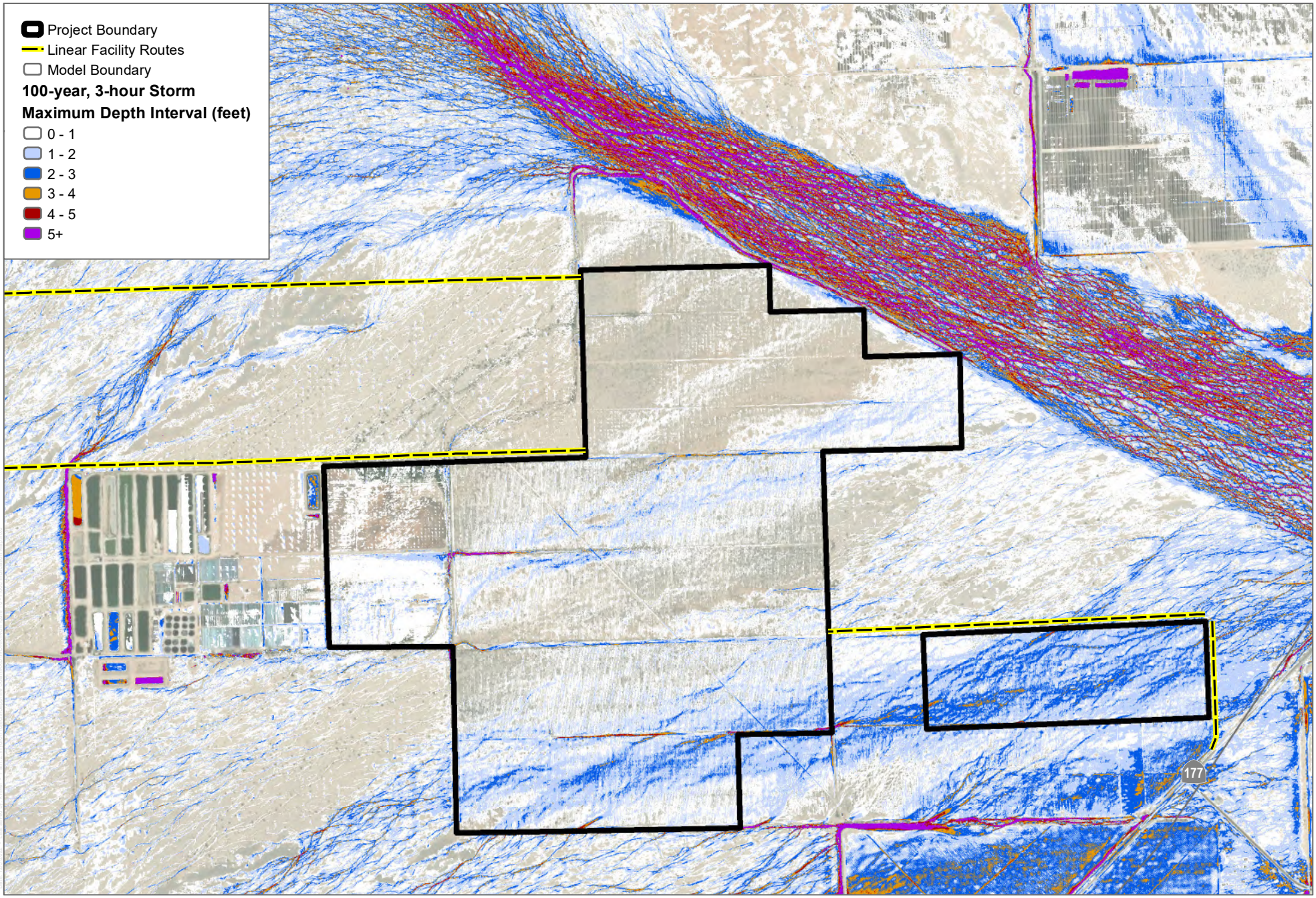
SOURCE: Esri World Imagery Basemap; Riverside County

DUDEK

0 1.5 3 Miles

FIGURE 9
Runoff Index
Sapphire Solar Project

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SOURCE: Esri World Imagery Basemap

DUDEK

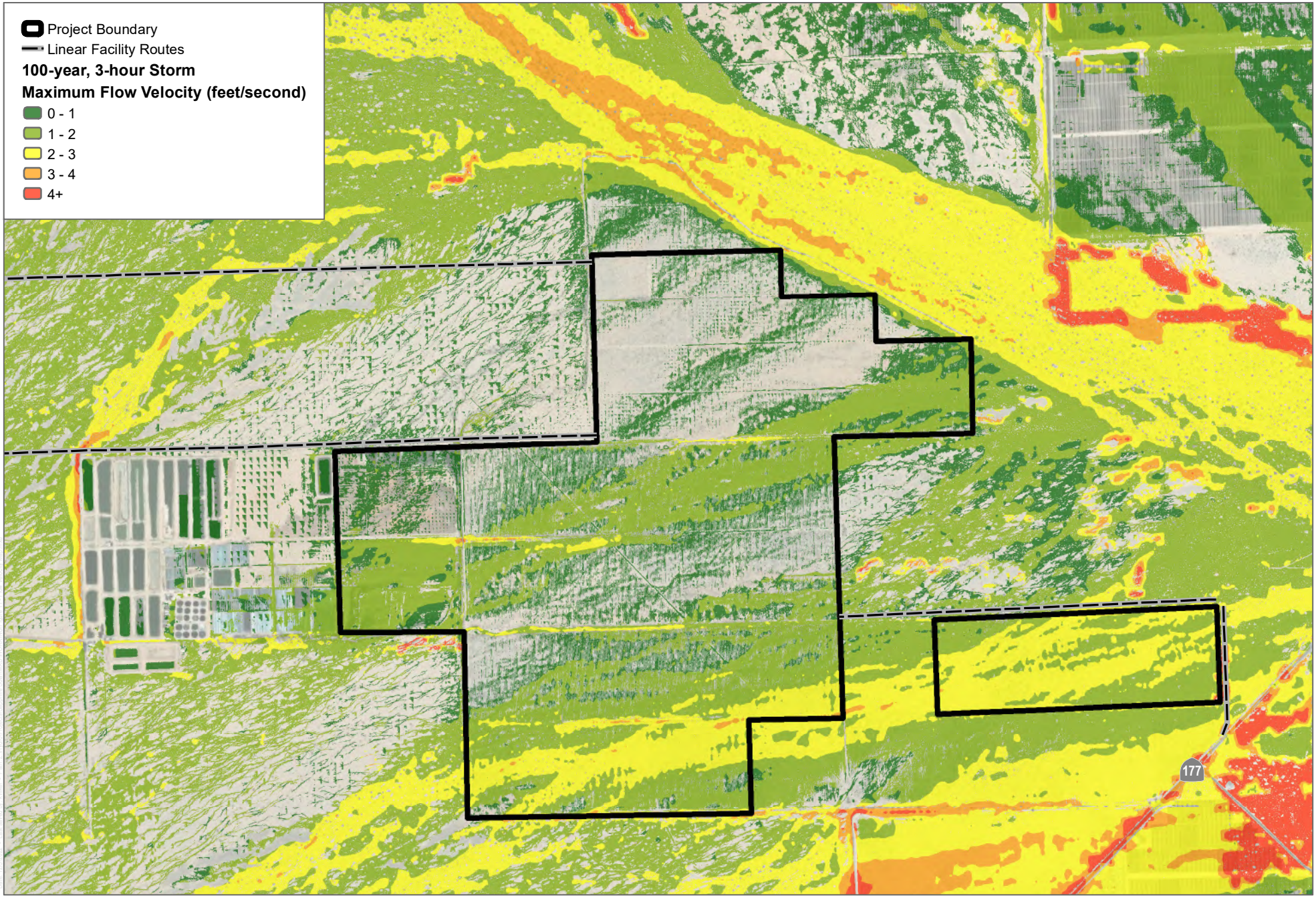
0 0.25 0.5 Miles

FIGURE 10

Flood Inundation Map

Sapphire Solar Project

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SOURCE: Esri World Imagery Basemap

DUDEK

0 0.25 0.5 Miles

FIGURE 11

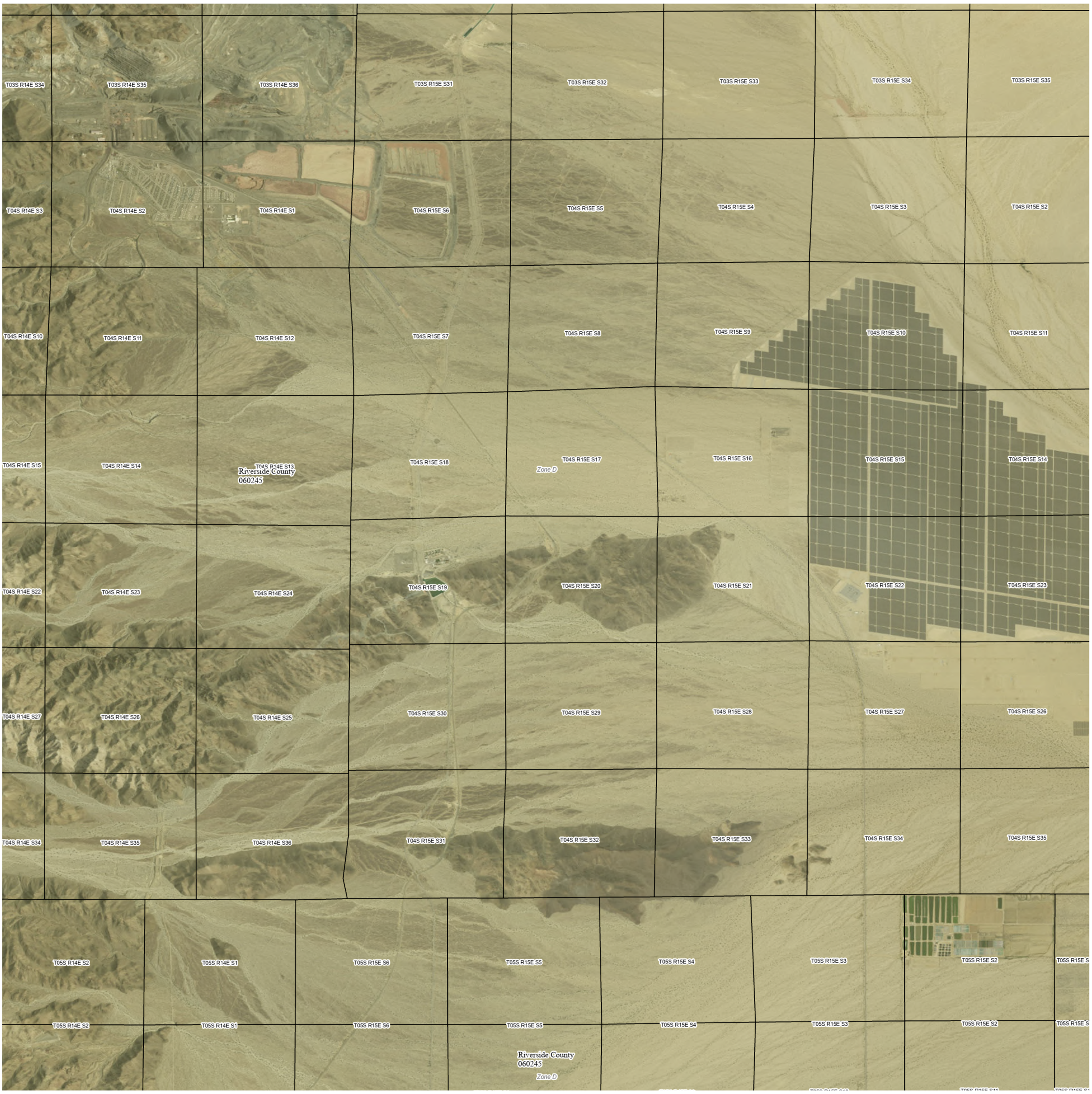
Flow Velocity Map

Sapphire Solar Project

Appendix A

FEMA Flood Insurance Rate Map

115°30'1.75"W 33°52'56.37"N



115°22'28.33"W 33°44'33.66"N

FLOOD HAZARD INFORMATION

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR DRAFT FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS

- Without Base Flood Elevation (BFE) *Zone A, V, A99*
- With BFE or Depth *Zone AE, AO, AH, VE, AR*
- Regulatory Floodway

OTHER AREAS OF FLOOD HAZARD

- 0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
- Future Conditions 1% Annual Chance Flood Hazard *Zone X*
- Area with Reduced Flood Risk due to Levee See Notes *Zone X*
- Area with Flood Risk due to Levee *Zone D*

OTHER AREAS

- NO SCREEN Area of Minimal Flood Hazard *Zone X*
- Effective LOMRs
- Area of Undetermined Flood Hazard *Zone D*

GENERAL STRUCTURES

- Channel, Culvert, or Storm Sewer
- Levee, Dike, or Floodwall

OTHER FEATURES

- 20.2 Cross Sections with 1% Annual Chance
- 17.5 Water Surface Elevation
- Coastal Transect
- Coastal Transect Baseline
- Profile Baseline
- Hydrographic Feature
- 513 Base Flood Elevation Line (BFE)
- Limit of Study
- Jurisdiction Boundary

NOTES TO USERS

For information and questions about this Flood Insurance Rate Map (FIRM), available products associated with this FIRM, including historic versions, the current map date for each FIRM panel, how to order products, or the National Flood Insurance Program (NFIP) in general, please call the FEMA Map Information eXchange at 1-877-FEMA-MAP (1-877-336-2627) or visit the FEMA Flood Map Service Center website at https://msc.fema.gov. Available products may include previously issued Letters of Map Change, a Flood Insurance Study Report, and/or digital versions of this map. Many of these products can be ordered or obtained directly from the website.

Communities annexing land on adjacent FIRM panels must obtain a current copy of the adjacent panel as well as the current FIRM Index. These may be ordered directly from the Flood Map Service Center at the number listed above.

For community and countywide map dates, refer to the Flood Insurance Study Report for this jurisdiction.

To determine if flood insurance is available in this community, contact your Insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

Basemap information shown on this FIRM was provided in digital format by the United States Geological Survey (USGS). The basemap shown is the USGS National Map: Orthoimagery. Last refreshed October, 2020.

This map was exported from FEMA's National Flood Hazard Layer (NFHL) on **9/8/2022 7:03 PM** and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time. For additional information, please see the Flood Hazard Mapping Updates Overview Fact Sheet at https://www.fema.gov/media-library/assets/documents/118418

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards. This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date.

SCALE

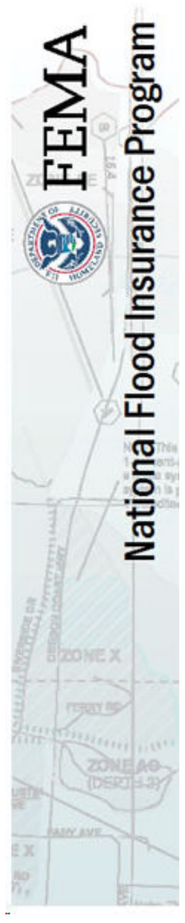
Map Projection:
GCS, Geodetic Reference System 1980;
Vertical Datum: No elevation features on this FIRM
For information about the specific vertical datum for elevation features, datum conversions, or vertical monuments used to create this map, please see the Flood Insurance Study (FIS) Report for your community at https://msc.fema.gov

N

1 inch = 2,000 feet 1:24,000

0 1,000 2,000 4,000 6,000 8,000 Feet

0 210 420 840 1,260 1,680 Meters



NATIONAL FLOOD INSURANCE PROGRAM

FLOOD INSURANCE RATE MAP

PANEL 1800 OF 3805

Panel Contains:

COMMUNITY	NUMBER	PANEL
RIVERSIDE COUNTY	060245	1800

MAP NUMBER
06065C1800G
EFFECTIVE DATE
August 28, 2008

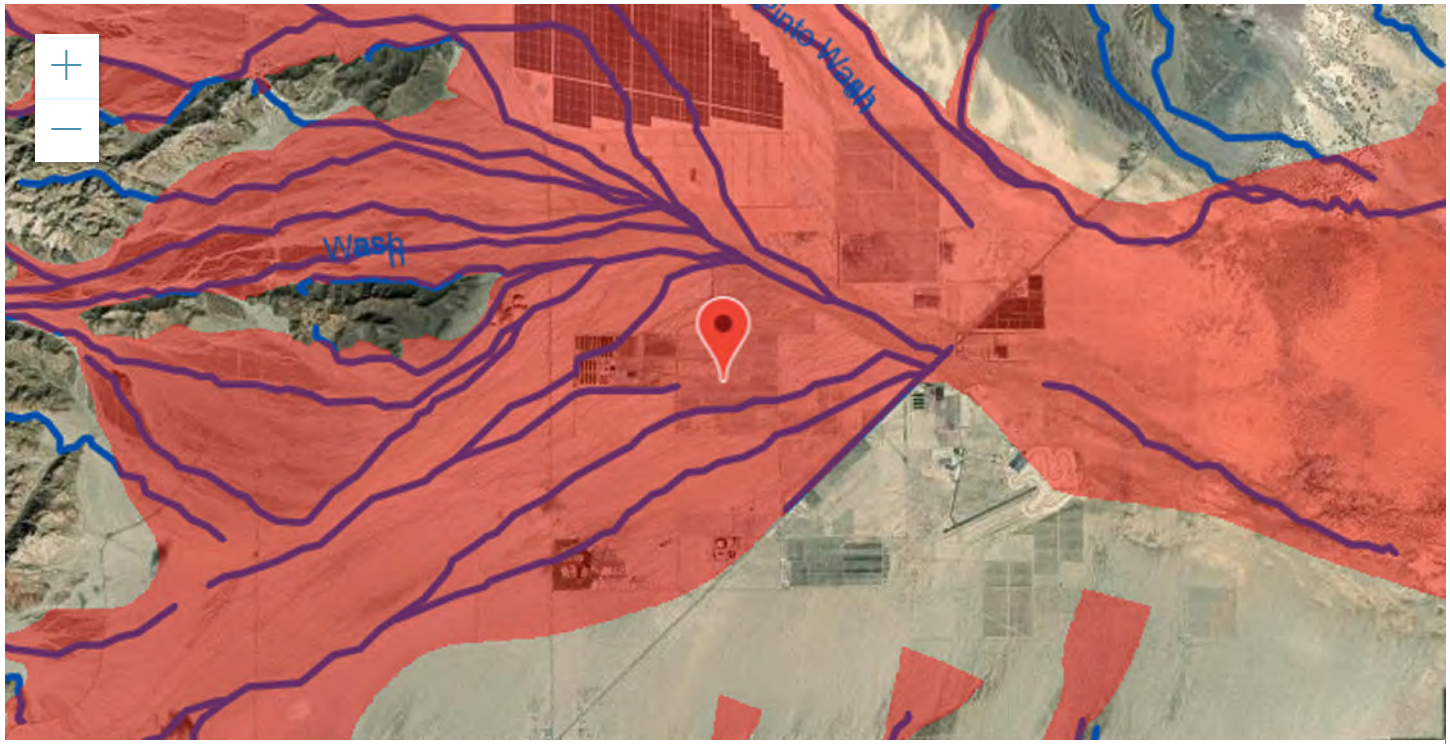
Appendix B

California Department of Water Resources
Floodplain Information

CALIFORNIA DEPARTMENT OF
WATER RESOURCES

Floodplain Information

Latitude: 33.73892, Longitude: -115.47796



County: Riverside (33.73892, -115.47796)

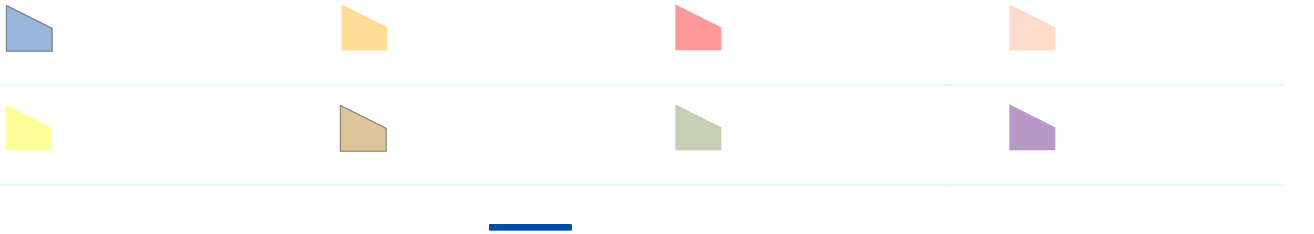
Floodplain Layer	100-YR	200-YR	500-YR

Y: The location is within the floodplain

FEMA Effective	N✓	N/A	N✓
DWR Awareness	Y✓	N/A	N/A
Regional/Special Studies	N✓	N/A	N✓
USACE Comp. Study	N✓	N✓	N✓

N: The location is not within the floodplain
N/A: Data not available
✓ = Active Layer(s)

Floodplains are displayed using semi transparent colors. When viewing overlapping floodplains, the combination of multiple semi transparent colors will not match the legend colors. For accurate color representation, view floodplains individually.



Appendix C
NOAA Rainfall Data

NOAA Atlas 14, Volume 6, Version 2
Location name: Desert Center, California, USA*
Latitude: 33.7644°, Longitude: -115.368°
Elevation: 614.36 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sarah Dietz, Sarah Heim, Lillian Hiner, Kazungu Maitaria, Deborah Martin, Sandra Pavlovic, Ishani Roy, Carl Trypaluk, Dale Unruh, Fenglin Yan, Michael Yekta, Tan Zhao, Geoffrey Bonnin, Daniel Brewer, Li-Chuan Chen, Tye Parzybok, John Yarchoan

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**0.080** (0.067-0.097)	**0.127** (0.105-0.154)	**0.191** (0.159-0.233)	**0.247** (0.203-0.303)	**0.327** (0.261-0.416)	**0.394** (0.307-0.511)	**0.466** (0.354-0.619)	**0.544** (0.402-0.744)	**0.659** (0.467-0.939)	**0.754** (0.516-1.11)
10-min	**0.115** (0.096-0.140)	**0.181** (0.151-0.220)	**0.274** (0.227-0.333)	**0.354** (0.291-0.434)	**0.469** (0.373-0.596)	**0.565** (0.440-0.732)	**0.667** (0.507-0.887)	**0.780** (0.576-1.07)	**0.944** (0.669-1.35)	**1.08** (0.740-1.60)
15-min	**0.139** (0.116-0.169)	**0.219** (0.183-0.266)	**0.331** (0.275-0.403)	**0.428** (0.352-0.525)	**0.568** (0.452-0.720)	**0.683** (0.532-0.885)	**0.807** (0.614-1.07)	**0.943** (0.697-1.29)	**1.14** (0.809-1.63)	**1.31** (0.895-1.93)
30-min	**0.194** (0.162-0.236)	**0.306** (0.255-0.372)	**0.462** (0.383-0.563)	**0.596** (0.491-0.732)	**0.792** (0.630-1.00)	**0.953** (0.742-1.24)	**1.13** (0.856-1.50)	**1.32** (0.972-1.80)	**1.59** (1.13-2.27)	**1.82** (1.25-2.69)
60-min	**0.262** (0.219-0.318)	**0.413** (0.344-0.501)	**0.624** (0.517-0.759)	**0.805** (0.662-0.988)	**1.07** (0.850-1.36)	**1.29** (1.00-1.67)	**1.52** (1.16-2.02)	**1.78** (1.31-2.43)	**2.15** (1.52-3.06)	**2.46** (1.69-3.63)
2-hr	**0.345** (0.287-0.418)	**0.524** (0.436-0.636)	**0.776** (0.644-0.945)	**0.997** (0.820-1.22)	**1.32** (1.05-1.68)	**1.59** (1.24-2.06)	**1.89** (1.43-2.51)	**2.21** (1.63-3.02)	**2.69** (1.91-3.84)	**3.10** (2.12-4.57)
3-hr	**0.395** (0.329-0.479)	**0.592** (0.492-0.718)	**0.871** (0.723-1.06)	**1.12** (0.919-1.37)	**1.48** (1.18-1.88)	**1.79** (1.39-2.32)	**2.12** (1.61-2.82)	**2.49** (1.84-3.40)	**3.04** (2.15-4.33)	**3.51** (2.40-5.18)
6-hr	**0.482** (0.401-0.584)	**0.717** (0.596-0.870)	**1.05** (0.873-1.28)	**1.35** (1.11-1.66)	**1.79** (1.42-2.27)	**2.16** (1.68-2.80)	**2.56** (1.95-3.41)	**3.02** (2.23-4.13)	**3.70** (2.62-5.27)	**4.28** (2.93-6.31)
12-hr	**0.561** (0.468-0.681)	**0.849** (0.706-1.03)	**1.26** (1.04-1.53)	**1.62** (1.33-1.98)	**2.15** (1.71-2.73)	**2.59** (2.02-3.36)	**3.08** (2.34-4.09)	**3.61** (2.67-4.94)	**4.41** (3.13-6.29)	**5.09** (3.48-7.51)
24-hr	**0.720** (0.637-0.831)	**1.11** (0.983-1.28)	**1.66** (1.47-1.93)	**2.15** (1.88-2.50)	**2.86** (2.42-3.44)	**3.44** (2.86-4.23)	**4.08** (3.32-5.13)	**4.79** (3.78-6.17)	**5.82** (4.42-7.81)	**6.69** (4.92-9.27)
2-day	**0.836** (0.740-0.964)	**1.30** (1.15-1.50)	**1.96** (1.73-2.27)	**2.53** (2.22-2.96)	**3.37** (2.86-4.06)	**4.06** (3.38-4.99)	**4.81** (3.91-6.04)	**5.63** (4.45-7.26)	**6.83** (5.19-9.16)	**7.83** (5.76-10.9)
3-day	**0.888** (0.786-1.02)	**1.39** (1.23-1.60)	**2.09** (1.85-2.42)	**2.71** (2.37-3.16)	**3.60** (3.05-4.33)	**4.34** (3.60-5.32)	**5.13** (4.17-6.45)	**6.01** (4.75-7.75)	**7.28** (5.54-9.78)	**8.35** (6.15-11.6)
4-day	**0.942** (0.834-1.09)	**1.47** (1.30-1.70)	**2.21** (1.95-2.56)	**2.86** (2.50-3.33)	**3.80** (3.22-4.58)	**4.58** (3.81-5.63)	**5.43** (4.41-6.82)	**6.35** (5.03-8.20)	**7.71** (5.86-10.3)	**8.84** (6.51-12.3)
7-day	**0.992**	**1.53**	**2.29**	**2.96**	**3.94**	**4.75**	**5.63**	**6.60**	**8.03**	**9.22**

	(0.878-1.14)	(1.35-1.77)	(2.02-2.65)	(2.59-3.45)	(3.34-4.74)	(3.95-5.83)	(4.57-7.08)	(5.22-8.52)	(6.11-10.8)	(6.79-12.8)
10-day	**1.02** (0.902-1.18)	**1.56** (1.38-1.81)	**2.34** (2.06-2.71)	**3.02** (2.64-3.52)	**4.01** (3.40-4.83)	**4.84** (4.03-5.95)	**5.75** (4.67-7.22)	**6.74** (5.33-8.70)	**8.20** (6.24-11.0)	**9.43** (6.94-13.1)
20-day	**1.11** (0.981-1.28)	**1.70** (1.51-1.97)	**2.55** (2.24-2.95)	**3.28** (2.87-3.83)	**4.36** (3.70-5.25)	**5.26** (4.37-6.46)	**6.23** (5.06-7.83)	**7.30** (5.77-9.42)	**8.86** (6.73-11.9)	**10.2** (7.47-14.1)
30-day	**1.18** (1.04-1.36)	**1.83** (1.62-2.11)	**2.75** (2.42-3.18)	**3.55** (3.10-4.14)	**4.72** (4.00-5.68)	**5.68** (4.72-6.97)	**6.72** (5.46-8.44)	**7.85** (6.21-10.1)	**9.48** (7.21-12.7)	**10.8** (7.97-15.0)
45-day	**1.25** (1.10-1.44)	**1.97** (1.74-2.28)	**3.00** (2.64-3.47)	**3.88** (3.40-4.53)	**5.18** (4.39-6.23)	**6.24** (5.19-7.66)	**7.37** (5.98-9.26)	**8.58** (6.79-11.1)	**10.3** (7.85-13.9)	**11.7** (8.64-16.3)
60-day	**1.34** (1.18-1.54)	**2.15** (1.90-2.48)	**3.29** (2.90-3.81)	**4.27** (3.74-4.99)	**5.70** (4.83-6.86)	**6.86** (5.70-8.42)	**8.09** (6.57-10.2)	**9.40** (7.43-12.1)	**11.3** (8.56-15.1)	**12.8** (9.39-17.7)

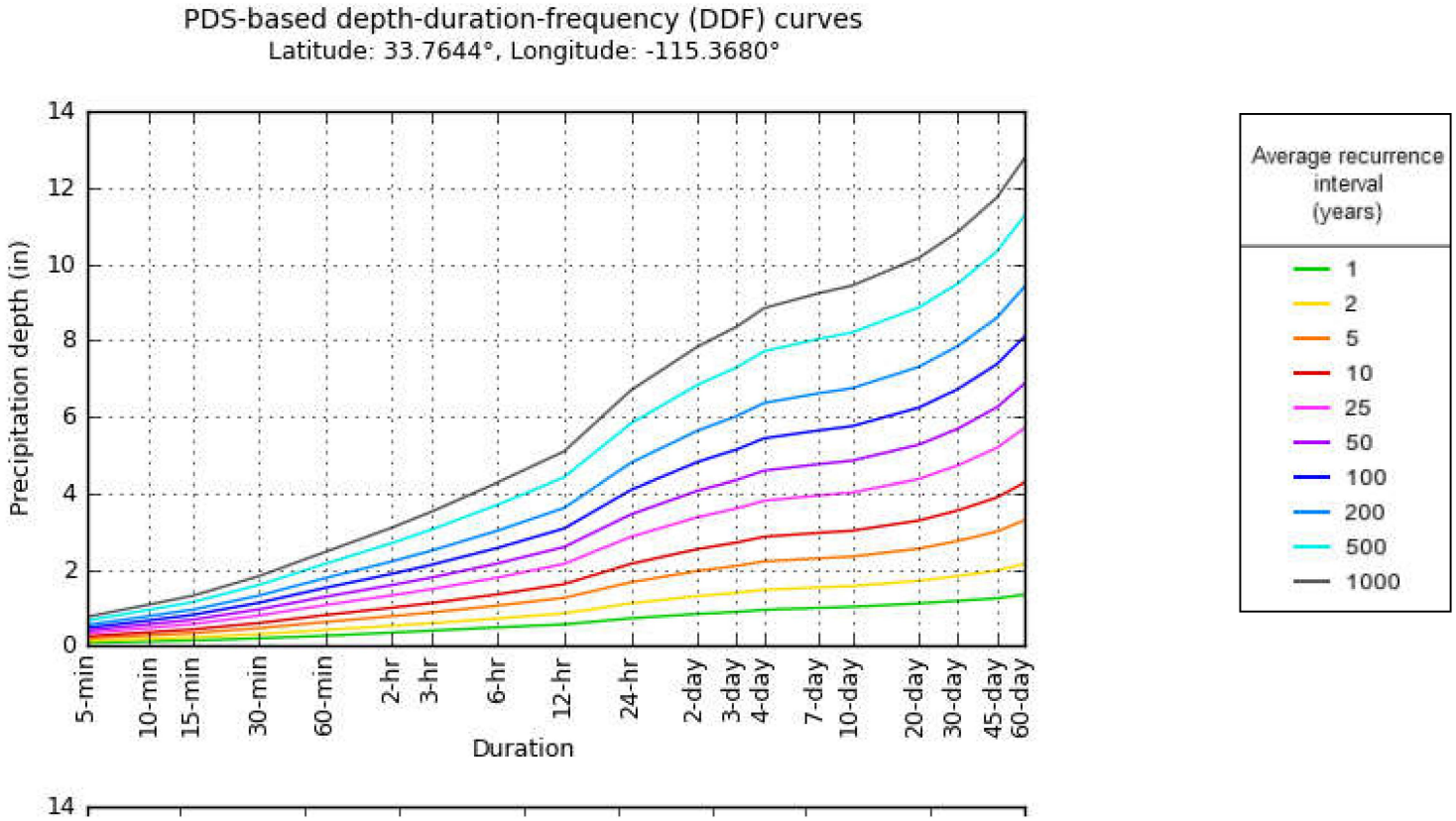
[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

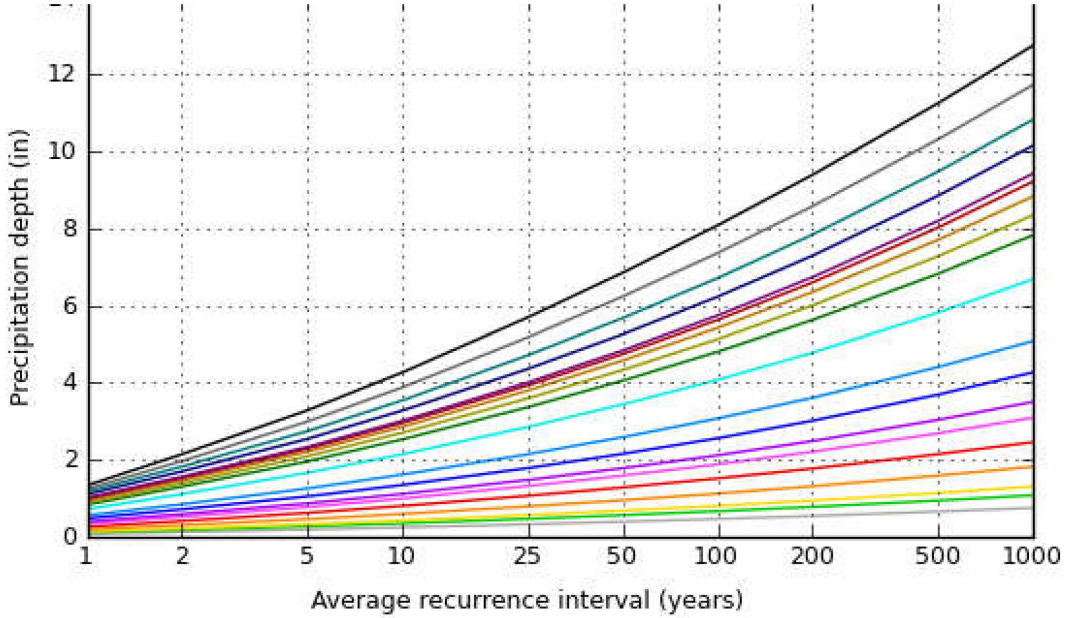
Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

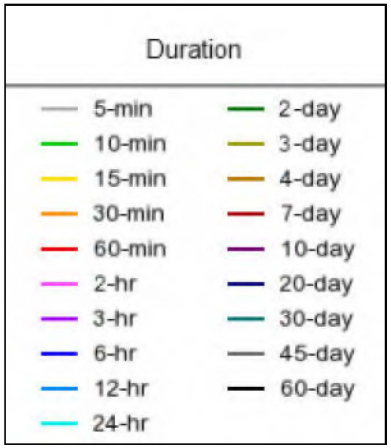
Please refer to NOAA Atlas 14 document for more information.

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PF graphical







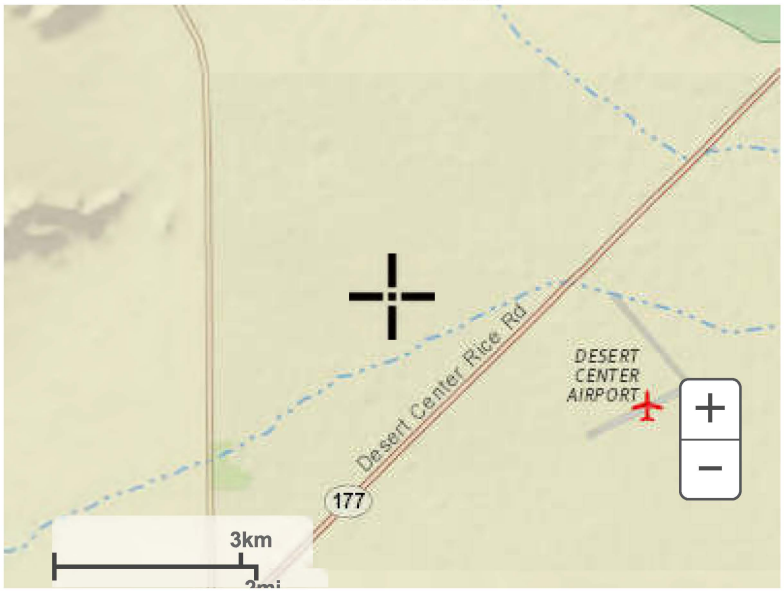
NOAA Atlas 14, Volume 6, Version 2

Created (GMT): Tue Sep 13 14:40:38 2022

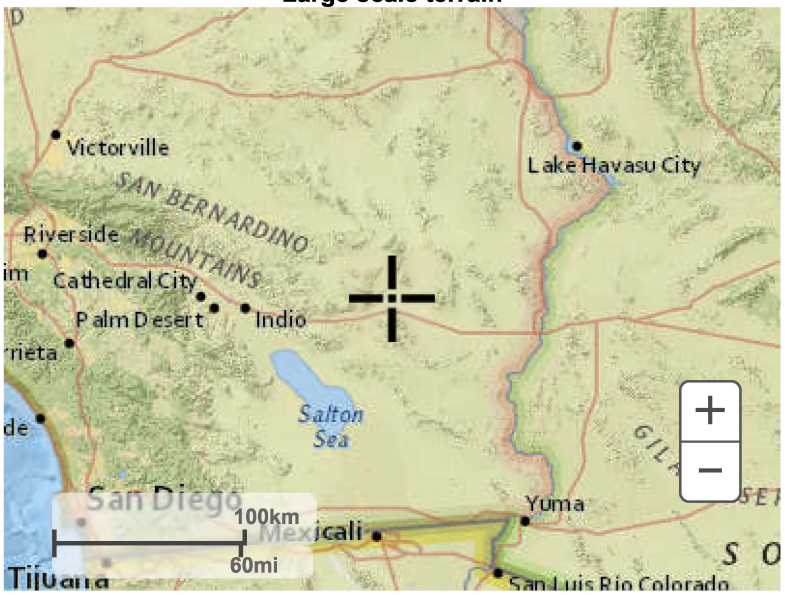
Back to Top

Maps & aerials

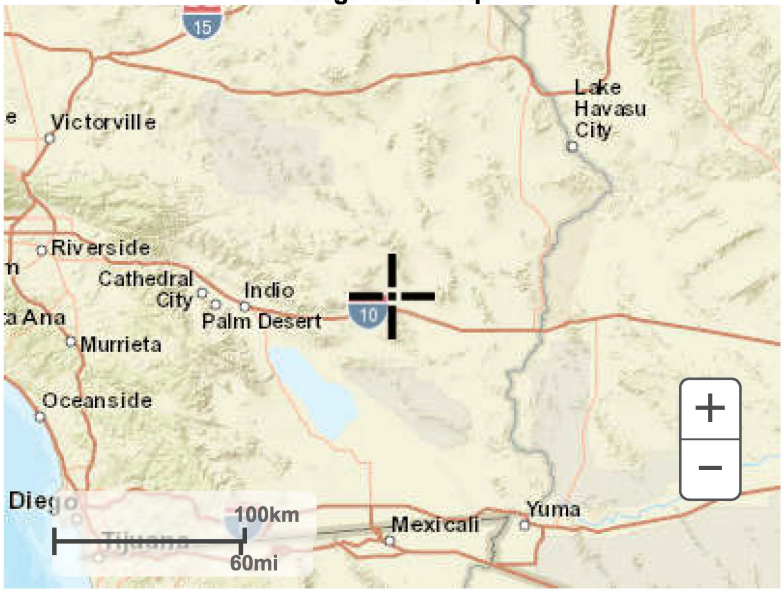
Small scale terrain



Large scale terrain



Large scale map



Large scale aerial



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National Weather Service
National Water Center
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Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

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NOAA Atlas 14, Volume 6, Version 2
Location name: Desert Center, California, USA*
Latitude: 33.7644°, Longitude: -115.368°
Elevation: 614.36 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sarah Dietz, Sarah Heim, Lillian Hiner, Kazungu Maitaria, Deborah Martin, Sandra Pavlovic, Ishani Roy, Carl Trypaluk, Dale Unruh, Fenglin Yan, Michael Yekta, Tan Zhao, Geoffrey Bonnin, Daniel Brewer, Li-Chuan Chen, Tye Parzybok, John Yarchoan

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches/hour)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**0.960** (0.804-1.16)	**1.52** (1.26-1.85)	**2.29** (1.91-2.80)	**2.96** (2.44-3.64)	**3.92** (3.13-4.99)	**4.73** (3.68-6.13)	**5.59** (4.25-7.43)	**6.53** (4.82-8.93)	**7.91** (5.60-11.3)	**9.05** (6.19-13.4)
10-min	**0.690** (0.576-0.840)	**1.09** (0.906-1.32)	**1.64** (1.36-2.00)	**2.12** (1.75-2.60)	**2.81** (2.24-3.58)	**3.39** (2.64-4.39)	**4.00** (3.04-5.32)	**4.68** (3.46-6.40)	**5.66** (4.01-8.07)	**6.49** (4.44-9.57)
15-min	**0.556** (0.464-0.676)	**0.876** (0.732-1.06)	**1.32** (1.10-1.61)	**1.71** (1.41-2.10)	**2.27** (1.81-2.88)	**2.73** (2.13-3.54)	**3.23** (2.46-4.29)	**3.77** (2.79-5.16)	**4.57** (3.24-6.51)	**5.23** (3.58-7.72)
30-min	**0.388** (0.324-0.472)	**0.612** (0.510-0.744)	**0.924** (0.766-1.13)	**1.19** (0.982-1.46)	**1.58** (1.26-2.01)	**1.91** (1.48-2.47)	**2.25** (1.71-2.99)	**2.63** (1.94-3.60)	**3.18** (2.26-4.54)	**3.65** (2.50-5.38)
60-min	**0.262** (0.219-0.318)	**0.413** (0.344-0.501)	**0.624** (0.517-0.759)	**0.805** (0.662-0.988)	**1.07** (0.850-1.36)	**1.29** (1.00-1.67)	**1.52** (1.16-2.02)	**1.78** (1.31-2.43)	**2.15** (1.52-3.06)	**2.46** (1.69-3.63)
2-hr	**0.172** (0.144-0.209)	**0.262** (0.218-0.318)	**0.388** (0.322-0.472)	**0.498** (0.410-0.612)	**0.660** (0.526-0.838)	**0.796** (0.620-1.03)	**0.943** (0.716-1.25)	**1.11** (0.817-1.51)	**1.35** (0.954-1.92)	**1.55** (1.06-2.29)
3-hr	**0.132** (0.110-0.160)	**0.197** (0.164-0.239)	**0.290** (0.241-0.353)	**0.372** (0.306-0.457)	**0.493** (0.392-0.626)	**0.594** (0.463-0.771)	**0.706** (0.536-0.938)	**0.829** (0.613-1.13)	**1.01** (0.718-1.44)	**1.17** (0.800-1.72)
6-hr	**0.080** (0.067-0.098)	**0.120** (0.100-0.145)	**0.176** (0.146-0.214)	**0.225** (0.185-0.276)	**0.298** (0.237-0.379)	**0.360** (0.281-0.467)	**0.428** (0.325-0.569)	**0.504** (0.372-0.689)	**0.617** (0.437-0.880)	**0.714** (0.489-1.05)
12-hr	**0.047** (0.039-0.057)	**0.070** (0.059-0.086)	**0.104** (0.087-0.127)	**0.134** (0.110-0.165)	**0.178** (0.142-0.226)	**0.215** (0.167-0.279)	**0.255** (0.194-0.339)	**0.300** (0.222-0.410)	**0.366** (0.260-0.522)	**0.422** (0.289-0.623)
24-hr	**0.030** (0.027-0.035)	**0.046** (0.041-0.054)	**0.069** (0.061-0.080)	**0.089** (0.078-0.104)	**0.119** (0.101-0.143)	**0.143** (0.119-0.176)	**0.170** (0.138-0.214)	**0.199** (0.158-0.257)	**0.242** (0.184-0.325)	**0.279** (0.205-0.386)
2-day	**0.017** (0.015-0.020)	**0.027** (0.024-0.031)	**0.041** (0.036-0.047)	**0.053** (0.046-0.062)	**0.070** (0.059-0.084)	**0.085** (0.070-0.104)	**0.100** (0.081-0.126)	**0.117** (0.093-0.151)	**0.142** (0.108-0.191)	**0.163** (0.120-0.226)
3-day	**0.012** (0.011-0.014)	**0.019** (0.017-0.022)	**0.029** (0.026-0.034)	**0.038** (0.033-0.044)	**0.050** (0.042-0.060)	**0.060** (0.050-0.074)	**0.071** (0.058-0.090)	**0.083** (0.066-0.108)	**0.101** (0.077-0.136)	**0.116** (0.085-0.161)
4-day	**0.010** (0.009-0.011)	**0.015** (0.014-0.018)	**0.023** (0.020-0.027)	**0.030** (0.026-0.035)	**0.040** (0.034-0.048)	**0.048** (0.040-0.059)	**0.057** (0.046-0.071)	**0.066** (0.052-0.085)	**0.080** (0.061-0.108)	**0.092** (0.068-0.128)

7-day	**0.006** (0.005-0.007)	**0.009** (0.008-0.011)	**0.014** (0.012-0.016)	**0.018** (0.015-0.021)	**0.023** (0.020-0.028)	**0.028** (0.023-0.035)	**0.034** (0.027-0.042)	**0.039** (0.031-0.051)	**0.048** (0.036-0.064)	**0.055** (0.040-0.076)
10-day	**0.004** (0.004-0.005)	**0.007** (0.006-0.008)	**0.010** (0.009-0.011)	**0.013** (0.011-0.015)	**0.017** (0.014-0.020)	**0.020** (0.017-0.025)	**0.024** (0.019-0.030)	**0.028** (0.022-0.036)	**0.034** (0.026-0.046)	**0.039** (0.029-0.054)
20-day	**0.002** (0.002-0.003)	**0.004** (0.003-0.004)	**0.005** (0.005-0.006)	**0.007** (0.006-0.008)	**0.009** (0.008-0.011)	**0.011** (0.009-0.013)	**0.013** (0.011-0.016)	**0.015** (0.012-0.020)	**0.018** (0.014-0.025)	**0.021** (0.016-0.029)
30-day	**0.002** (0.001-0.002)	**0.003** (0.002-0.003)	**0.004** (0.003-0.004)	**0.005** (0.004-0.006)	**0.007** (0.006-0.008)	**0.008** (0.007-0.010)	**0.009** (0.008-0.012)	**0.011** (0.009-0.014)	**0.013** (0.010-0.018)	**0.015** (0.011-0.021)
45-day	**0.001** (0.001-0.001)	**0.002** (0.002-0.002)	**0.003** (0.002-0.003)	**0.004** (0.003-0.004)	**0.005** (0.004-0.006)	**0.006** (0.005-0.007)	**0.007** (0.006-0.009)	**0.008** (0.006-0.010)	**0.010** (0.007-0.013)	**0.011** (0.008-0.015)
60-day	**0.001** (0.001-0.001)	**0.001** (0.001-0.002)	**0.002** (0.002-0.003)	**0.003** (0.003-0.003)	**0.004** (0.003-0.005)	**0.005** (0.004-0.006)	**0.006** (0.005-0.007)	**0.007** (0.005-0.008)	**0.008** (0.006-0.010)	**0.009** (0.007-0.012)

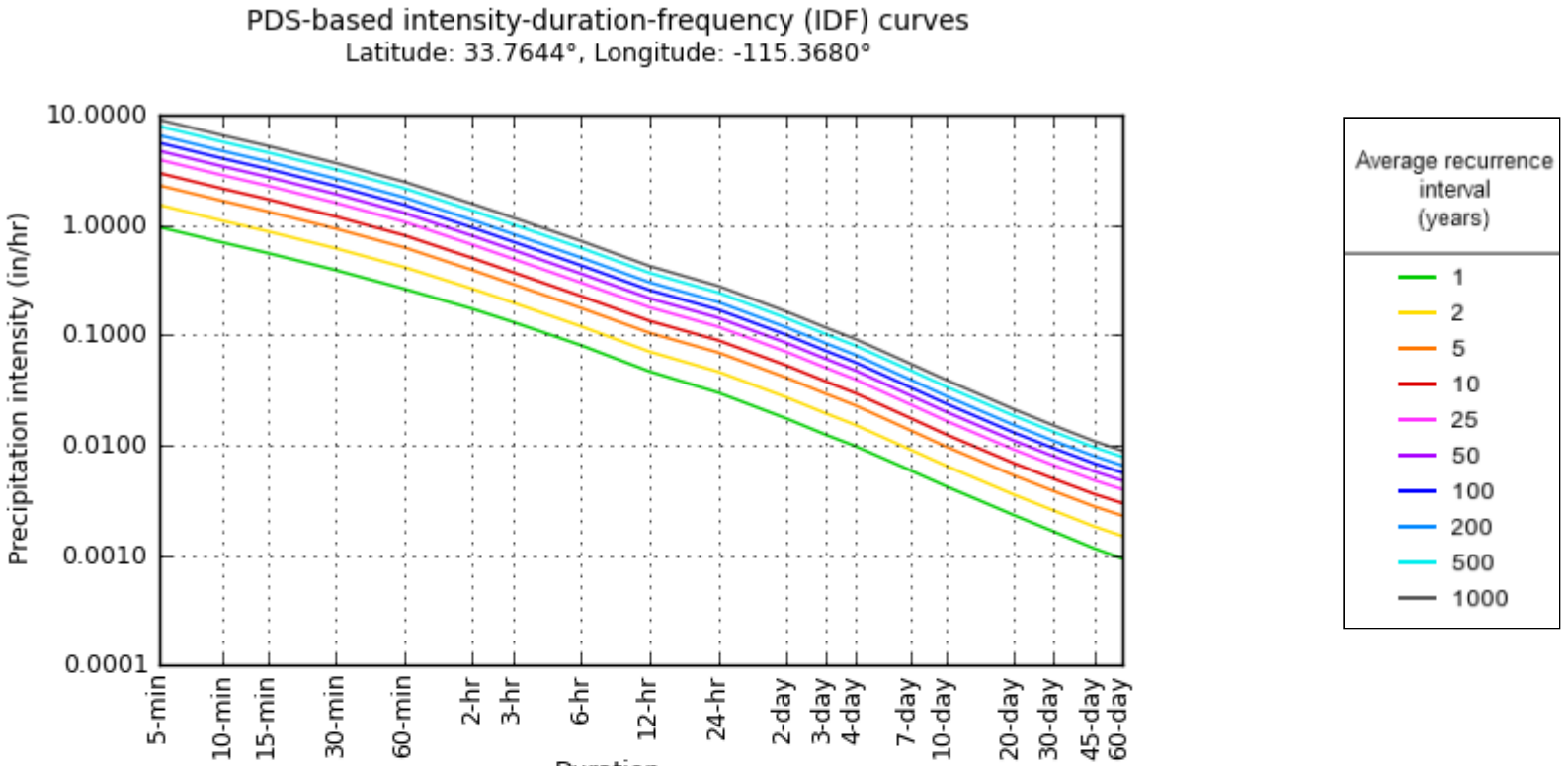
[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

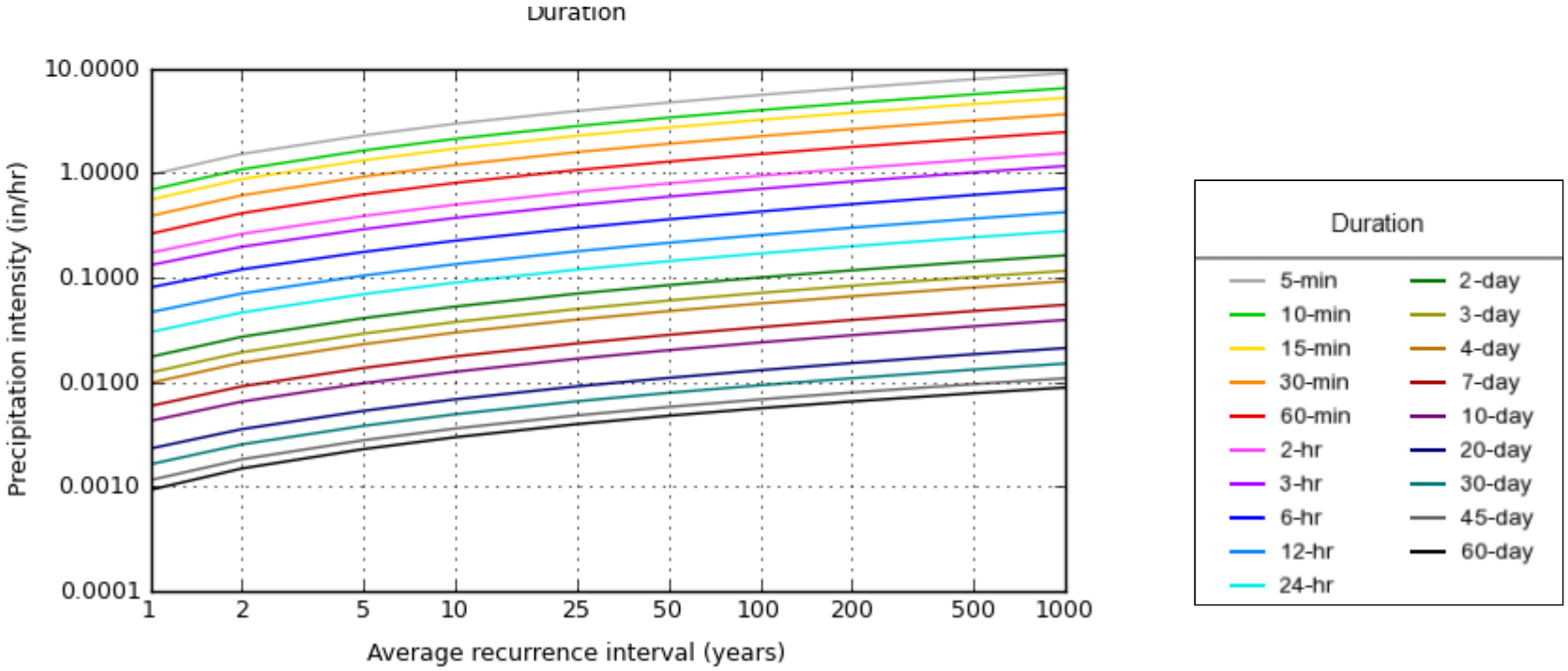
Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

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PF graphical





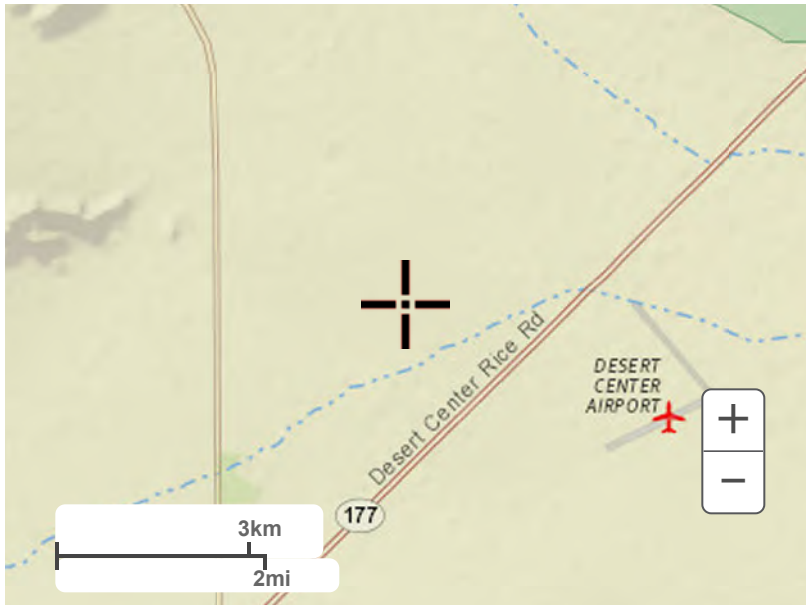
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Created (GMT): Fri Sep 23 16:03:22 2022

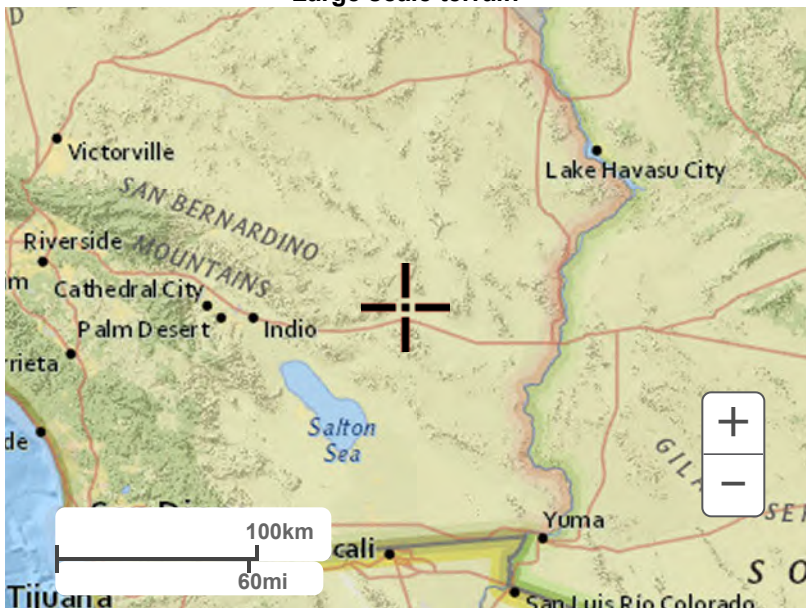
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Maps & aerials

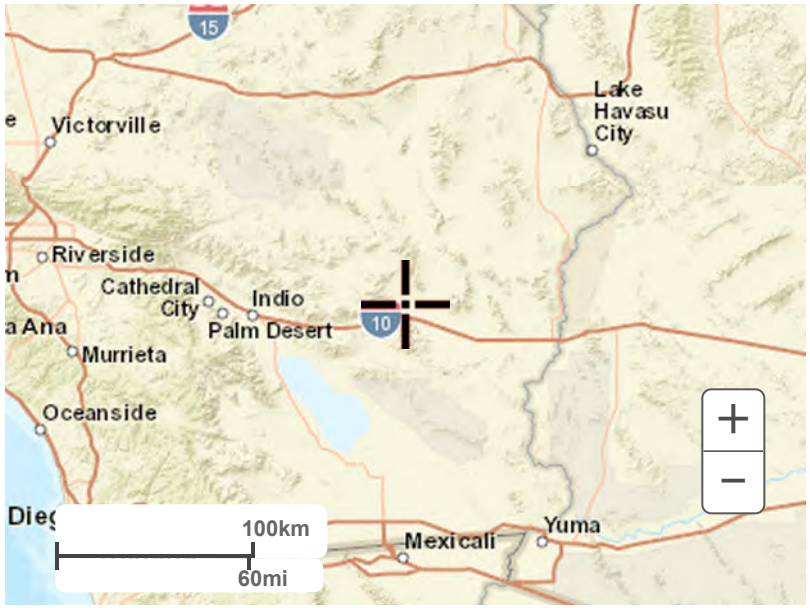
Small scale terrain



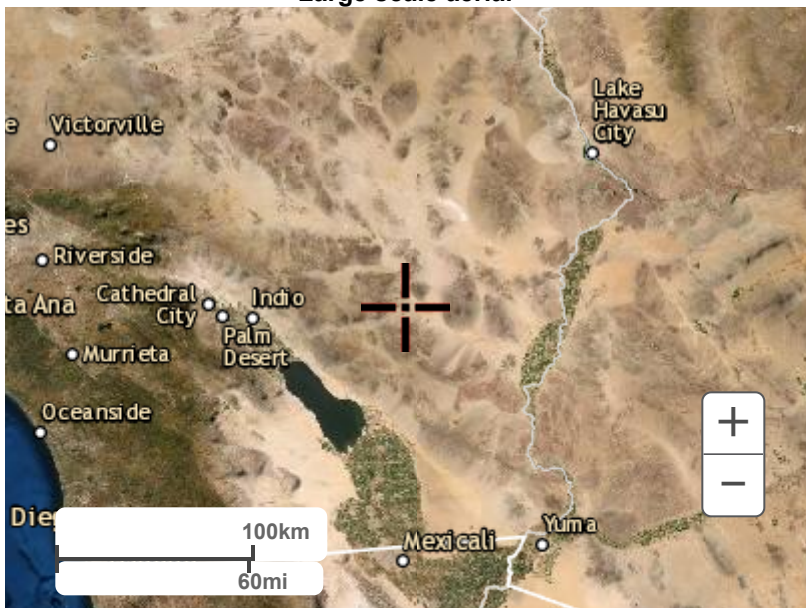
Large scale terrain



Large scale map



Large scale aerial



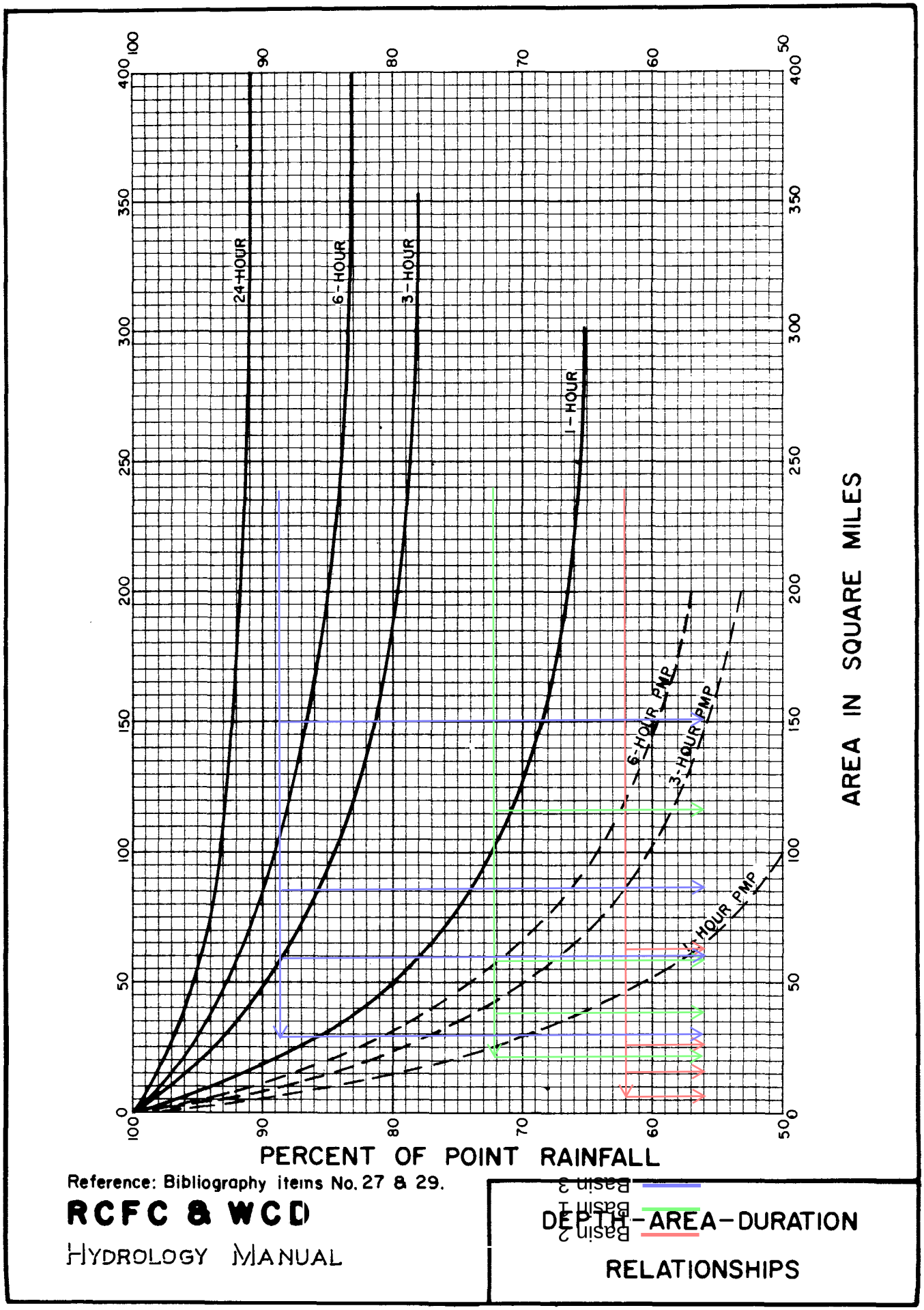
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Appendix D

Hydrology Manual Rainfall Calculations



Reference: Bibliography items No. 27 & 29.

RCFC & WCD

HYDROLOGY MANUAL

Basin 3
Basin 1
Basin 2

DEPTH-AREA-DURATION RELATIONSHIPS

PLATE E-5.8

Lag Equation per RCFCWCD Hydrology Manual

Lag - Lag for a drainage area is defined as the elapsed time in hours from the beginning of unit effective rainfall to the instant that the summation hydrograph for the concentration point of an area reaches 50 percent of ultimate discharge. Lag can be calculated from the physical characteristics of a drainage area by the empirical formula:

$$\text{Lag (hours)} = 24\bar{n}\left[\frac{L \cdot L_{ca}}{S^{1/2}}\right]^{.38}$$

where:

$\bar{n}$ = The visually estimated mean of the n (Manning's formula) values of all collection streams and channels within the watershed

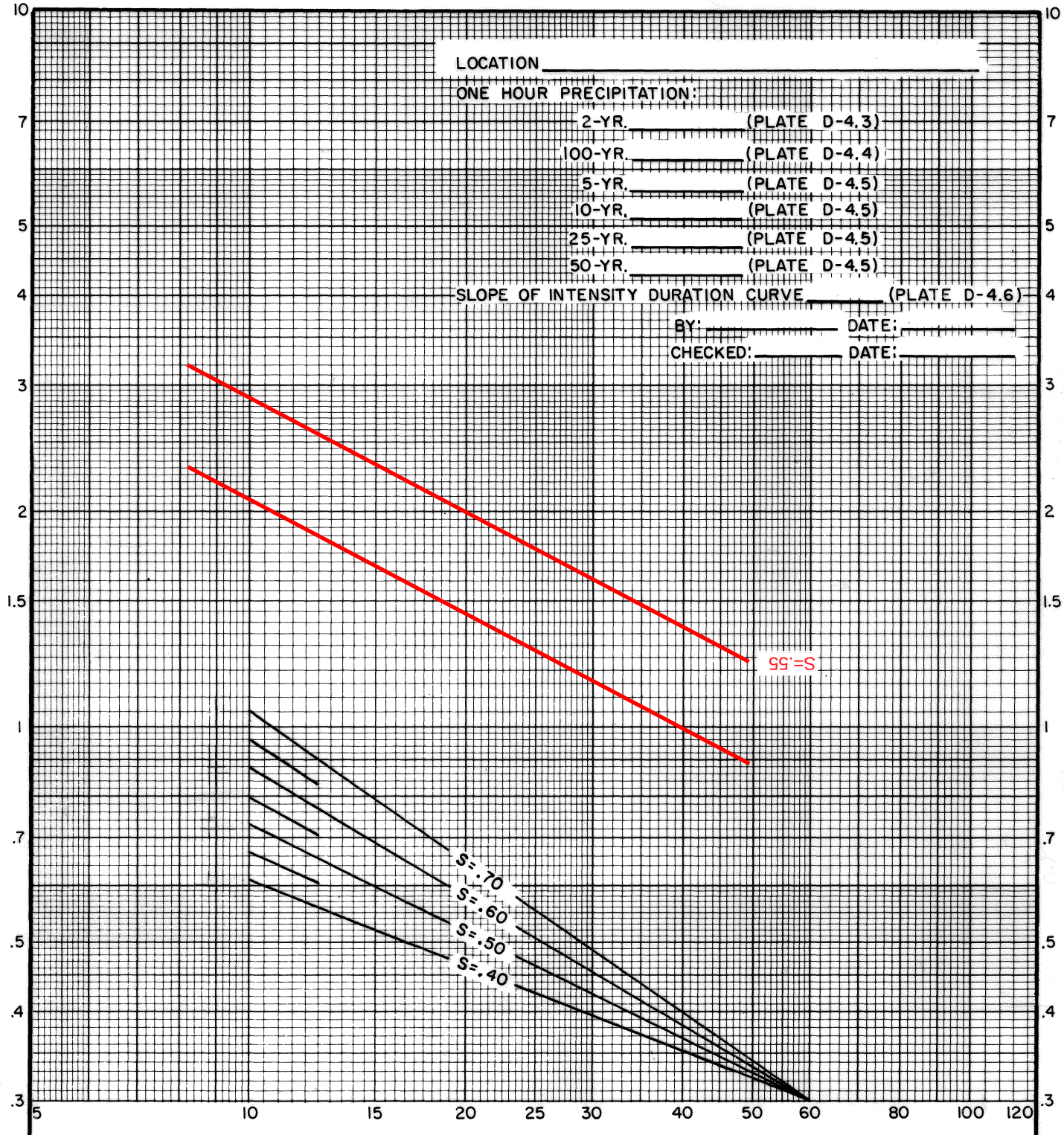
L = Length of longest watercourse - miles

Lca = Length along longest watercourse, measured upstream to a point opposite the centroid of the area - miles

S = Overall slope of longest watercourse between headwaters and the collection point feet per mile

Table A. Lag Calculations

	Basin 1	**Basin 2**	**Basin 3**
L (ft)	102,253	65,794	140,673
L (mi)	19.4	12.5	26.6
L_{ca} (ft)	49,205	35,703	73,432
Upstream El (ft)	3,870	3,600	4,410
Downstream El (ft)	540	600	540
Elev Difference (ft)	3,330	3,000	3,870
S (ft/mi)	172	241	145
Basin Factor - n	0.030	0.030	0.030
Lag (hours)	**1.95**	**1.37**	**2.65**



RCFC & WCD

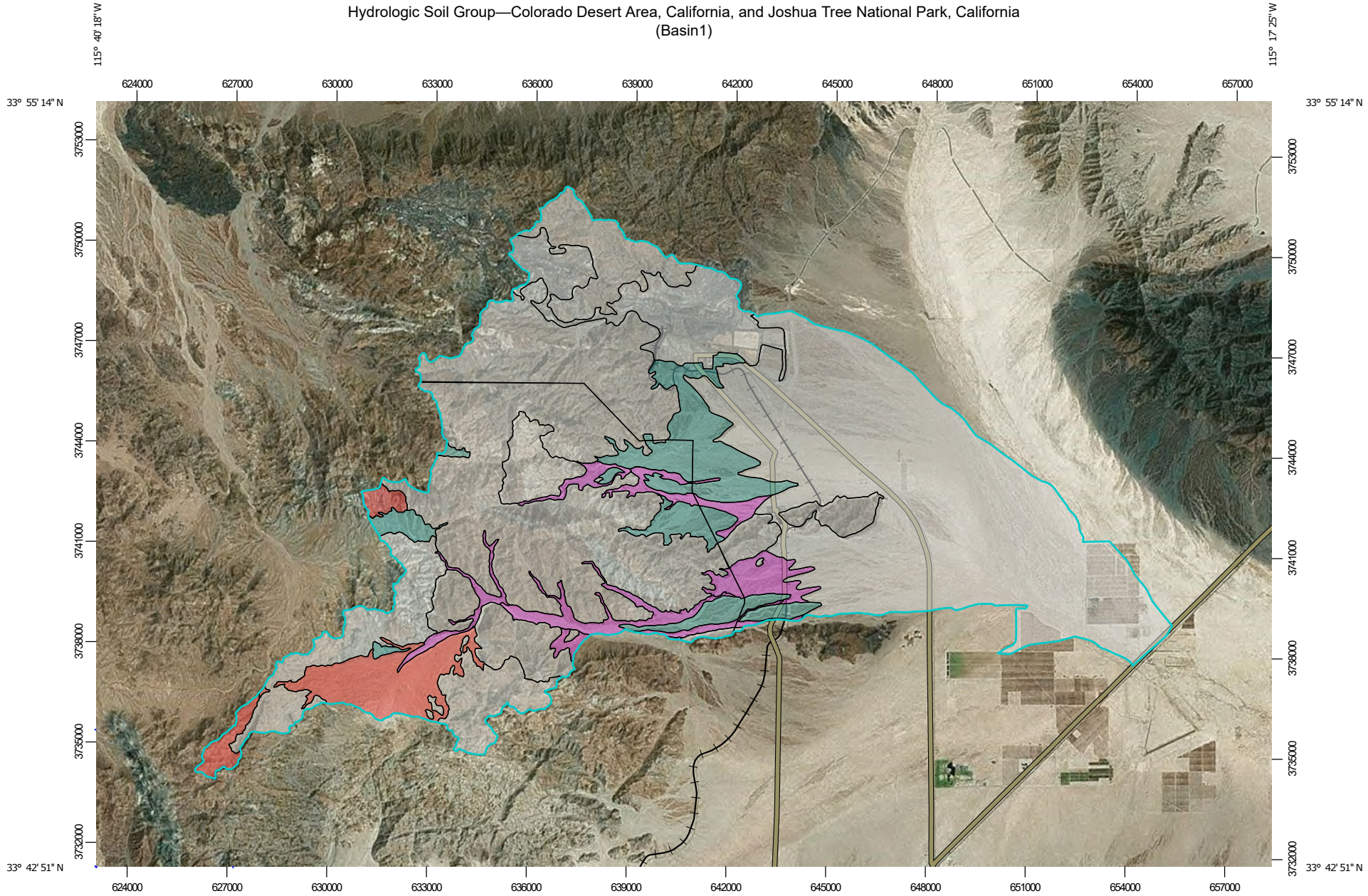
HYDROLOGY MANUAL

INTENSITY - DURATION CURVES CALCULATION SHEET

PLATE D-4.7

Appendix E
USDA Soil Reports

Hydrologic Soil Group—Colorado Desert Area, California, and Joshua Tree National Park, California
(Basin1)



Map Scale: 1:161,000 if printed on A landscape (11" x 8.5") sheet.

N

Meters
0 2000 4000 8000 12000

Feet
0 5000 10000 20000 30000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 11N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Soil Rating Lines

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Soil Rating Points

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Colorado Desert Area, California
Survey Area Data: Version 9, Sep 13, 2021

Soil Survey Area: Joshua Tree National Park, California
Survey Area Data: Version 11, Sep 13, 2021

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jan 1, 1999—Dec 31, 2003

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
2090	Deprave-Rockhound-Rizzo complex, 2 to 4 percent slopes	C	2,137.0	4.1%
2402	Rizzo complex, 2 to 8 percent slopes	A	786.5	1.5%
2408	Rizzo complex, 2 to 8 percent slopes, flooded	A	62.3	0.1%
2835	Rock outcrop-Blackeagle complex, 30 to 75 percent slopes		6,811.0	13.0%
ML	Mined land		3,178.8	6.1%
NOTCOM	No Digital Data Available		17,202.3	32.8%
Subtotals for Soil Survey Area			**30,178.0**	**57.6%**
Totals for Area of Interest			**52,395.5**	**100.0%**

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
1220	Jadestorm-Blackeagle-Rock outcrop complex, 15 to 50 percent slopes	D	219.4	0.4%
2090	Deprave-Rockhound-Rizzo complex, 2 to 4 percent slopes	C	1,482.1	2.8%
2402	Rizzo complex, 2 to 8 percent slopes	A	392.4	0.7%
2408	Rizzo complex, 2 to 8 percent slopes, flooded	A	995.8	1.9%
2440	Rizzo complex, 8 to 15 percent slopes	A	113.4	0.2%
2830	Rock outcrop-Blackeagle complex, 30 to 75 percent slopes, dry		945.4	1.8%
2835	Rock outcrop-Blackeagle complex, 30 to 75 percent slopes		11,221.5	21.4%
2840	Rock outcrop-Jadestorm complex, 30 to 60 percent slopes		3,828.6	7.3%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
3120	Aguilareal-Blackeagle-Rock outcrop complex, 30 to 60 percent slopes	D	362.0	0.7%
4260	Minhoyt-Corbilt association, 2 to 8 percent slopes	D	1,942.7	3.7%
4270	Yuccabutte very gravelly loam, 8 to 50 percent slopes	C	411.3	0.8%
4440	Dragonwash association, 2 to 4 percent slopes	A	302.8	0.6%
Subtotals for Soil Survey Area			**22,217.5**	**42.4%**
Totals for Area of Interest			**52,395.5**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

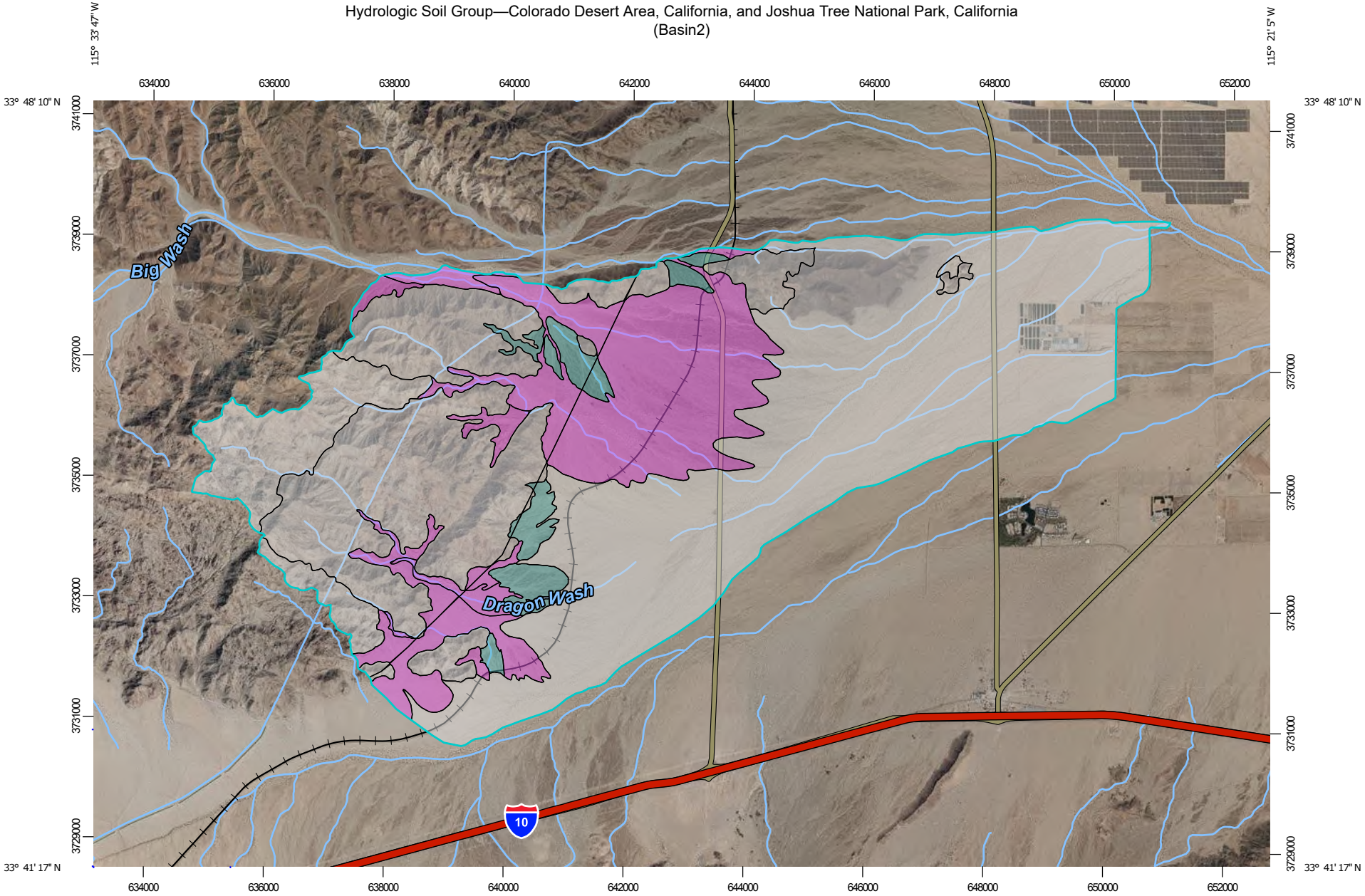
Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Hydrologic Soil Group—Colorado Desert Area, California, and Joshua Tree National Park, California
(Basin2)



Map Scale: 1:89,700 if printed on A landscape (11" x 8.5") sheet.

N

Meters
0 1000 2000 4000 6000

Feet
0 4000 8000 16000 24000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 11N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Colorado Desert Area, California
Survey Area Data: Version 9, Sep 13, 2021

Soil Survey Area: Joshua Tree National Park, California
Survey Area Data: Version 11, Sep 13, 2021

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Feb 6, 2021—May 29, 2021

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
1555	Goldrose-Carsitas-Chemwash complex, 4 to 8 percent slopes	A	509.1	2.7%
2090	Deprave-Rockhound-Rizzo complex, 2 to 4 percent slopes	C	481.8	2.5%
2402	Rizzo complex, 2 to 8 percent slopes	A	2,139.1	11.3%
2408	Rizzo complex, 2 to 8 percent slopes, flooded	A	32.2	0.2%
2409	Rizzo-Chemwash-Carsitas complex, 4 to 8 percent slopes	A	81.4	0.4%
2835	Rock outcrop-Blackeagle complex, 30 to 75 percent slopes		539.2	2.8%
2840	Rock outcrop-Jadestorm complex, 30 to 60 percent slopes		12.4	0.1%
Dumps	Dumps		20.4	0.1%
NOTCOM	No Digital Data Available		8,610.1	45.4%
Subtotals for Soil Survey Area			**12,425.7**	**65.6%**
Totals for Area of Interest			**18,953.6**	**100.0%**

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
1555	Goldrose-Carsitas-Chemwash complex, 4 to 8 percent slopes	A	265.8	1.4%
2090	Deprave-Rockhound-Rizzo complex, 2 to 4 percent slopes	C	194.7	1.0%
2402	Rizzo complex, 2 to 8 percent slopes	A	543.2	2.9%
2408	Rizzo complex, 2 to 8 percent slopes, flooded	A	94.5	0.5%
2409	Rizzo-Chemwash-Carsitas complex, 4 to 8 percent slopes	A	44.0	0.2%
2440	Rizzo complex, 8 to 15 percent slopes	A	156.0	0.8%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
2835	Rock outcrop-Blackeagle complex, 30 to 75 percent slopes		3,866.5	20.4%
2840	Rock outcrop-Jadestorm complex, 30 to 60 percent slopes		1,363.2	7.2%
Subtotals for Soil Survey Area			**6,527.9**	**34.4%**
Totals for Area of Interest			**18,953.6**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

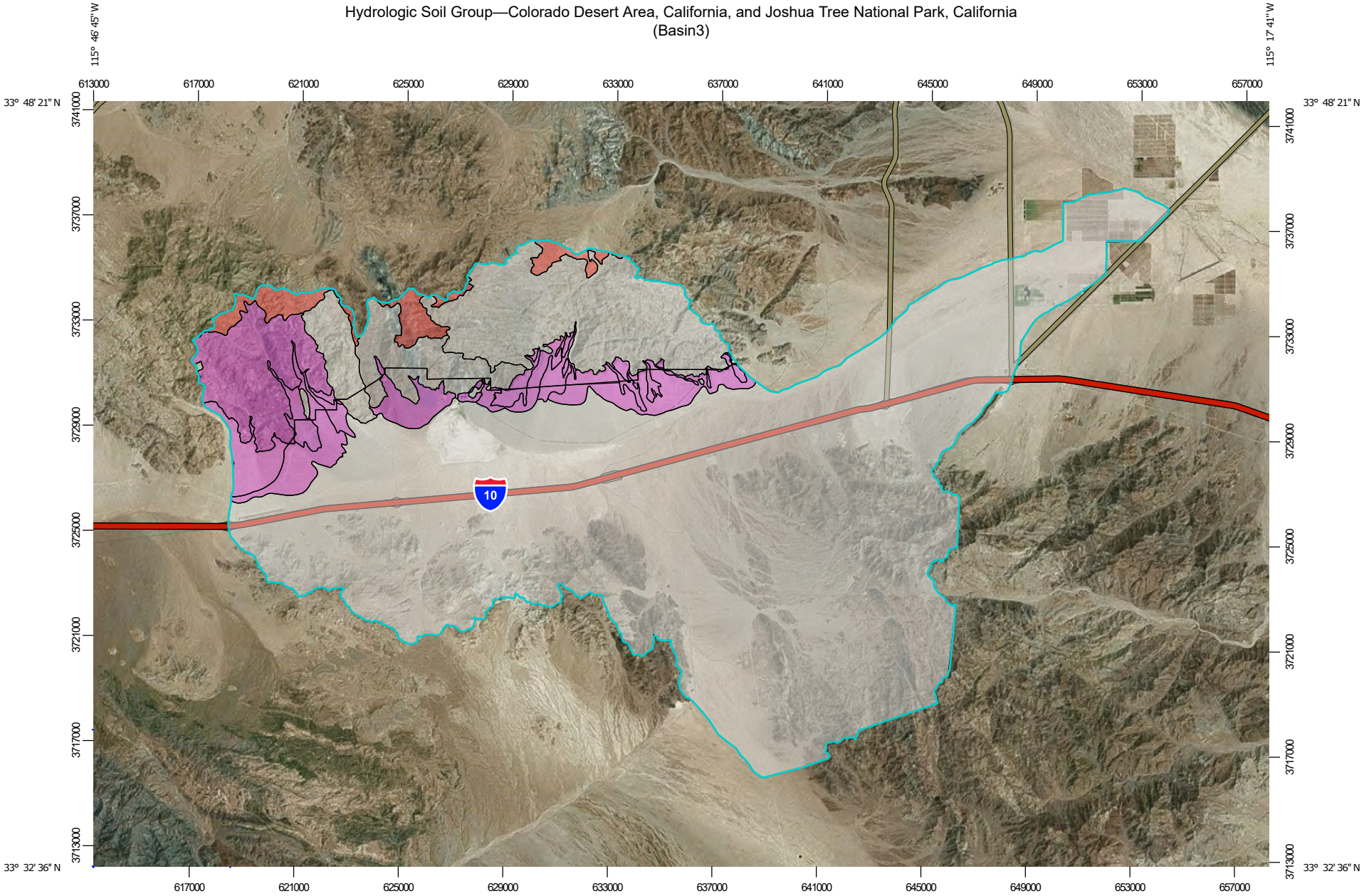
Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Hydrologic Soil Group—Colorado Desert Area, California, and Joshua Tree National Park, California
(Basin3)



Map Scale: 1:205,000 if printed on A landscape (11" x 8.5") sheet.

N

Meters
0 3000 6000 12000 18000

Feet
0 5000 10000 20000 30000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 11N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Soil Rating Lines

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Soil Rating Points

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Colorado Desert Area, California
Survey Area Data: Version 9, Sep 13, 2021

Soil Survey Area: Joshua Tree National Park, California
Survey Area Data: Version 11, Sep 13, 2021

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jan 1, 1999—Dec 31, 2003

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
1242	Meccapass-Jadestorm-Rock outcrop complex, 15 to 75 percent slopes	A	9.1	0.0%
1555	Goldrose-Carsitas-Chemwash complex, 4 to 8 percent slopes	A	2,886.9	2.9%
2121	Rizzo very cobbly coarse sandy loam, 4 to 15 percent slopes, rubbly	A	224.0	0.2%
2409	Rizzo-Chemwash-Carsitas complex, 4 to 8 percent slopes	A	691.5	0.7%
2440	Rizzo complex, 8 to 15 percent slopes	A	904.9	0.9%
2830	Rock outcrop-Blackeagle complex, 30 to 75 percent slopes, dry		244.9	0.2%
2835	Rock outcrop-Blackeagle complex, 30 to 75 percent slopes		690.9	0.7%
2840	Rock outcrop-Jadestorm complex, 30 to 60 percent slopes		80.4	0.1%
Dumps	Dumps		7.4	0.0%
NOTCOM	No Digital Data Available		72,458.8	72.8%
Pits	Pits		32.3	0.0%
Subtotals for Soil Survey Area			**78,231.0**	**78.6%**
Totals for Area of Interest			**99,469.8**	**100.0%**

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
1242	Meccapass-Jadestorm-Rock outcrop complex, 15 to 75 percent slopes	A	4,176.8	4.2%
1555	Goldrose-Carsitas-Chemwash complex, 4 to 8 percent slopes	A	1,935.1	1.9%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
2121	Rizzo very cobbly coarse sandy loam, 4 to 15 percent slopes, rubbly	A	203.7	0.2%
2409	Rizzo-Chemwash-Carsitas complex, 4 to 8 percent slopes	A	523.0	0.5%
2440	Rizzo complex, 8 to 15 percent slopes	A	27.8	0.0%
2830	Rock outcrop-Blackeagle complex, 30 to 75 percent slopes, dry		1,304.2	1.3%
2835	Rock outcrop-Blackeagle complex, 30 to 75 percent slopes		2,123.7	2.1%
2840	Rock outcrop-Jadestorm complex, 30 to 60 percent slopes		8,898.5	8.9%
3120	Aguilareal-Blackeagle-Rock outcrop complex, 30 to 60 percent slopes	D	1,605.4	1.6%
4260	Minhoyt-Corbilt association, 2 to 8 percent slopes	D	420.8	0.4%
4830	Rock outcrop-Pinecity complex, 8 to 30 percent slopes		20.0	0.0%
Subtotals for Soil Survey Area			**21,238.9**	**21.4%**
Totals for Area of Interest			**99,469.8**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

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Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Appendix F
HEC-HMS Preprocessor Input

HEC HMS Preprocessor

User Manual
Contact Project Planning **(951) 955-1200**

S-Graph

Loss Rate Data Effective Rainfall S-Graphs

Run S Graphs

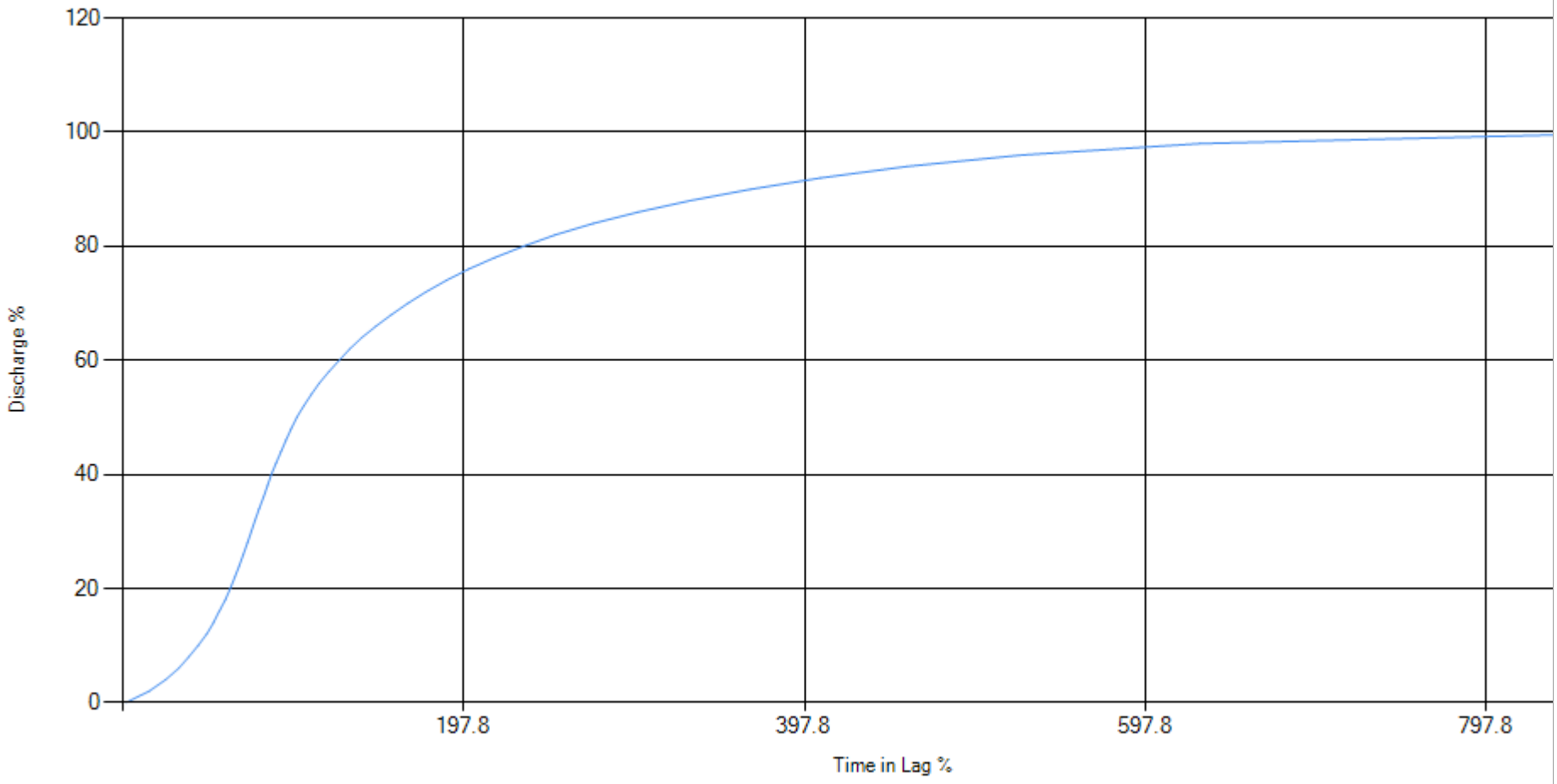
S-Graph 1		S-Graph 2		S-Graph 3		S-Graph 4	
Type:	Mountain	Type:	Valley	Type:	Foothill	Type:	Desert
Weight %	25	Weight %	25	Weight %	25	Weight %	25

S-Graph Combined	
Type:	Combined
Weight %	

Time in Percent of Lag	Discharge (percent)	Time in Percent of Lag	Discharge (percent)	Time in Percent of Lag	Discharge (percent)	Time in Percent of Lag	Discharge (percent)	Time in Percent of Lag	Discharge (percent)
0	0	0	0	0	0	0	0	0	0
2.2	2	3	2	3.8	2	4.5	2	13.5	2
4.2	4	5.2	4	6.5	4	7.2	4	23.1	4
5.8	6	7	6	8.8	6	9.2	6	30.8	6
7.2	8	8.5	8	10.2	8	10.8	8	36.7	8
8.2	10	9.8	10	12.2	10	12	10	42.2	10
9.2	12	11	12	13.8	12	13.2	12	47.2	12
10.2	14	12	14	15	14	14	14	51.2	14
11	16	12.8	16	16	16	14.8	16	54.6	16
11.8	18	13.8	18	17	18	15.5	18	58.1	18
12.5	20	14.5	20	18	20	16	20	61	20
13	22	15.2	22	19	22	16.5	22	63.7	22
13.8	24	16	24	19.5	24	17	24	66.3	24
14.2	26	16.8	26	20.2	26	17.5	26	68.7	26
14.8	28	17.5	28	20.8	28	18	28	71.1	28
15.2	30	18.2	30	21.5	30	18.5	30	73.4	30
16	32	18.8	32	21.8	32	19	32	75.6	32
16.8	34	19.5	34	22.2	34	19.5	34	78	34
17.5	36	20.2	36	22.8	36	20	36	80.5	36
18.2	38	20.8	38	23	38	20.8	38	82.8	38
19.2	40	21.5	40	23.2	40	21.2	40	85.1	40
20.2	42	22.2	42	23.5	42	22	42	87.9	42
21.2	44	23	44	23.8	44	22.8	44	90.8	44
22.5	46	23.5	46	24.2	46	23.5	46	93.7	46
23.8	48	24.2	48	24.5	48	24.2	48	96.7	48
25	50	25	50	25	50	25	50	100	50
26.5	52	25.8	52	25.8	52	26	52	104.1	52
28.2	54	26.8	54	26.5	54	27	54	108.5	54
30.2	56	27.8	56	27.2	56	28	56	113.2	56
32.8	58	28.8	58	28	58	29.2	58	118.8	58
35.2	60	30	60	29.2	60	30.5	60	124.9	60
37.8	62	31.5	62	30	62	31.8	62	131.1	62
40.8	64	33	64	31.2	64	33.2	64	138.2	64
44	66	34.5	66	33	66	35	66	146.5	66
47.5	68	36.5	68	34.5	68	37	68	155.5	68
51.5	70	38.5	70	36.2	70	39	70	165.2	70
55.5	72	41	72	38	72	41.2	72	175.7	72
60.5	74	43.5	74	39.8	74	43.8	74	187.6	74
66	76	46.5	76	41.8	76	46.5	76	200.8	76
72	78	50	78	44.2	78	49.8	78	216	78
79	80	53.8	80	47	80	53.2	80	233	80
86.5	82	58.2	82	49.8	82	57	82	251.5	82
95.8	84	63.5	84	53	84	61.5	84	273.8	84
107	86	69.8	86	56.5	86	67	86	300.3	86
119.8	88	77.2	88	60.5	88	73.2	88	330.7	88
134	90	85.8	90	65.5	90	80.8	90	366.1	90
150.2	92	96.5	92	71	92	89.8	92	407.5	92
169.5	94	110	94	77.8	94	100.5	94	457.8	94
194.8	96	127	96	87	96	116.5	96	525.3	96

229.5	98	152.8	98	102.5	98	145	98		629.8	98
325	100	205	100	175	100	195	100		900	100

S-Graph Combined



HEC HMS Preprocessor

Basin 1 Input

User Manual
Contact Project Planning **(951) 955-1200**

Watershed Area 81.9 sq mi

1 Hour Storm

Point Precipitation	.81	in.
Areal Adjustment Factor	75	%
Adjusted Point Precipitation	0.61	
Slope of Rainfall Intensity - Duration Curve	.55	

3 Hour Storm

Point Precipitation	1.12	in.
Areal Adjustment Factor	86	%
Adjusted Point Precipitation	0.96	

6 Hour Storm

Point Precipitation	1.35	in.
Areal Adjustment Factor	91	%
Adjusted Point Precipitation	1.23	

24 Hour Storm

Point Precipitation	2.15	in.
Areal Adjustment Factor	94	%
Adjusted Point Precipitation	2.02	

Lag Time Calculator

Basin Factor - n	.030	
Length along longest watercourse - L	102253	ft
Length along longest watercourse measured upstream to a point opposite the centroid of the area - Lca	49205	ft
Elevation Difference	3330	ft
Lag Time	**1.95**	**hr**
40% Lag Time	46.8	min

Run

Loss Rate Data Effective Rainfall S-Graphs

(●) Average Adjusted Loss Rate Calculator (Plate E-2.1) ( ) Average Adjusted Loss Rate (Manual Entry)

Add Loss Rate Values

AMC Condition: II

Soil Group / Cover Type View Chart	RI Number	Perv. Area Infiltrn Rate (in/hr)	Land Use	Imp. Area Decimal %	Adj.Infiltrn Rate (in/hr)	Area (acres)		
-							Add	

Soil Group / Cover Type	RI Number	Perv. Area Infiltrn Rate (in/hr)	Land Use	Imp. Area Decimal %	Adj.Infiltrn Rate (in/hr)	Area (acres)	Area/ Total Area	Ave. Adj. Rate (in/hr)
Barren N/A A	78	0.26800	Commercial, Downtown Business or Industrial (90)	90	0.051	11	0	0 X
Barren N/A C	91	0.11700	Commercial, Downtown Business or Industrial (90)	90	0.022	48	0.001	0 X
Barren N/A D	93	0.09100	Commercial, Downtown Business or Industrial (90)	90	0.017	3621	0.069	0.001 X
Barren N/A D	93	0.09100	Natural or Agriculture (0)	0	0.091	955	0.018	0.002 X
Open Brush Fair A	46	0.61100	Natural or Agriculture (0)	0	0.611	2642	0.05	0.031 X
Open Brush Fair C	77	0.27900	Natural or Agriculture (0)	0	0.279	3982	0.076	0.021 X
Open Brush Fair D	83	0.21000	Natural or Agriculture (0)	0	0.21	41129	0.785	0.165 X
Meadow or Cienegas Fair D	84	0.19800	Natural or Agriculture (0)	0	0.198	6	0	0 X
					Total area =	52394		
							Average Soil Loss =	0.22

HEC HMS Preprocessor

Basin 1 10-year

User Manual
Contact Project Planning **(951) 955-1200**

Watershed Area 81.9 sq mi

1 Hour Storm

Point Precipitation	.81	in.
Areal Adjustment Factor	75	%
Adjusted Point Precipitation	0.61	
Slope of Rainfall Intensity - Duration Curve	.55	

3 Hour Storm

Point Precipitation	1.12	in.
Areal Adjustment Factor	86	%
Adjusted Point Precipitation	0.96	

6 Hour Storm

Point Precipitation	1.35	in.
Areal Adjustment Factor	91	%
Adjusted Point Precipitation	1.23	

24 Hour Storm

Point Precipitation	2.15	in.
Areal Adjustment Factor	94	%
Adjusted Point Precipitation	2.02	

Lag Time Calculator

Basin Factor - n	.030	
Length along longest watercourse - L	102253	ft
Length along longest watercourse measured upstream to a point opposite the centroid of the area - Lca	49205	ft
Elevation Difference	3330	ft
Lag Time	**1.95**	**hr**
40% Lag Time	46.8	min

Run

Loss Rate Data Effective Rainfall S-Graphs

Unit Time Period 30 min (Use interval less than 40% of lag time)

Low Loss 90 %

Fm (Percentage of F) (24-hour Storm Only) 50 % (Typically 50-75%)

Run

1 Hour

Unit Time	Effective Rainfall (inches)
00:00	
00:05	
00:10	
00:15	
00:20	
00:25	
00:30	
00:35	
00:40	
00:45	
00:50	
00:55	
01:00	

3 Hour

Unit Time	Effective Rainfall (inches)
00:30	0.008
01:00	0.01
01:30	0.024
02:00	0.058
02:30	0.178
03:00	0.086

6 Hour

Unit Time	Effective Rainfall (inches)
00:30	0.004
01:00	0.005
01:30	0.006
02:00	0.006
02:30	0.007
03:00	0.007
03:30	0.008
04:00	0.011
04:30	0.033
05:00	0.067
05:30	0.198
06:00	0.005

24 Hour

Unit Time	Effective Rainfall (inches)
00:30	0.001
01:00	0.001
01:30	0.001
02:00	0.001
02:30	0.002
03:00	0.002
03:30	0.002
04:00	0.002
04:30	0.003
05:00	0.003
05:30	0.003
06:00	0.003
06:30	0.004
07:00	0.004
07:30	0.004
08:00	0.005
08:30	0.006
09:00	0.007
09:30	0.008
10:00	0.009
10:30	0.006
11:00	0.008
11:30	0.008
12:00	0.007
12:30	0.01
13:00	0.017
13:30	0.042
14:00	0.009
14:30	0.017
15:00	0.016
15:30	0.011
16:00	0.008
16:30	0.002
17:00	0.001
17:30	0.002
18:00	0.002
18:30	0.002

19:00	0.001
19:30	0.001
20:00	0.001
20:30	0.001
21:00	0.001
21:30	0.001
22:00	0.001
22:30	0.001
23:00	0.001
23:30	0.001
00:00	0.001

HEC HMS Preprocessor

Basin 1 100-year

User Manual
Contact Project Planning **(951) 955-1200**

Watershed Area 81.9 sq mi

1 Hour Storm		3 Hour Storm		6 Hour Storm		24 Hour Storm	
Point Precipitation	1.52 in.	Point Precipitation	2.12 in.	Point Precipitation	2.56 in.	Point Precipitation	4.08 in.
Areal Adjustment Factor	75 %	Areal Adjustment Factor	86 %	Areal Adjustment Factor	91 %	Areal Adjustment Factor	94 %
Adjusted Point Precipitation	1.14	Adjusted Point Precipitation	1.82	Adjusted Point Precipitation	2.33	Adjusted Point Precipitation	3.84
Slope of Rainfall Intensity - Duration Curve	.55						

Lag Time Calculator

Basin Factor - n	.030	
Length along longest watercourse - L	102253	ft
Length along longest watercourse measured upstream to a point opposite the centroid of the area - Lca	49205	ft
Elevation Difference	3330	ft
Lag Time	**1.95**	**hr**
40% Lag Time	46.8	min

Run

Loss Rate Data Effective Rainfall S-Graphs

Unit Time Period 30 min (Use interval less than 40% of lag time)

Low Loss 90 %

Fm (Percentage of F) (24-hour Storm Only) 50 % (Typically 50-75%)

Run

1 Hour

Unit Time	Effective Rainfall (inches)
00:00	
00:05	
00:10	
00:15	
00:20	
00:25	
00:30	
00:35	
00:40	
00:45	
00:50	
00:55	
01:00	

3 Hour

Unit Time	Effective Rainfall (inches)
00:30	0.045
01:00	0.072
01:30	0.143
02:00	0.207
02:30	0.435
03:00	0.26

6 Hour

Unit Time	Effective Rainfall (inches)
00:30	0.008
01:00	0.01
01:30	0.011
02:00	0.011
02:30	0.013
03:00	0.025
03:30	0.048
04:00	0.1
04:30	0.16
05:00	0.225
05:30	0.475
06:00	0.01

24 Hour

Unit Time	Effective Rainfall (inches)
00:30	0.002
01:00	0.003
01:30	0.002
02:00	0.003
02:30	0.003
03:00	0.004
03:30	0.004
04:00	0.004
04:30	0.005
05:00	0.006
05:30	0.005
06:00	0.006
06:30	0.007
07:00	0.008
07:30	0.008
08:00	0.01
08:30	0.012
09:00	0.013
09:30	0.029
10:00	0.047
10:30	0.012
11:00	0.043
11:30	0.038
12:00	0.03
12:30	0.094
13:00	0.12
13:30	0.165
14:00	0.084
14:30	0.114
15:00	0.109
15:30	0.096
16:00	0.064
16:30	0.003
17:00	0.002
17:30	0.004
18:00	0.003
18:30	0.003

19:00	0.002
19:30	0.003
20:00	0.002
20:30	0.002
21:00	0.002
21:30	0.002
22:00	0.002
22:30	0.002
23:00	0.002
23:30	0.002
00:00	0.002

HEC HMS Preprocessor

Basin 2 Input

User Manual
Contact Project Planning **(951) 955-1200**

Watershed Area 29.6 sq mi

1 Hour Storm

Point Precipitation	.81	in.
Areal Adjustment Factor	86	%
Adjusted Point Precipitation	0.7	
Slope of Rainfall Intensity - Duration Curve	.55	

3 Hour Storm

Point Precipitation	1.12	in.
Areal Adjustment Factor	93	%
Adjusted Point Precipitation	1.04	

6 Hour Storm

Point Precipitation	1.35	in.
Areal Adjustment Factor	95	%
Adjusted Point Precipitation	1.28	

24 Hour Storm

Point Precipitation	2.15	in.
Areal Adjustment Factor	97	%
Adjusted Point Precipitation	2.09	

Lag Time Calculator

Basin Factor - n	.030	
Length along longest watercourse - L	65794	ft
Length along longest watercourse measured upstream to a point opposite the centroid of the area - Lca	35703	ft
Elevation Difference	3000	ft
Lag Time	**1.37**	**hr**
40% Lag Time	32.9	min

Run

Loss Rate Data Effective Rainfall S-Graphs

(●) Average Adjusted Loss Rate Calculator (Plate E-2.1) ( ) Average Adjusted Loss Rate (Manual Entry)

Add Loss Rate Values

AMC Condition: II

Soil Group / Cover Type View Chart	RI Number	Perv. Area Infiltrn Rate (in/hr)	Land Use	Imp. Area Decimal %	Adj.Infiltrn Rate (in/hr)	Area (acres)		
-							Add	

Soil Group / Cover Type	RI Number	Perv. Area Infiltrn Rate (in/hr)	Land Use	Imp. Area Decimal %	Adj.Infiltrn Rate (in/hr)	Area (acres)	Area/ Total Area	Ave. Adj. Rate (in/hr)
Barren N/A A	78	0.26800	Commercial, Downtown Business or Industrial (90)	90	0.051	26	0.001	0 X
Barren N/A C	91	0.11700	Commercial, Downtown Business or Industrial (90)	90	0.022	6	0	0 X
Barren N/A D	93	0.09100	Commercial, Downtown Business or Industrial (90)	90	0.017	48	0.003	0 X
Barren N/A A	78	0.26800	Natural or Agriculture (0)	0	0.268	7	0	0 X
Open Brush Fair A	46	0.61100	Natural or Agriculture (0)	0	0.611	3839	0.203	0.124 X
Open Brush Fair C	77	0.27900	Natural or Agriculture (0)	0	0.279	670	0.035	0.01 X
Open Brush Fair D	83	0.21000	Natural or Agriculture (0)	0	0.21	14356	0.757	0.159 X
Meadow or Cienegas Fair D	84	0.19800	Natural or Agriculture (0)	0	0.198	1	0	0 X
					Total area =	18953		
							Average Soil Loss =	0.293

HEC HMS Preprocessor

Basin 2 10-year

User Manual
Contact Project Planning **(951) 955-1200**

Watershed Area 29.6 sq mi

1 Hour Storm

Point Precipitation	.81	in.
Areal Adjustment Factor	86	%
Adjusted Point Precipitation	0.7	
Slope of Rainfall Intensity - Duration Curve	.55	

3 Hour Storm

Point Precipitation	1.12	in.
Areal Adjustment Factor	93	%
Adjusted Point Precipitation	1.04	

6 Hour Storm

Point Precipitation	1.35	in.
Areal Adjustment Factor	95	%
Adjusted Point Precipitation	1.28	

24 Hour Storm

Point Precipitation	2.15	in.
Areal Adjustment Factor	97	%
Adjusted Point Precipitation	2.09	

Lag Time Calculator

Basin Factor - n	.030	
Length along longest watercourse - L	65794	ft
Length along longest watercourse measured upstream to a point opposite the centroid of the area - Lca	35703	ft
Elevation Difference	3000	ft
Lag Time	**1.37**	**hr**
40% Lag Time	32.9	min

Run

Loss Rate Data Effective Rainfall S-Graphs

Unit Time Period 30 min (Use interval less than 40% of lag time)

Low Loss 90 %

Fm (Percentage of F) (24-hour Storm Only) 50 % (Typically 50-75%)

Run

1 Hour

Unit Time	Effective Rainfall (inches)
00:00	
00:05	
00:10	
00:15	
00:20	
00:25	
00:30	
00:35	
00:40	
00:45	
00:50	
00:55	
01:00	

3 Hour

Unit Time	Effective Rainfall (inches)
00:30	0.009
01:00	0.01
01:30	0.014
02:00	0.035
02:30	0.165
03:00	0.065

6 Hour

Unit Time	Effective Rainfall (inches)
00:30	0.005
01:00	0.006
01:30	0.006
02:00	0.006
02:30	0.007
03:00	0.007
03:30	0.009
04:00	0.012
04:30	0.015
05:00	0.038
05:30	0.175
06:00	0.006

24 Hour

Unit Time	Effective Rainfall (inches)
00:30	0.001
01:00	0.001
01:30	0.001
02:00	0.001
02:30	0.002
03:00	0.002
03:30	0.002
04:00	0.002
04:30	0.003
05:00	0.003
05:30	0.003
06:00	0.003
06:30	0.004
07:00	0.004
07:30	0.004
08:00	0.005
08:30	0.006
09:00	0.007
09:30	0.008
10:00	0.009
10:30	0.006
11:00	0.008
11:30	0.008
12:00	0.007
12:30	0.011
13:00	0.012
13:30	0.015
14:00	0.01
14:30	0.011
15:00	0.011
15:30	0.01
16:00	0.008
16:30	0.002
17:00	0.001
17:30	0.002
18:00	0.002
18:30	0.002

19:00	0.001
19:30	0.001
20:00	0.001
20:30	0.001
21:00	0.001
21:30	0.001
22:00	0.001
22:30	0.001
23:00	0.001
23:30	0.001
00:00	0.001

HEC HMS Preprocessor

Basin 2 100-year

User Manual
Contact Project Planning **(951) 955-1200**

Watershed Area 29.6 sq mi

1 Hour Storm

Point Precipitation	1.52	in.
Areal Adjustment Factor	86	%
Adjusted Point Precipitation	1.31	
Slope of Rainfall Intensity - Duration Curve	.55	

3 Hour Storm

Point Precipitation	2.12	in.
Areal Adjustment Factor	93	%
Adjusted Point Precipitation	1.97	

6 Hour Storm

Point Precipitation	2.56	in.
Areal Adjustment Factor	95	%
Adjusted Point Precipitation	2.43	

24 Hour Storm

Point Precipitation	4.08	in.
Areal Adjustment Factor	97	%
Adjusted Point Precipitation	3.96	

Lag Time Calculator

Basin Factor - n	.030	
Length along longest watercourse - L	65794	ft
Length along longest watercourse measured upstream to a point opposite the centroid of the area - Lca	35703	ft
Elevation Difference	3000	ft
Lag Time	**1.37**	**hr**
40% Lag Time	32.9	min

Run

Loss Rate Data Effective Rainfall S-Graphs

Unit Time Period 30 min (Use interval less than 40% of lag time)

Low Loss 90 %

Fm (Percentage of F) (24-hour Storm Only) 50 % (Typically 50-75%)

Run

1 Hour

Unit Time	Effective Rainfall (inches)
00:00	
00:05	
00:10	
00:15	
00:20	
00:25	
00:30	
00:35	
00:40	
00:45	
00:50	
00:55	
01:00	

3 Hour

Unit Time	Effective Rainfall (inches)
00:30	0.021
01:00	0.051
01:30	0.128
02:00	0.197
02:30	0.443
03:00	0.254

6 Hour

Unit Time	Effective Rainfall (inches)
00:30	0.009
01:00	0.01
01:30	0.012
02:00	0.012
02:30	0.013
03:00	0.014
03:30	0.019
04:00	0.072
04:30	0.136
05:00	0.204
05:30	0.464
06:00	0.011

24 Hour

Unit Time	Effective Rainfall (inches)
00:30	0.002
01:00	0.003
01:30	0.002
02:00	0.003
02:30	0.003
03:00	0.004
03:30	0.004
04:00	0.004
04:30	0.005
05:00	0.006
05:30	0.005
06:00	0.006
06:30	0.007
07:00	0.008
07:30	0.008
08:00	0.01
08:30	0.012
09:00	0.013
09:30	0.015
10:00	0.017
10:30	0.012
11:00	0.016
11:30	0.015
12:00	0.014
12:30	0.067
13:00	0.095
13:30	0.142
14:00	0.059
14:30	0.09
15:00	0.086
15:30	0.074
16:00	0.041
16:30	0.003
17:00	0.002
17:30	0.004
18:00	0.004
18:30	0.003

19:00	0.002
19:30	0.003
20:00	0.002
20:30	0.002
21:00	0.002
21:30	0.002
22:00	0.002
22:30	0.002
23:00	0.002
23:30	0.002
00:00	0.002

HEC HMS Preprocessor

Basin 3 Input

User Manual
Contact Project Planning **(951) 955-1200**

Watershed Area 162.6 sq mi

1 Hour Storm

Point Precipitation	.81	in.
Areal Adjustment Factor	68	%
Adjusted Point Precipitation	0.55	
Slope of Rainfall Intensity - Duration Curve	.55	

3 Hour Storm

Point Precipitation	1.12	in.
Areal Adjustment Factor	81	%
Adjusted Point Precipitation	0.91	

6 Hour Storm

Point Precipitation	1.35	in.
Areal Adjustment Factor	86	%
Adjusted Point Precipitation	1.16	

24 Hour Storm

Point Precipitation	2.15	in.
Areal Adjustment Factor	92	%
Adjusted Point Precipitation	1.98	

Lag Time Calculator

Basin Factor - n	.03	
Length along longest watercourse - L	140673	ft
Length along longest watercourse measured upstream to a point opposite the centroid of the area - Lca	73432	ft
Elevation Difference	3870	ft
Lag Time	**2.647**	**hr**
40% Lag Time	63.5	min

Run

Loss Rate Data Effective Rainfall S-Graphs

(●) Average Adjusted Loss Rate Calculator (Plate E-2.1) ( ) Average Adjusted Loss Rate (Manual Entry)

Add Loss Rate Values

AMC Condition: II

Soil Group / Cover Type View Chart	RI Number	Perv. Area Infiltrn Rate (in/hr)	Land Use	Imp. Area Decimal %	Adj.Infiltrn Rate (in/hr)	Area (acres)		
-							Add	

Soil Group / Cover Type	RI Number	Perv. Area Infiltrn Rate (in/hr)	Land Use	Imp. Area Decimal %	Adj.Infiltrn Rate (in/hr)	Area (acres)	Area/ Total Area	Ave. Adj. Rate (in/hr)
Barren N/A A	78	0.26800	Commercial, Downtown Business or Industrial (90)	90	0.051	35	0	0 X
Barren N/A D	93	0.09100	Commercial, Downtown Business or Industrial (90)	90	0.017	1025	0.01	0 X
Barren N/A A	78	0.26800	Natural or Agriculture (0)	0	0.268	10	0	0 X
Barren N/A D	93	0.09100	Natural or Agriculture (0)	0	0.091	298	0.003	0 X
Open Brush Fair A	46	0.61100	Natural or Agriculture (0)	0	0.611	11545	0.111	0.068 X
Open Brush Fair D	83	0.21000	Natural or Agriculture (0)	0	0.21	90265	0.867	0.182 X
Meadow or Cienegas Fair D	84	0.19800	Natural or Agriculture (0)	0	0.198	899	0.009	0.002 X
					Total area =	104077		
							Average Soil Loss =	0.252

HEC HMS Preprocessor

Basin 3 10-year

User Manual
Contact Project Planning **(951) 955-1200**

Watershed Area 162.6 sq mi

1 Hour Storm

Point Precipitation	.81	in.
Areal Adjustment Factor	68	%
Adjusted Point Precipitation	0.55	
Slope of Rainfall Intensity - Duration Curve	.55	

3 Hour Storm

Point Precipitation	1.12	in.
Areal Adjustment Factor	81	%
Adjusted Point Precipitation	0.91	

6 Hour Storm

Point Precipitation	1.35	in.
Areal Adjustment Factor	86	%
Adjusted Point Precipitation	1.16	

24 Hour Storm

Point Precipitation	2.15	in.
Areal Adjustment Factor	92	%
Adjusted Point Precipitation	1.98	

Lag Time Calculator

Basin Factor - n	.03	
Length along longest watercourse - L	140673	ft
Length along longest watercourse measured upstream to a point opposite the centroid of the area - Lca	73432	ft
Elevation Difference	3870	ft
Lag Time	**2.647**	**hr**
40% Lag Time	63.5	min

Run

Loss Rate Data Effective Rainfall S-Graphs

Unit Time Period 30 min (Use interval less than 40% of lag time)

Low Loss 90 %

Fm (Percentage of F) (24-hour Storm Only) 50 % (Typically 50-75%)

Run

1 Hour

Unit Time	Effective Rainfall (inches)
00:00	
00:05	
00:10	
00:15	
00:20	
00:25	
00:30	
00:35	
00:40	
00:45	
00:50	
00:55	
01:00	

3 Hour

Unit Time	Effective Rainfall (inches)
00:30	0.008
01:00	0.009
01:30	0.013
02:00	0.032
02:30	0.145
03:00	0.058

6 Hour

Unit Time	Effective Rainfall (inches)
00:30	0.004
01:00	0.005
01:30	0.006
02:00	0.006
02:30	0.006
03:00	0.007
03:30	0.008
04:00	0.01
04:30	0.013
05:00	0.041
05:30	0.165
06:00	0.005

24 Hour

Unit Time	Effective Rainfall (inches)
00:30	0.001
01:00	0.001
01:30	0.001
02:00	0.001
02:30	0.002
03:00	0.002
03:30	0.002
04:00	0.002
04:30	0.003
05:00	0.003
05:30	0.003
06:00	0.003
06:30	0.004
07:00	0.004
07:30	0.004
08:00	0.005
08:30	0.006
09:00	0.007
09:30	0.008
10:00	0.009
10:30	0.006
11:00	0.008
11:30	0.008
12:00	0.007
12:30	0.01
13:00	0.011
13:30	0.025
14:00	0.009
14:30	0.01
15:00	0.01
15:30	0.009
16:00	0.008
16:30	0.002
17:00	0.001
17:30	0.002
18:00	0.002
18:30	0.002

19:00	0.001
19:30	0.001
20:00	0.001
20:30	0.001
21:00	0.001
21:30	0.001
22:00	0.001
22:30	0.001
23:00	0.001
23:30	0.001
00:00	0.001

HEC HMS Preprocessor

Basin 3 100-year

User Manual
Contact Project Planning **(951) 955-1200**

Watershed Area 162.6 sq mi

1 Hour Storm

Point Precipitation	1.52	in.
Areal Adjustment Factor	68	%
Adjusted Point Precipitation	1.03	
Slope of Rainfall Intensity - Duration Curve	.55	

3 Hour Storm

Point Precipitation	2.12	in.
Areal Adjustment Factor	81	%
Adjusted Point Precipitation	1.72	

6 Hour Storm

Point Precipitation	2.56	in.
Areal Adjustment Factor	86	%
Adjusted Point Precipitation	2.2	

24 Hour Storm

Point Precipitation	4.08	in.
Areal Adjustment Factor	92	%
Adjusted Point Precipitation	3.75	

Lag Time Calculator

Basin Factor - n	.03	
Length along longest watercourse - L	140673	ft
Length along longest watercourse measured upstream to a point opposite the centroid of the area - Lca	73432	ft
Elevation Difference	3870	ft
Lag Time	**2.647**	**hr**
40% Lag Time	63.5	min

Run

Loss Rate Data Effective Rainfall S-Graphs

Unit Time Period 30 min (Use interval less than 40% of lag time)

Low Loss 90 %

Fm (Percentage of F) (24-hour Storm Only) 50 % (Typically 50-75%)

Run

1 Hour

Unit Time	Effective Rainfall (inches)
00:00	
00:05	
00:10	
00:15	
00:20	
00:25	
00:30	
00:35	
00:40	
00:45	
00:50	
00:55	
01:00	

3 Hour

Unit Time	Effective Rainfall (inches)
00:30	0.02
01:00	0.046
01:30	0.113
02:00	0.173
02:30	0.387
03:00	0.223

6 Hour

Unit Time	Effective Rainfall (inches)
00:30	0.008
01:00	0.009
01:30	0.011
02:00	0.011
02:30	0.012
03:00	0.013
03:30	0.024
04:00	0.072
04:30	0.129
05:00	0.191
05:30	0.427
06:00	0.01

24 Hour

Unit Time	Effective Rainfall (inches)
00:30	0.002
01:00	0.003
01:30	0.002
02:00	0.003
02:30	0.003
03:00	0.004
03:30	0.004
04:00	0.004
04:30	0.005
05:00	0.006
05:30	0.005
06:00	0.006
06:30	0.007
07:00	0.008
07:30	0.008
08:00	0.009
08:30	0.011
09:00	0.012
09:30	0.015
10:00	0.027
10:30	0.011
11:00	0.023
11:30	0.019
12:00	0.013
12:30	0.075
13:00	0.101
13:30	0.146
14:00	0.067
14:30	0.096
15:00	0.092
15:30	0.08
16:00	0.049
16:30	0.003
17:00	0.002
17:30	0.004
18:00	0.003
18:30	0.003

19:00	0.002
19:30	0.003
20:00	0.002
20:30	0.002
21:00	0.002
21:30	0.002
22:00	0.002
22:30	0.002
23:00	0.002
23:30	0.002
00:00	0.002

Appendix G
Hydrology Reports

Project: Sapphire_Solar
Simulation Run: 03h 10yr
Simulation Start: 31 December 1999, 24:00
Simulation End: 1 January 2000, 18:00

HMS Version: 4.9
Executed: 04 October 2022, 22:57

Global Parameter Summary - Subbasin

Area (MI^2)

Element Name	Area (MI^2)
Basin - 1	81.9

Transform: User - Specified S - Graph

Element Name	S - graph	Lag Method	Lag
Basin - 1	Combined S - Graph	Specified	1.95

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Basin - 1	81.9	5971.91	01Jan2000, 03:30	0.36

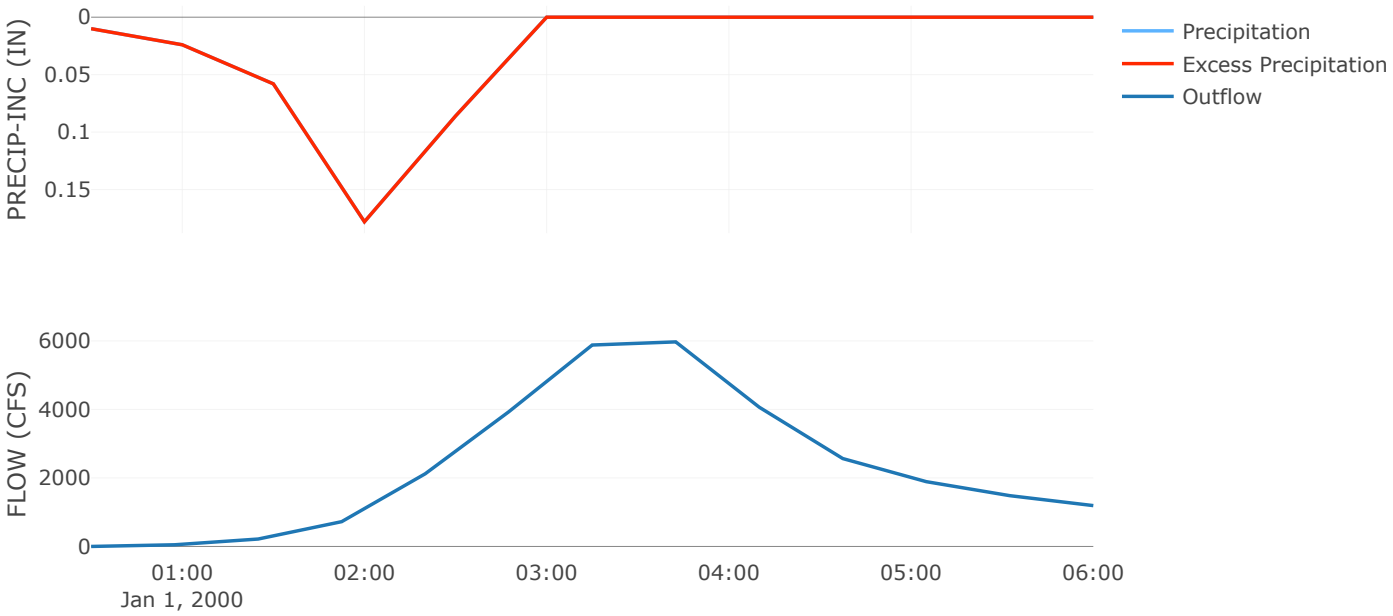
Subbasin: Basin-1

Area (MI^2) : 81.9

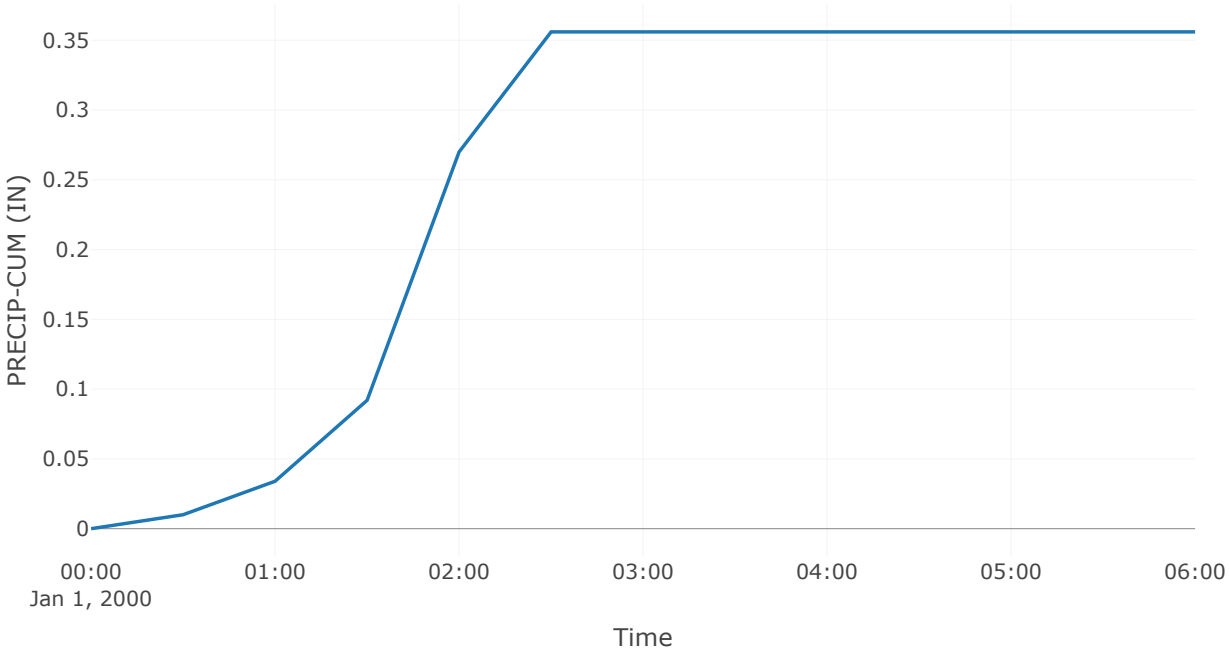
Transform: User - Specified S - Graph	
S - graph	Combined S - Graph
Lag Method	Specified
Lag	1.95

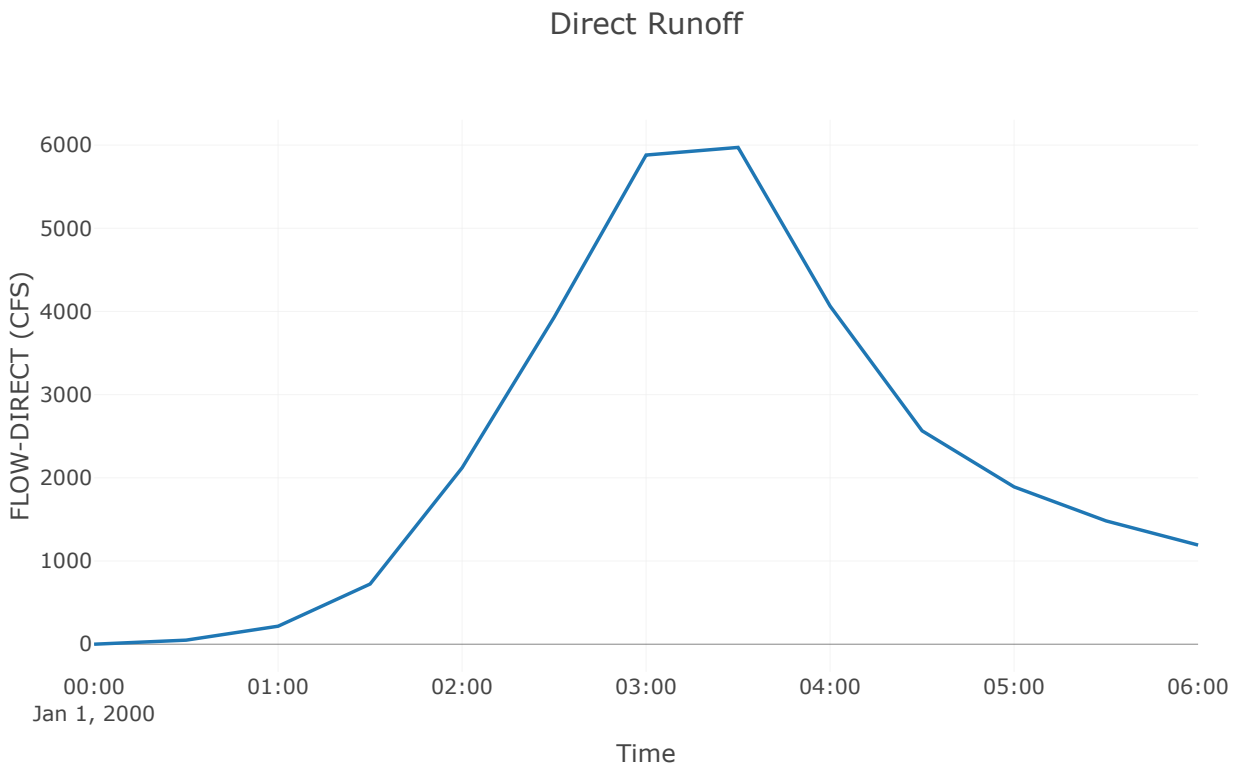
Results: Basin-1	
Peak Discharge (CFS)	5971.91
Time of Peak Discharge	01Jan2000, 03:30
Volume (IN)	0.36
Precipitation Volume (AC - FT)	1555.01
Loss Volume (AC - FT)	0
Excess Volume (AC - FT)	1555.01
Direct Runoff Volume (AC - FT)	1550.84
Baseflow Volume (AC - FT)	0

Precipitation and Outflow



Cumulative Precipitation




Direct Runoff
6000
5000
4000
3000
2000
1000
0
FLOW-DIRECT (CFS)
00:00
Jan 1, 2000
01:00
02:00
03:00
04:00
05:00
06:00
Time

Project: Sapphire_Solar
Simulation Run: 03h 100yr
Simulation Start: 31 December 1999, 24:00
Simulation End: 1 January 2000, 18:00

HMS Version: 4.9
Executed: 04 October 2022, 22:57

Global Parameter Summary - Subbasin

Area (MI^2)

Element Name	Area (MI^2)
Basin - 1	81.9

Transform: User - Specified S - Graph

Element Name	S - graph	Lag Method	Lag
Basin - 1	Combined S - Graph	Specified	1.95

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Basin - 1	81.9	17323.61	01Jan2000, 03:00	1.11

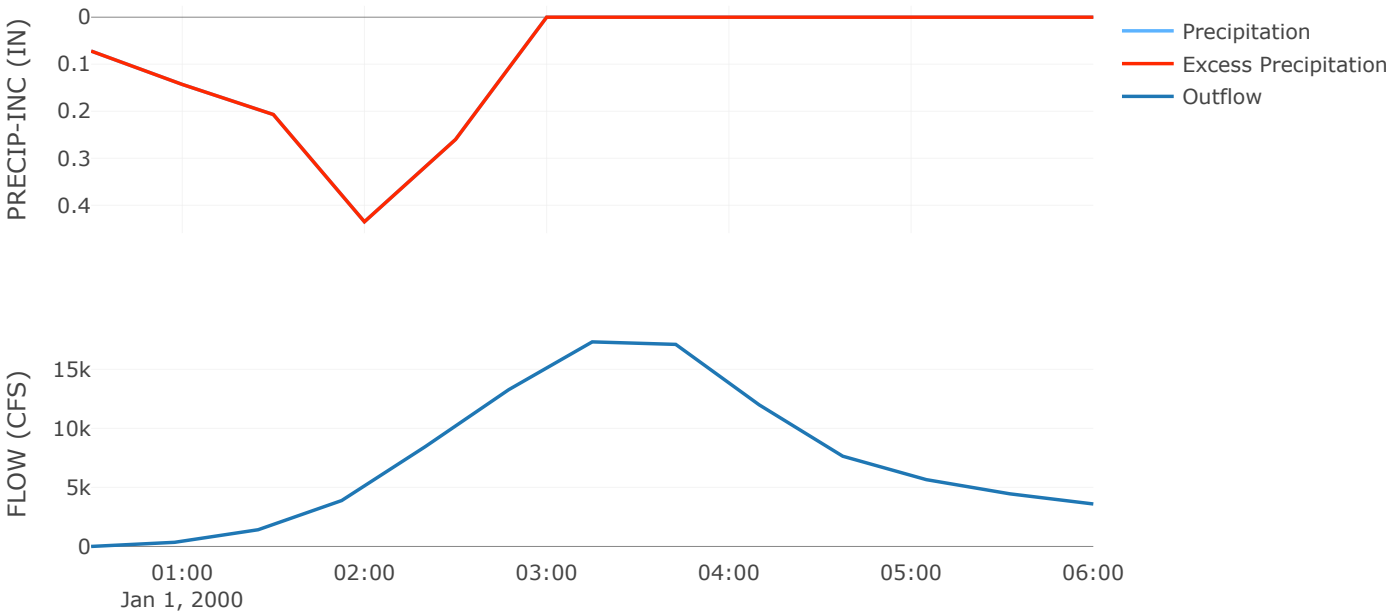
Subbasin: Basin-1

Area (MI^2) : 81.9

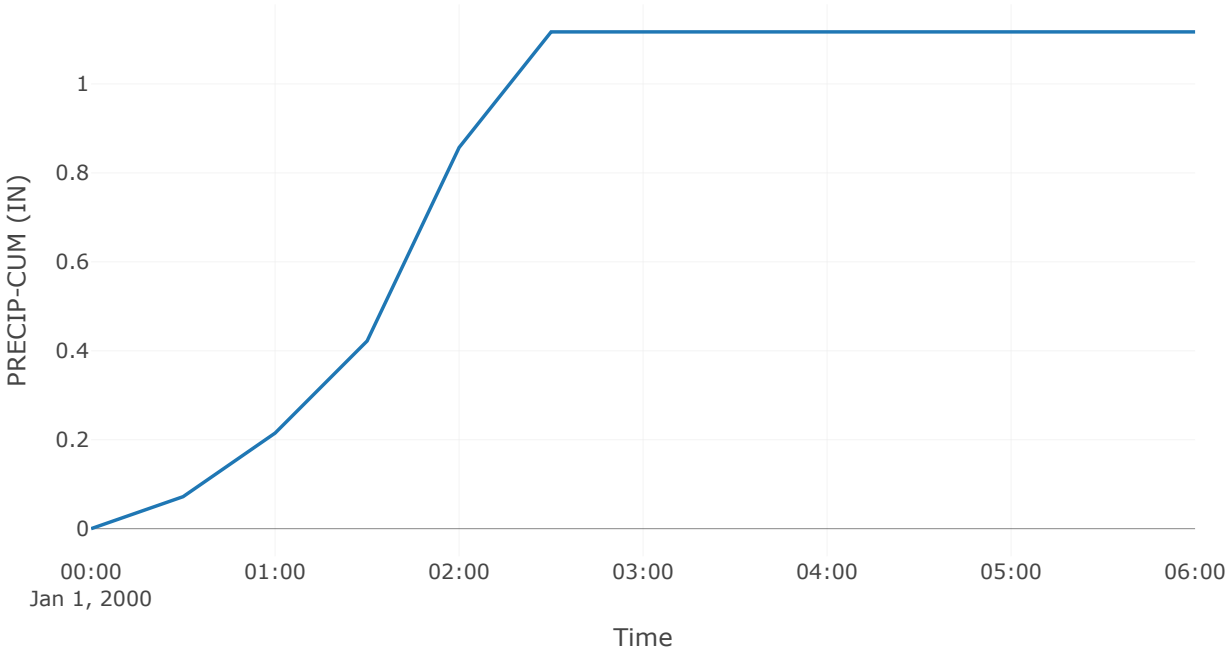
Transform: User - Specified S - Graph	
S - graph	Combined S - Graph
Lag Method	Specified
Lag	1.95

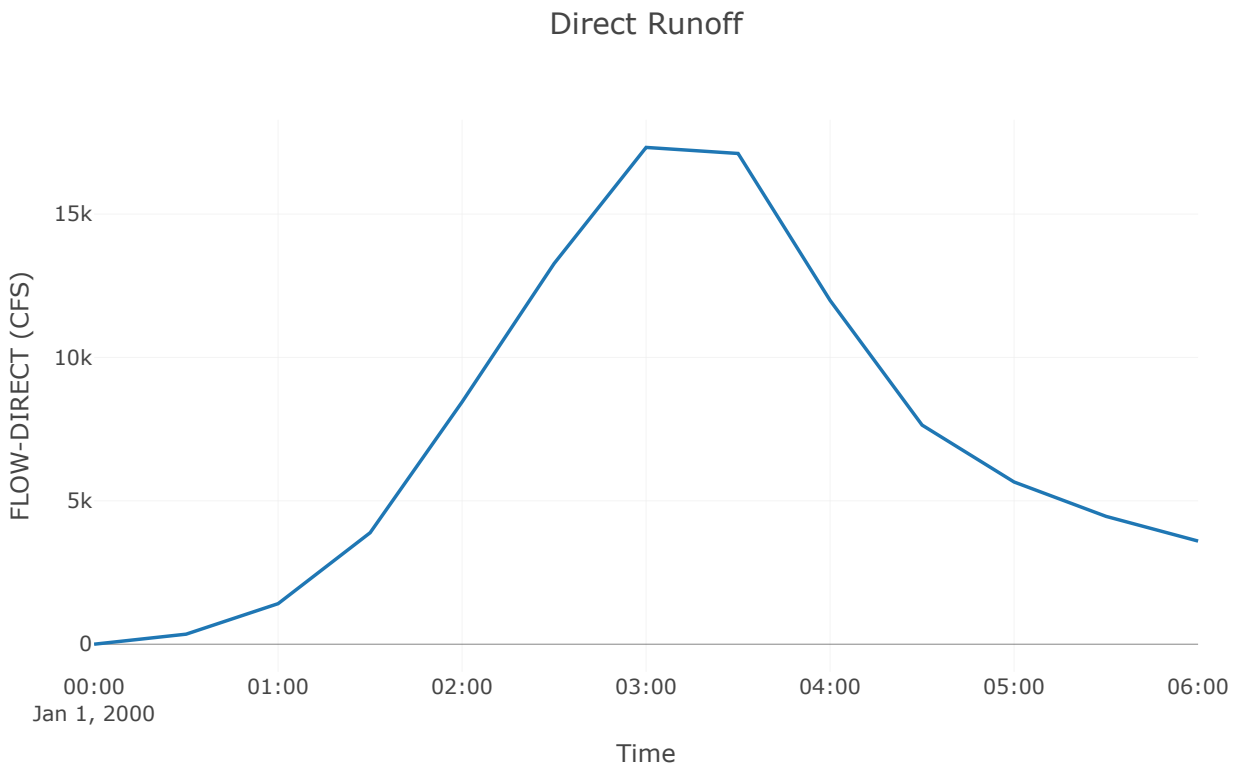
Results: Basin-1	
Peak Discharge (CFS)	17323.61
Time of Peak Discharge	01Jan2000, 03:00
Volume (IN)	1.11
Precipitation Volume (AC - FT)	4879.06
Loss Volume (AC - FT)	0
Excess Volume (AC - FT)	4879.06
Direct Runoff Volume (AC - FT)	4867.27
Baseflow Volume (AC - FT)	0

Precipitation and Outflow



Cumulative Precipitation




Direct Runoff
FLOW-DIRECT (CFS)
15k
10k
5k
0
00:00
Jan 1, 2000
01:00
02:00
03:00
04:00
05:00
06:00
Time

Project: Sapphire_Solar
Simulation Run: 06h 10yr
Simulation Start: 31 December 1999, 24:00
Simulation End: 1 January 2000, 18:00

HMS Version: 4.9
Executed: 04 October 2022, 22:57

Global Parameter Summary - Subbasin

Area (MI^2)

Element Name	Area (MI^2)
Basin - 1	81.9

Transform: User - Specified S - Graph

Element Name	S - graph	Lag Method	Lag
Basin - 1	Combined S - Graph	Specified	1.95

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Basin - 1	81.9	5890.54	01Jan2000, 06:30	0.35

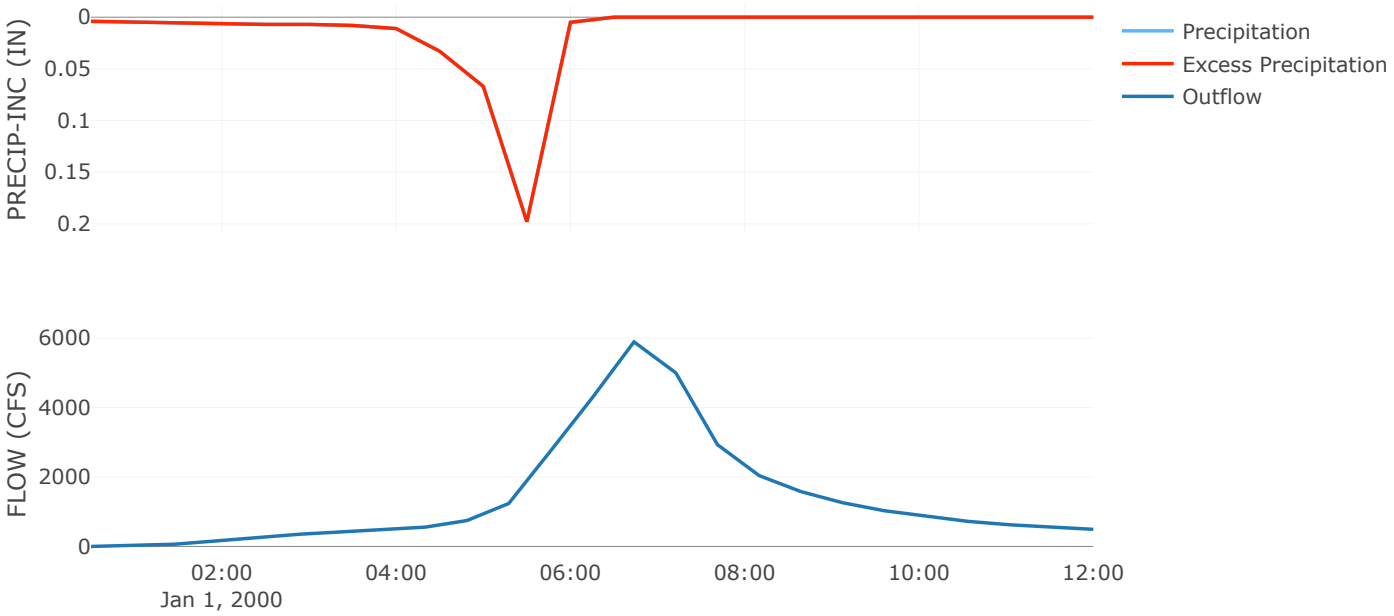
Subbasin: Basin-1

Area (MI^2) : 81.9

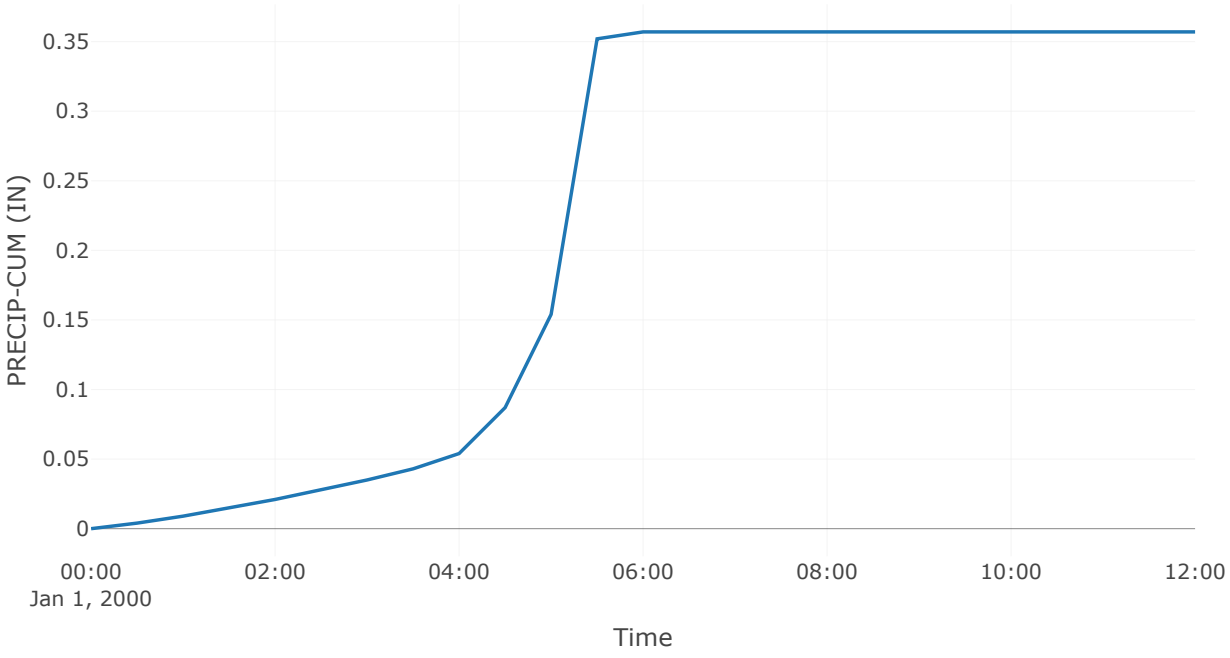
Transform: User - Specified S - Graph	
S - graph	Combined S - Graph
Lag Method	Specified
Lag	1.95

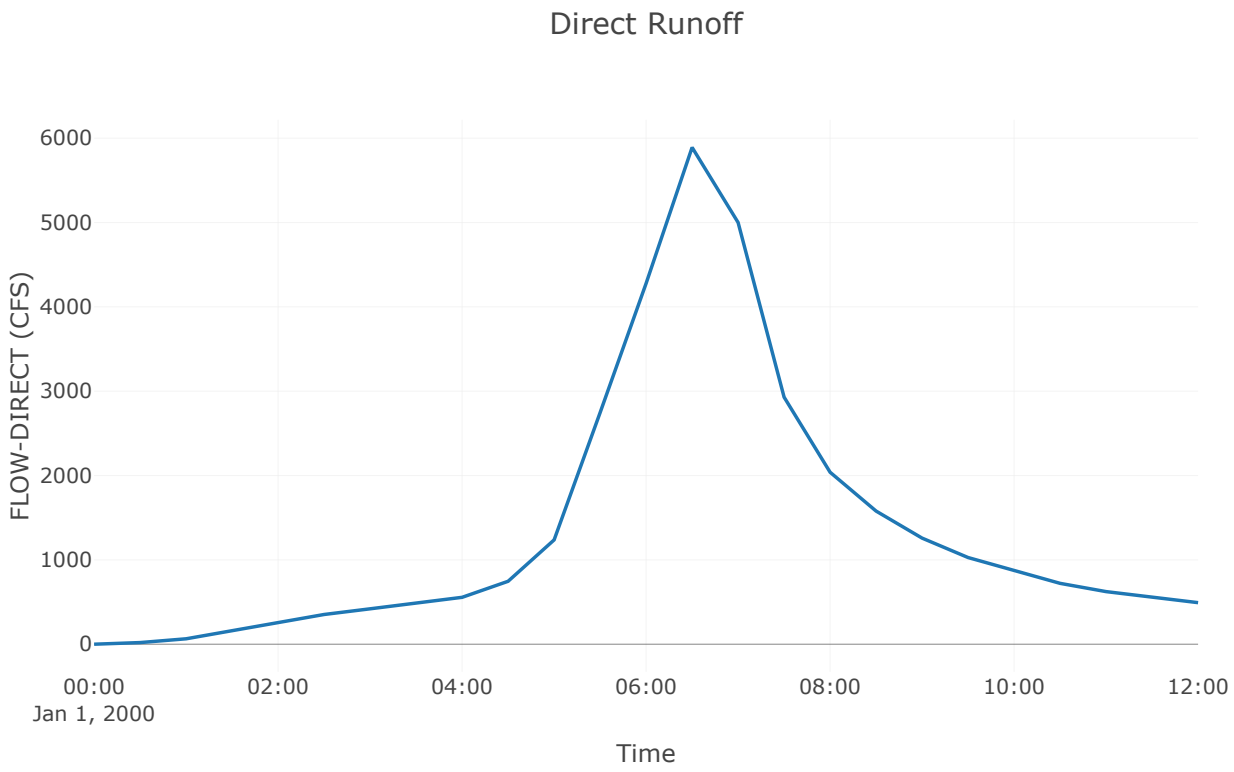
Results: Basin-1	
Peak Discharge (CFS)	5890.54
Time of Peak Discharge	01Jan2000, 06:30
Volume (IN)	0.35
Precipitation Volume (AC - FT)	1559.38
Loss Volume (AC - FT)	0
Excess Volume (AC - FT)	1559.38
Direct Runoff Volume (AC - FT)	1537.61
Baseflow Volume (AC - FT)	0

Precipitation and Outflow



Cumulative Precipitation




Direct Runoff
6000
5000
4000
3000
2000
1000
0
FLOW-DIRECT (CFS)
00:00
Jan 1, 2000
02:00
04:00
06:00
08:00
10:00
12:00
Time

Project: Sapphire_Solar
Simulation Run: 06h 100yr
Simulation Start: 31 December 1999, 24:00
Simulation End: 1 January 2000, 18:00

HMS Version: 4.9
Executed: 04 October 2022, 22:57

Global Parameter Summary - Subbasin

Area (MI^2)

Element Name	Area (MI^2)
Basin - 1	81.9

Transform: User - Specified S - Graph

Element Name	S - graph	Lag Method	Lag
Basin - 1	Combined S - Graph	Specified	1.95

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Basin - 1	81.9	16842.59	01Jan2000, 06:30	1.08

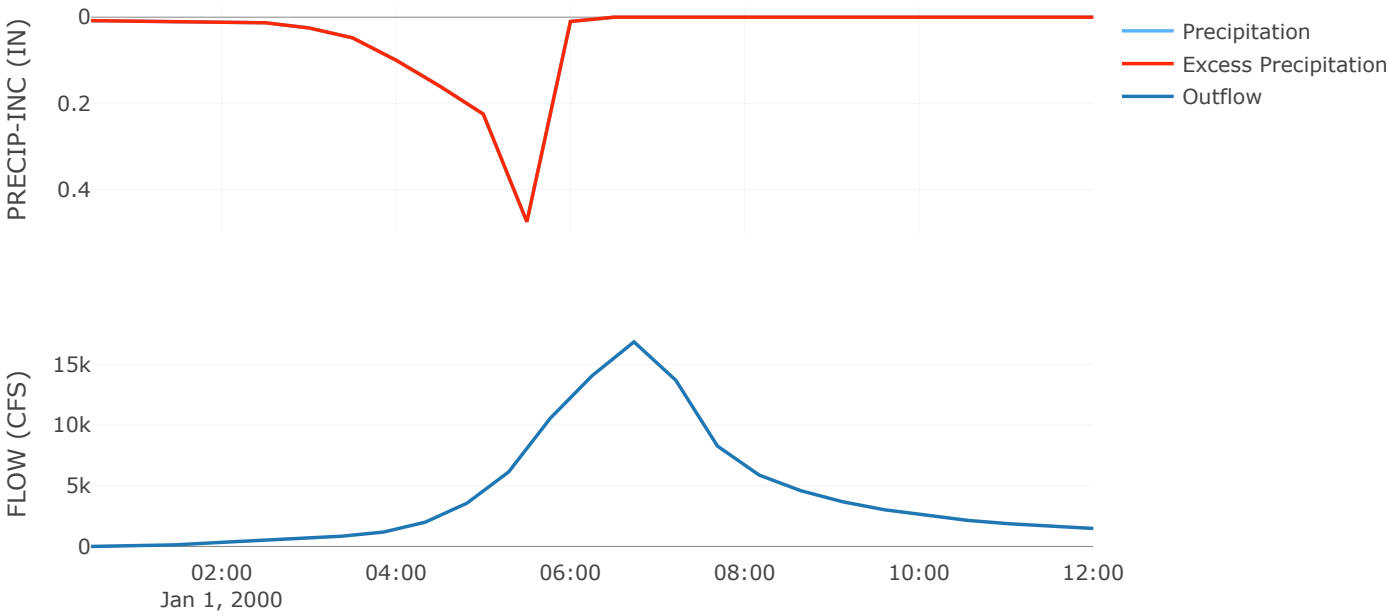
Subbasin: Basin-1

Area (MI^2) : 81.9

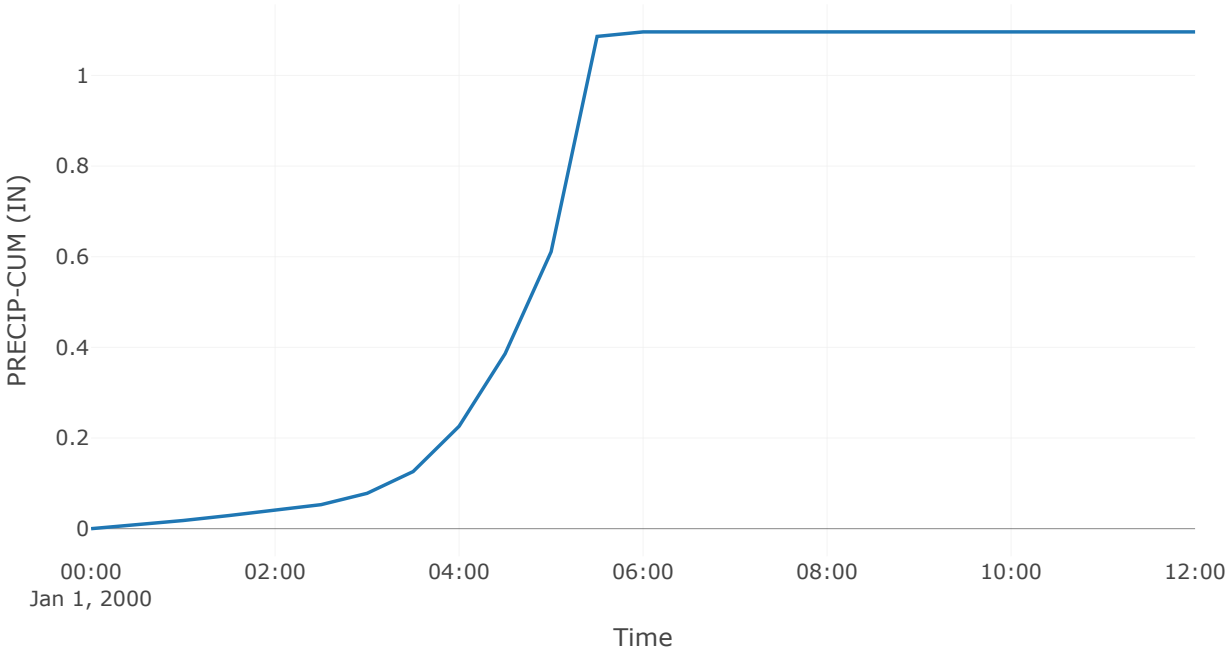
Transform: User - Specified S - Graph	
S - graph	Combined S - Graph
Lag Method	Specified
Lag	1.95

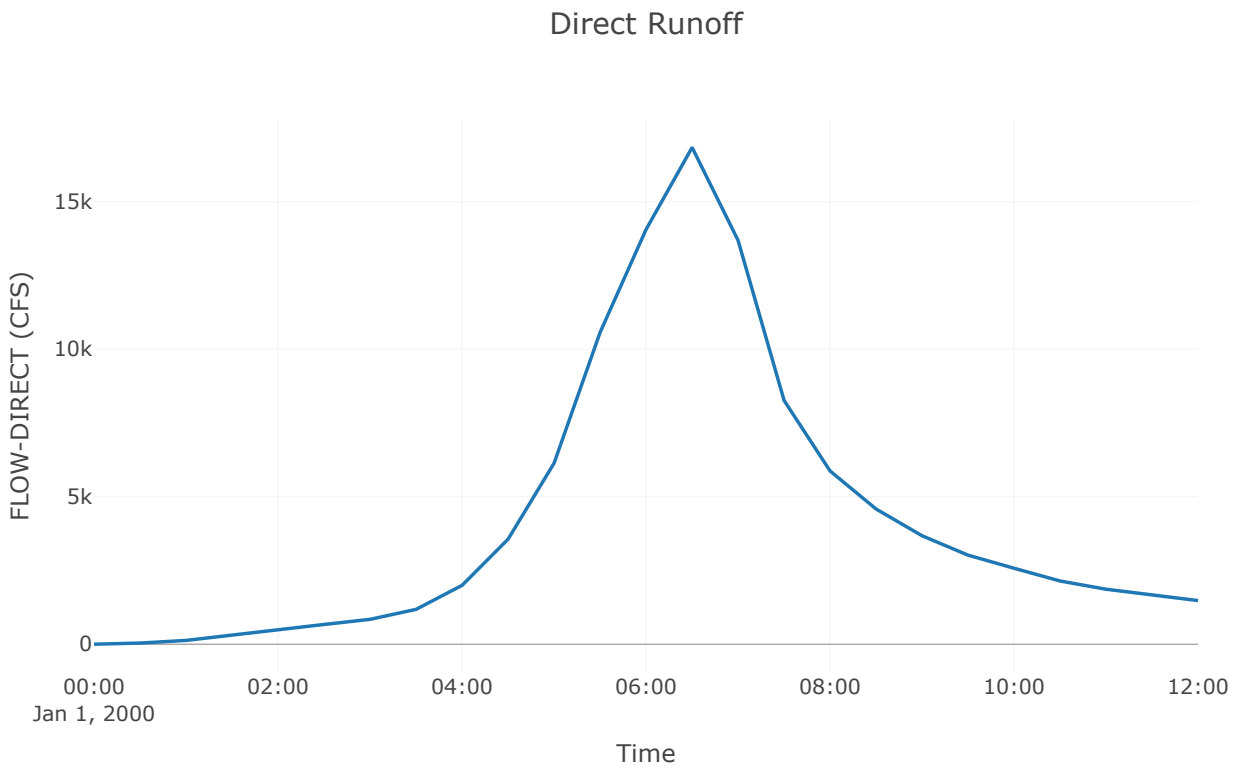
Results: Basin-1	
Peak Discharge (CFS)	16842.59
Time of Peak Discharge	01Jan2000, 06:30
Volume (IN)	1.08
Precipitation Volume (AC - FT)	4787.33
Loss Volume (AC - FT)	0
Excess Volume (AC - FT)	4787.33
Direct Runoff Volume (AC - FT)	4723.58
Baseflow Volume (AC - FT)	0

Precipitation and Outflow



Cumulative Precipitation




Direct Runoff
15k
10k
5k
0
FLOW-DIRECT (CFS)
00:00
Jan 1, 2000
02:00
04:00
06:00
08:00
10:00
12:00
Time

Project: Sapphire_Solar
Simulation Run: 24h 10yr
Simulation Start: 31 December 1999, 24:00
Simulation End: 2 January 2000, 06:00

HMS Version: 4.9
Executed: 04 October 2022, 22:57

Global Parameter Summary - Subbasin

Area (MI^2)

Element Name	Area (MI^2)
Basin - 1	81.9

Transform: User - Specified S - Graph

Element Name	S - graph	Lag Method	Lag
Basin - 1	Combined S - Graph	Specified	1.95

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Basin - 1	81.9	1700.12	01Jan2000, 14:30	0.25

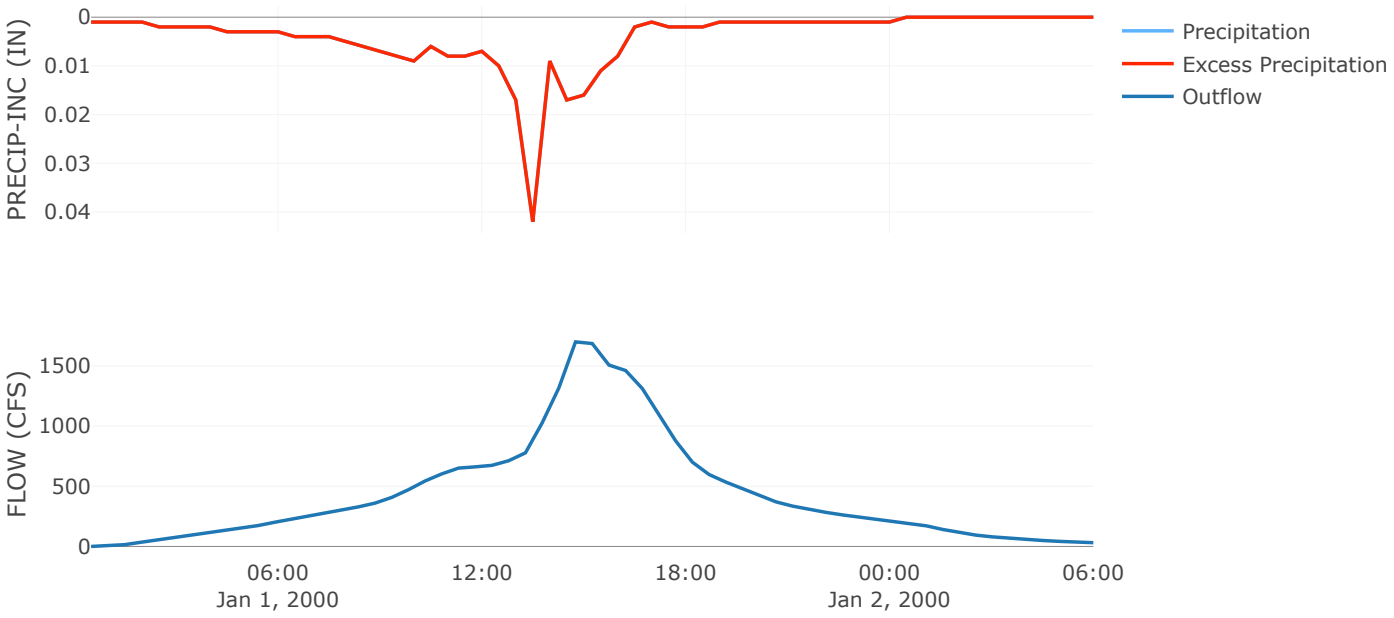
Subbasin: Basin-1

Area (MI^2) : 81.9

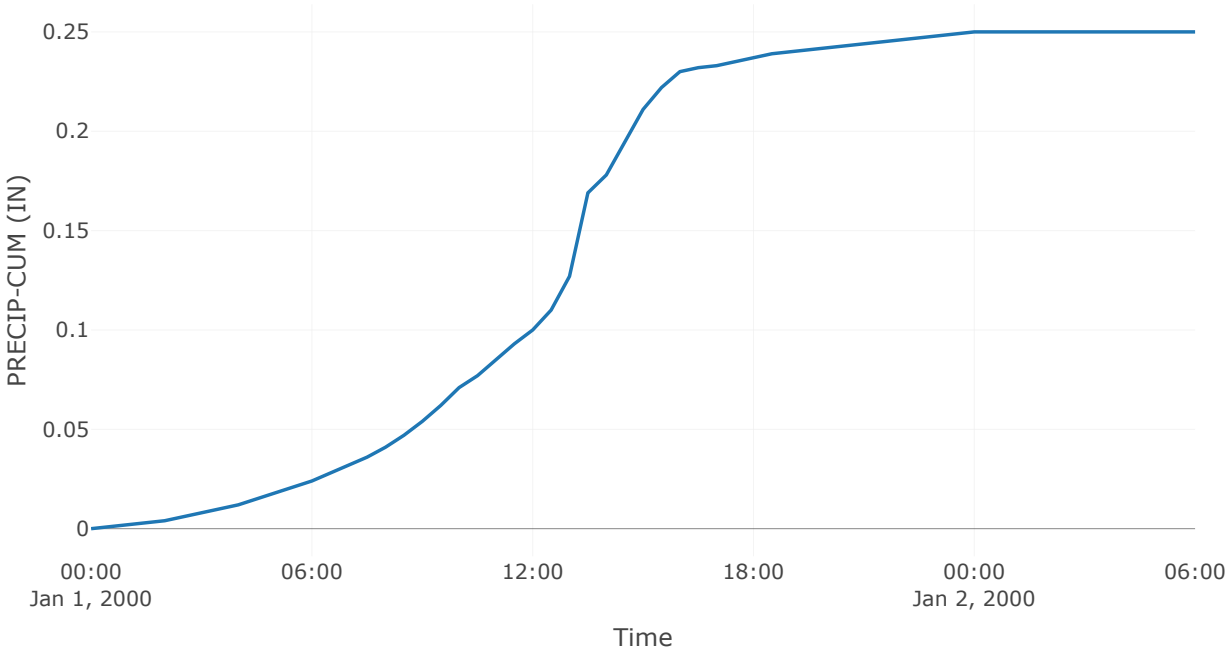
Transform: User - Specified S - Graph	
S - graph	Combined S - Graph
Lag Method	Specified
Lag	1.95

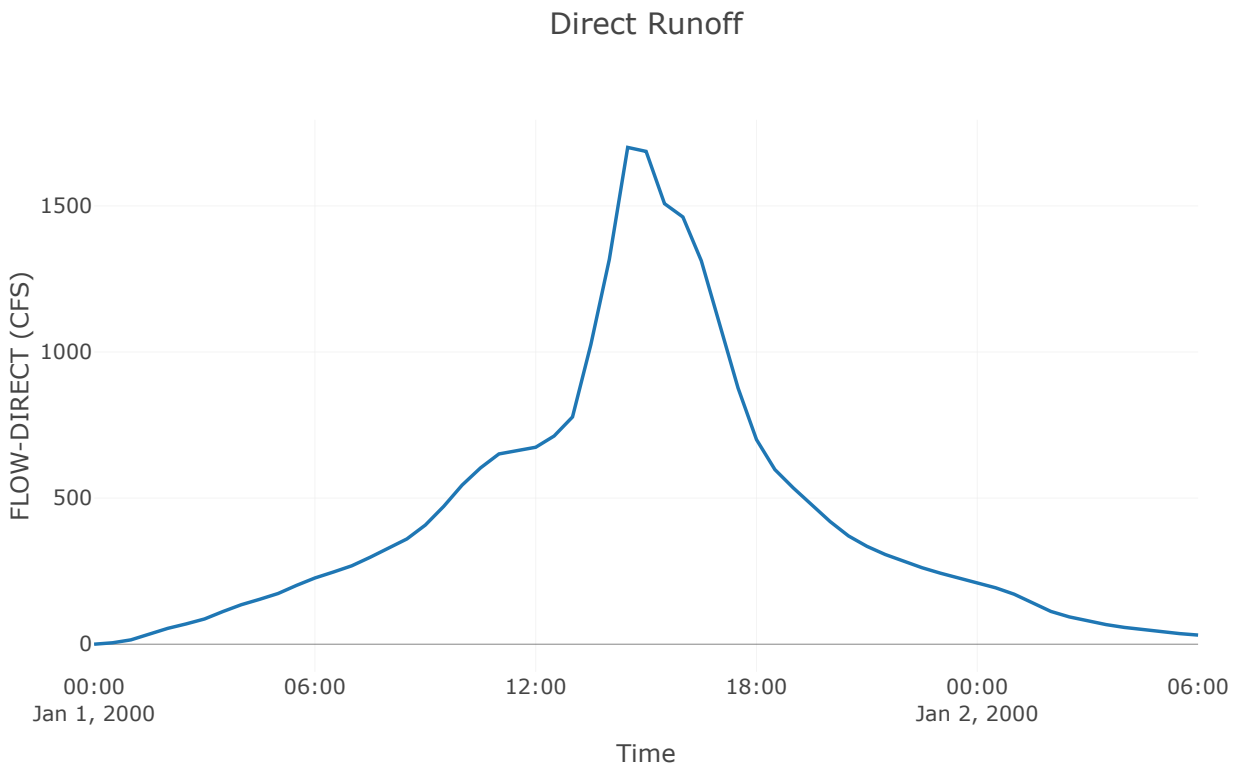
Results: Basin-1	
Peak Discharge (CFS)	1700.12
Time of Peak Discharge	01Jan2000, 14:30
Volume (IN)	0.25
Precipitation Volume (AC - FT)	1092
Loss Volume (AC - FT)	0
Excess Volume (AC - FT)	1092
Direct Runoff Volume (AC - FT)	1086.18
Baseflow Volume (AC - FT)	0

Precipitation and Outflow



Cumulative Precipitation




Direct Runoff
FLOW-DIRECT (CFS)
1500
1000
500
0
00:00
Jan 1, 2000
06:00
12:00
18:00
00:00
Jan 2, 2000
06:00
Time

Project: Sapphire_Solar
Simulation Run: 24hr 100yr
Simulation Start: 31 December 1999, 24:00
Simulation End: 2 January 2000, 06:00

HMS Version: 4.9
Executed: 04 October 2022, 22:57

Global Parameter Summary - Subbasin

Area (MI^2)

Element Name	Area (MI^2)
Basin - 1	81.9

Transform: User - Specified S - Graph

Element Name	S - graph	Lag Method	Lag
Basin - 1	Combined S - Graph	Specified	1.95

Global Results Summary

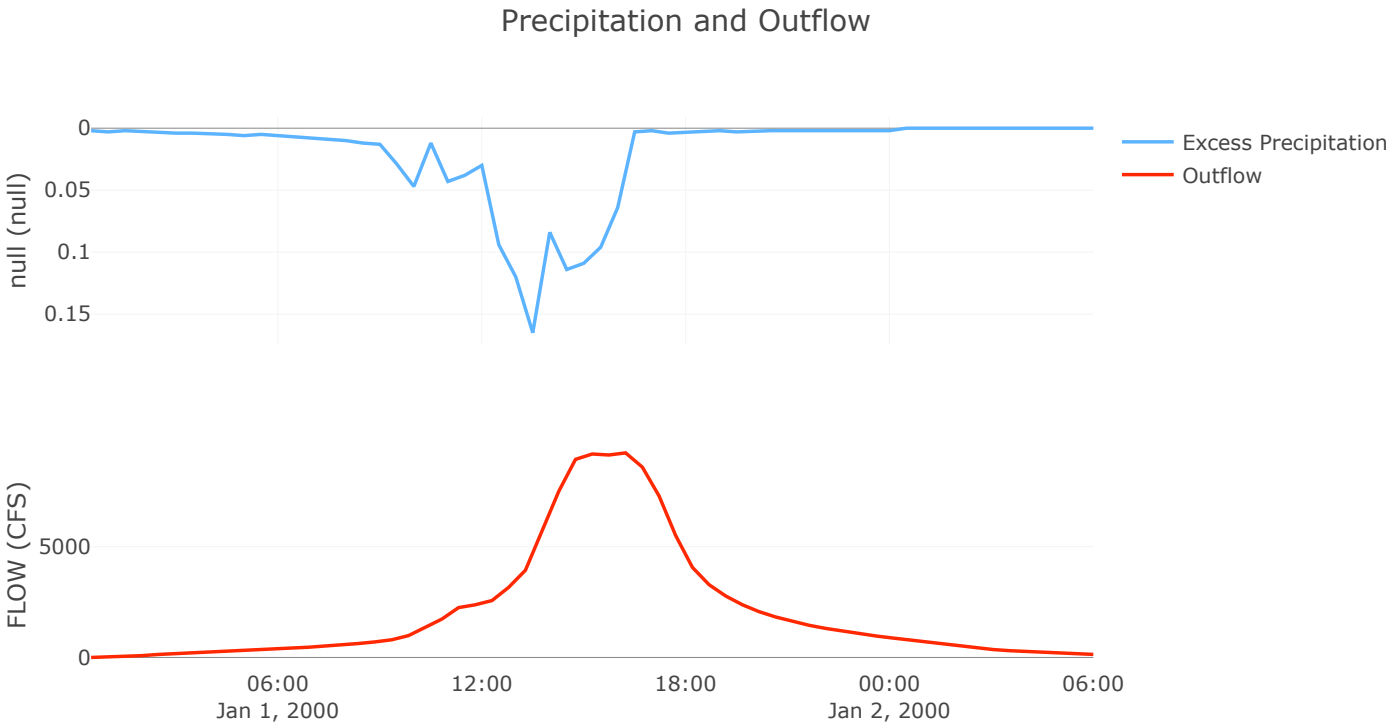
Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Basin - 1	81.9	9241.09	01Jan2000, 16:00	1.18

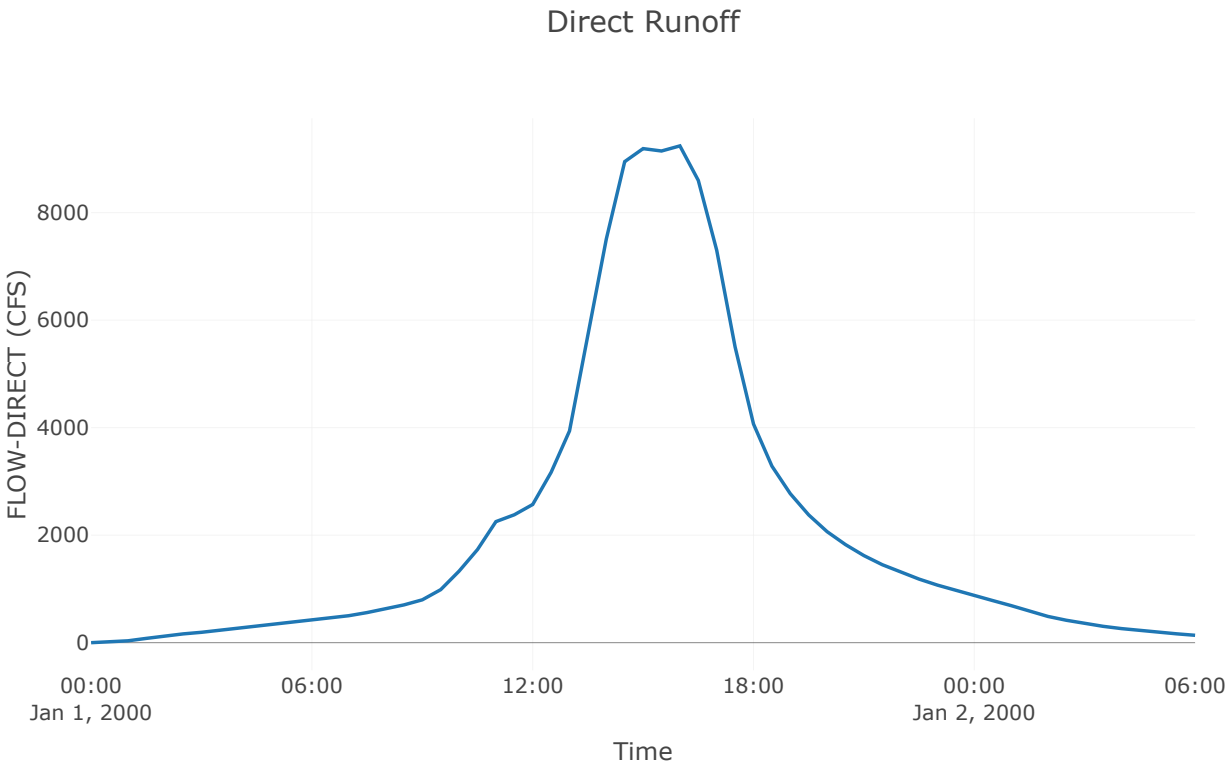
Subbasin: Basin-1

Area (MI^2) : 81.9

Transform: User - Specified S - Graph	
S - graph	Combined S - Graph
Lag Method	Specified
Lag	1.95

Results: Basin-1	
Peak Discharge (CFS)	9241.09
Time of Peak Discharge	01Jan2000, 16:00
Volume (IN)	1.18
Precipitation Volume (AC - FT)	5189.18
Loss Volume (AC - FT)	0
Excess Volume (AC - FT)	5189.18
Direct Runoff Volume (AC - FT)	5168.57
Baseflow Volume (AC - FT)	0


Precipitation and Outflow
Excess Precipitation
Outflow
null (null)
0
0.05
0.1
0.15
FLOW (CFS)
5000
0
06:00
Jan 1, 2000
12:00
18:00
00:00
Jan 2, 2000
06:00


Direct Runoff
FLOW-DIRECT (CFS)
8000
6000
4000
2000
0
00:00
Jan 1, 2000
06:00
12:00
18:00
00:00
Jan 2, 2000
06:00
Time

Project: Basin2
Simulation Run: 03h 10yr
Simulation Start: 31 December 1999, 24:00
Simulation End: 1 January 2000, 18:00

HMS Version: 4.9
Executed: 04 October 2022, 23:05

Global Parameter Summary - Subbasin

Area (MI^2)

Element Name	Area (MI^2)
Basin - 2	29.6

Transform: User - Specified S - Graph

Element Name	S - graph	Lag Method	Lag
Basin - 2	Combined S - Graph	Specified	1.37

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Basin - 2	29.6	2328.3	01Jan2000, 03:30	0.3

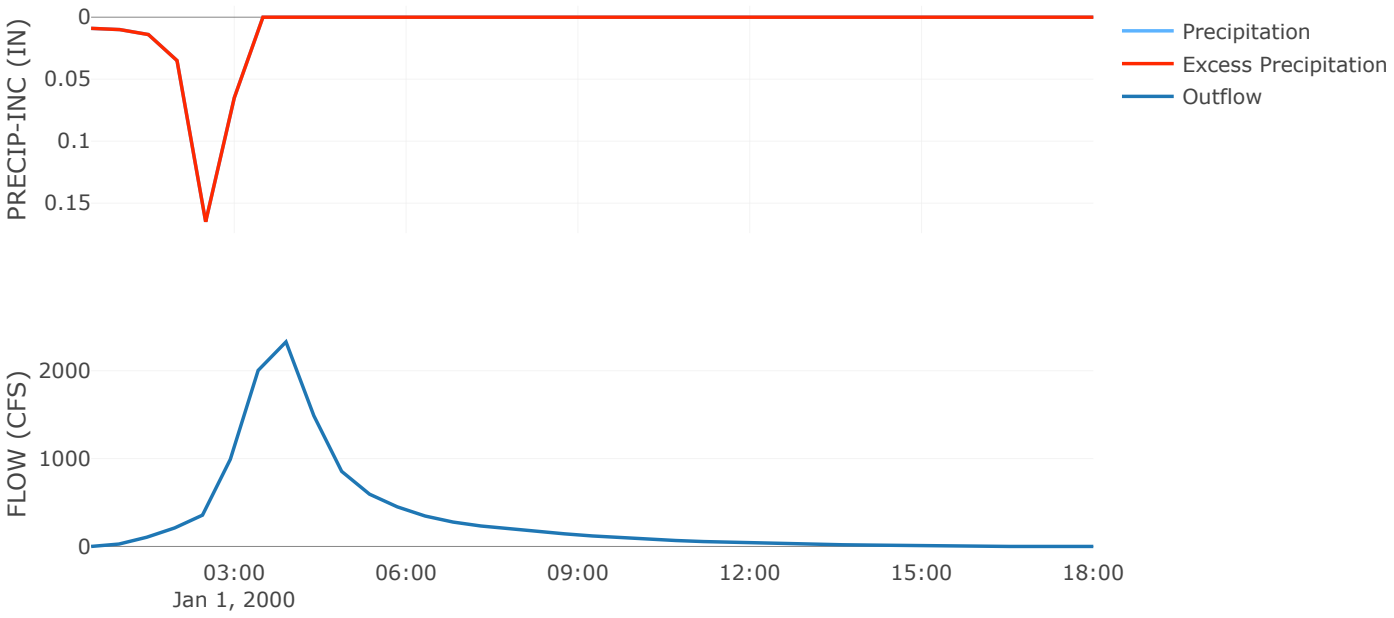
Subbasin: Basin-2

Area (MI^2) : 29.6

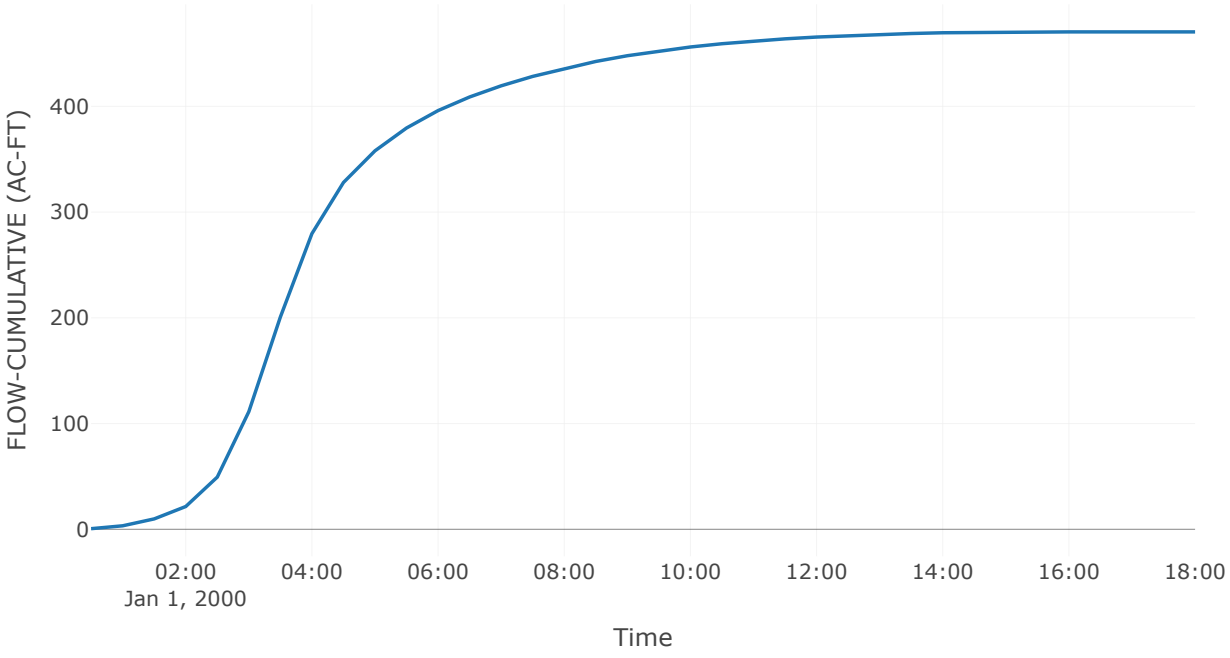
Transform: User - Specified S - Graph	
S - graph	Combined S - Graph
Lag Method	Specified
Lag	1.37

Results: Basin-2	
Peak Discharge (CFS)	2328.3
Time of Peak Discharge	01Jan2000, 03:30
Volume (IN)	0.3
Precipitation Volume (AC - FT)	470.44
Loss Volume (AC - FT)	0
Excess Volume (AC - FT)	470.44
Direct Runoff Volume (AC - FT)	470.44
Baseflow Volume (AC - FT)	0

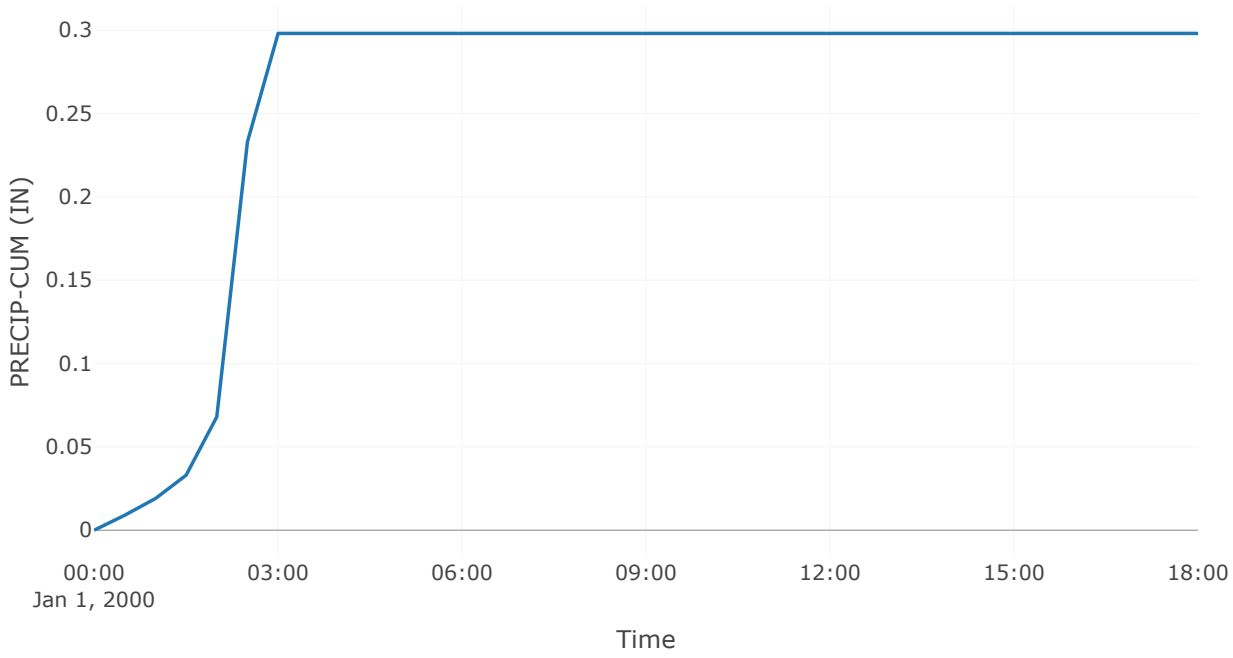
Precipitation and Outflow



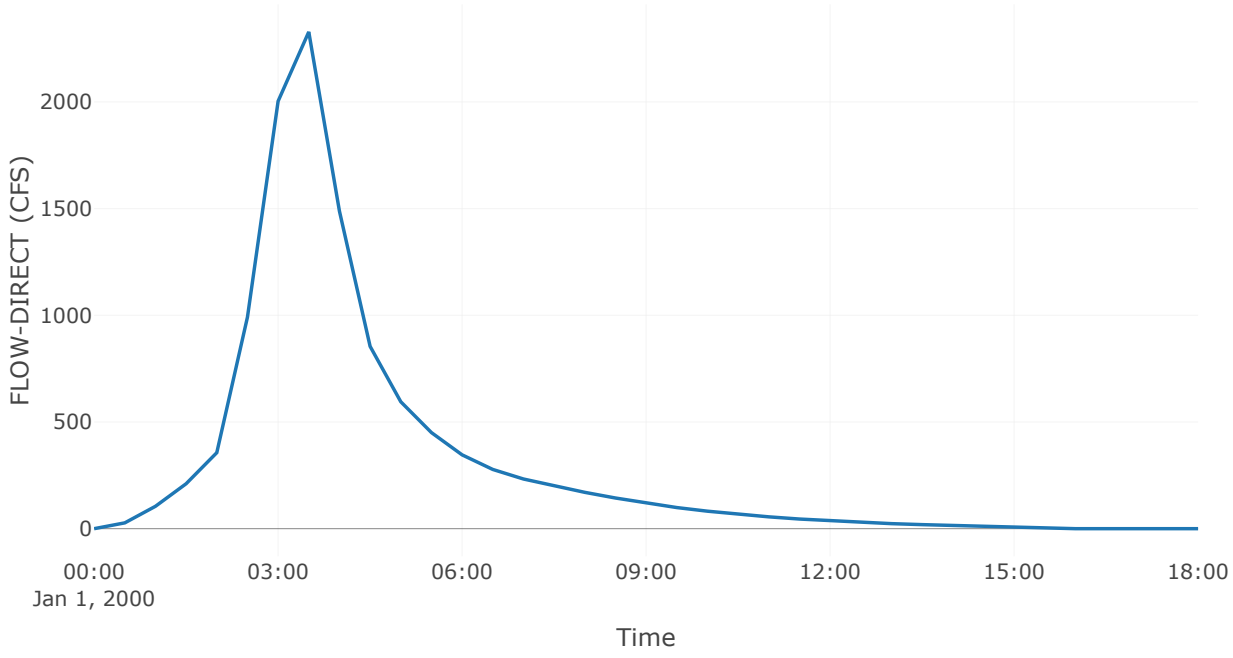
Cumulative Outflow



Cumulative Precipitation



Direct Runoff



Project: Basin2
Simulation Run: 03h 100yr
Simulation Start: 31 December 1999, 24:00
Simulation End: 1 January 2000, 18:00

HMS Version: 4.9
Executed: 04 October 2022, 23:05

Global Parameter Summary - Subbasin

Area (MI^2)

Element Name	Area (MI^2)
Basin - 2	29.6

Transform: User - Specified S - Graph

Element Name	S - graph	Lag Method	Lag
Basin - 2	Combined S - Graph	Specified	1.37

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Basin - 2	29.6	7655.47	01Jan2000, 03:30	1.09

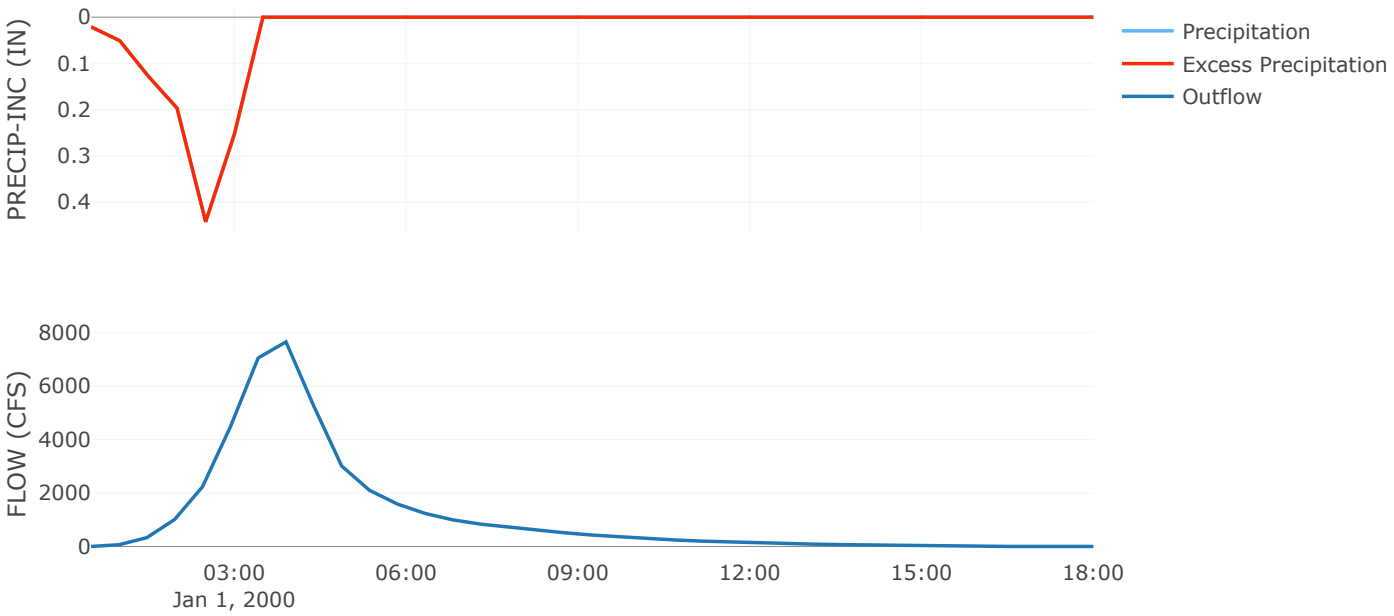
Subbasin: Basin-2

Area (MI^2) : 29.6

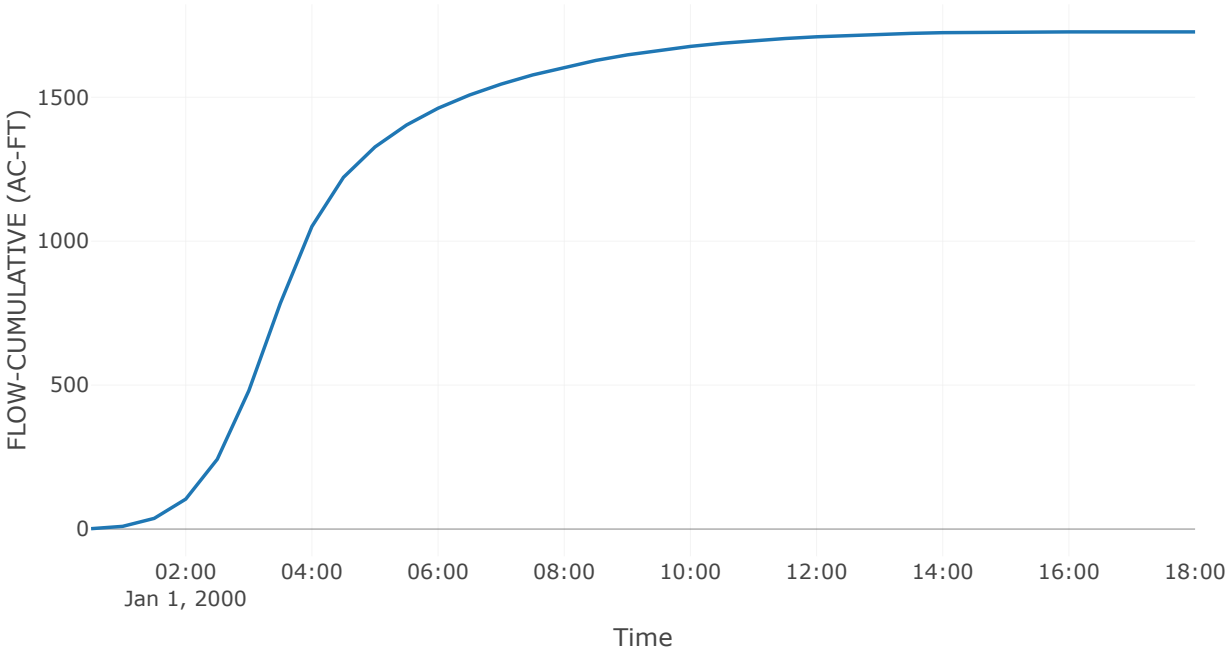
Transform: User - Specified S - Graph	
S - graph	Combined S - Graph
Lag Method	Specified
Lag	1.37

Results: Basin-2	
Peak Discharge (CFS)	7655.47
Time of Peak Discharge	01Jan2000, 03:30
Volume (IN)	1.09
Precipitation Volume (AC - FT)	1727.06
Loss Volume (AC - FT)	0
Excess Volume (AC - FT)	1727.06
Direct Runoff Volume (AC - FT)	1727.06
Baseflow Volume (AC - FT)	0

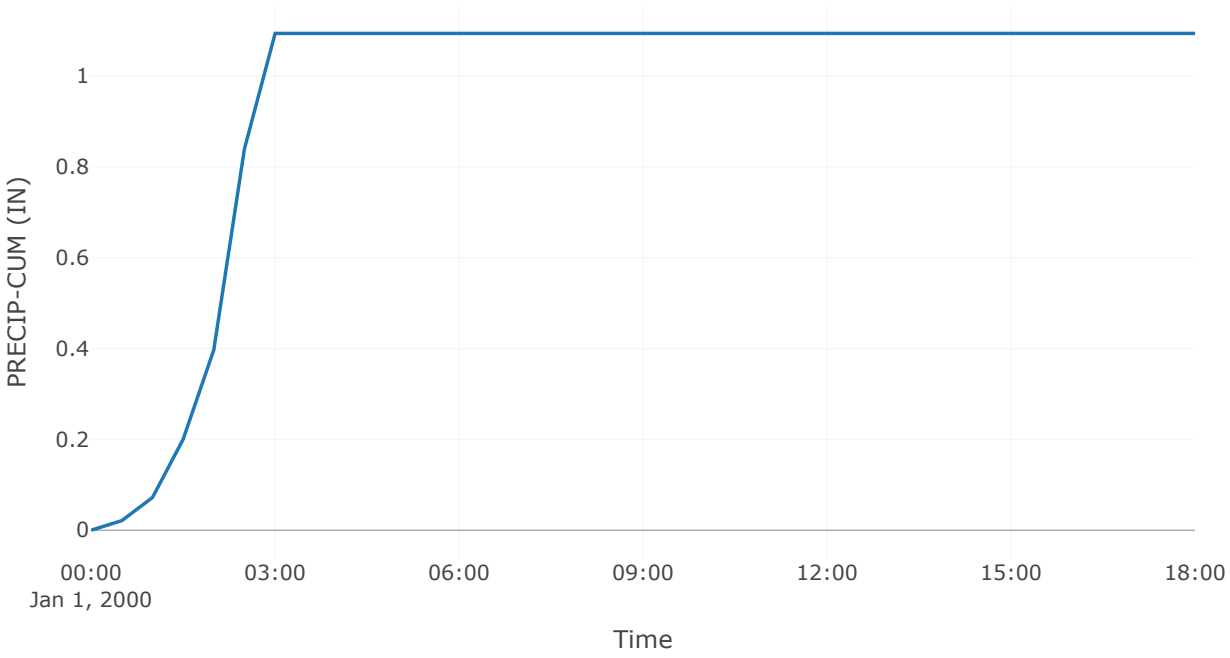
Precipitation and Outflow



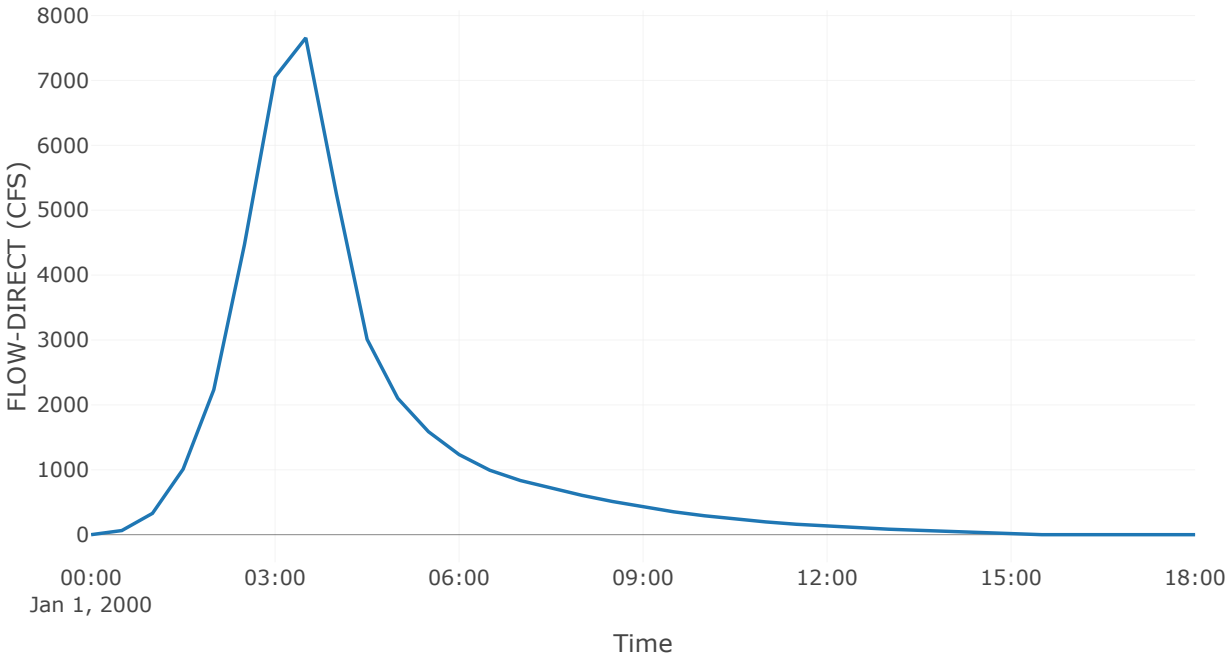
Cumulative Outflow



Cumulative Precipitation



Direct Runoff



Project: Basin2
Simulation Run: 06h 10yr
Simulation Start: 31 December 1999, 24:00
Simulation End: 1 January 2000, 18:00

HMS Version: 4.9
Executed: 04 October 2022, 23:05

Global Parameter Summary - Subbasin

Area (MI^2)

Element Name	Area (MI^2)
Basin - 2	29.6

Transform: User - Specified S - Graph

Element Name	S - graph	Lag Method	Lag
Basin - 2	Combined S - Graph	Specified	1.37

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Basin - 2	29.6	1983.13	01Jan2000, 06:30	0.29

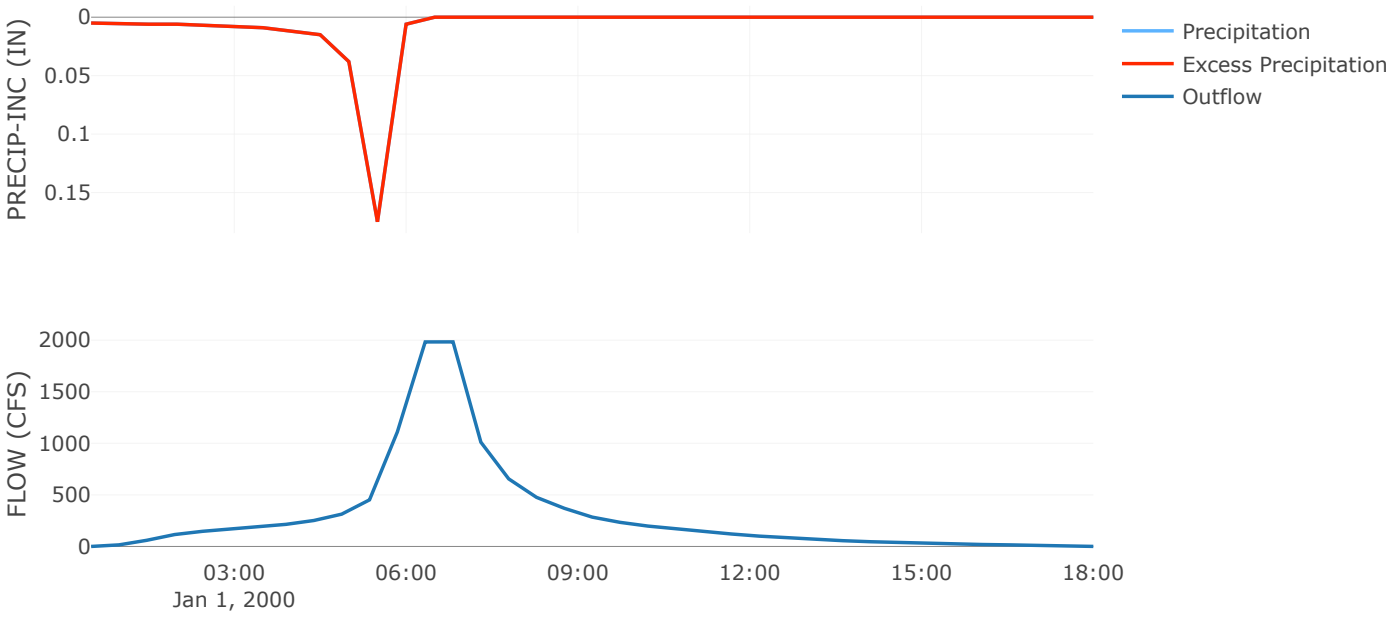
Subbasin: Basin-2

Area (MI^2) : 29.6

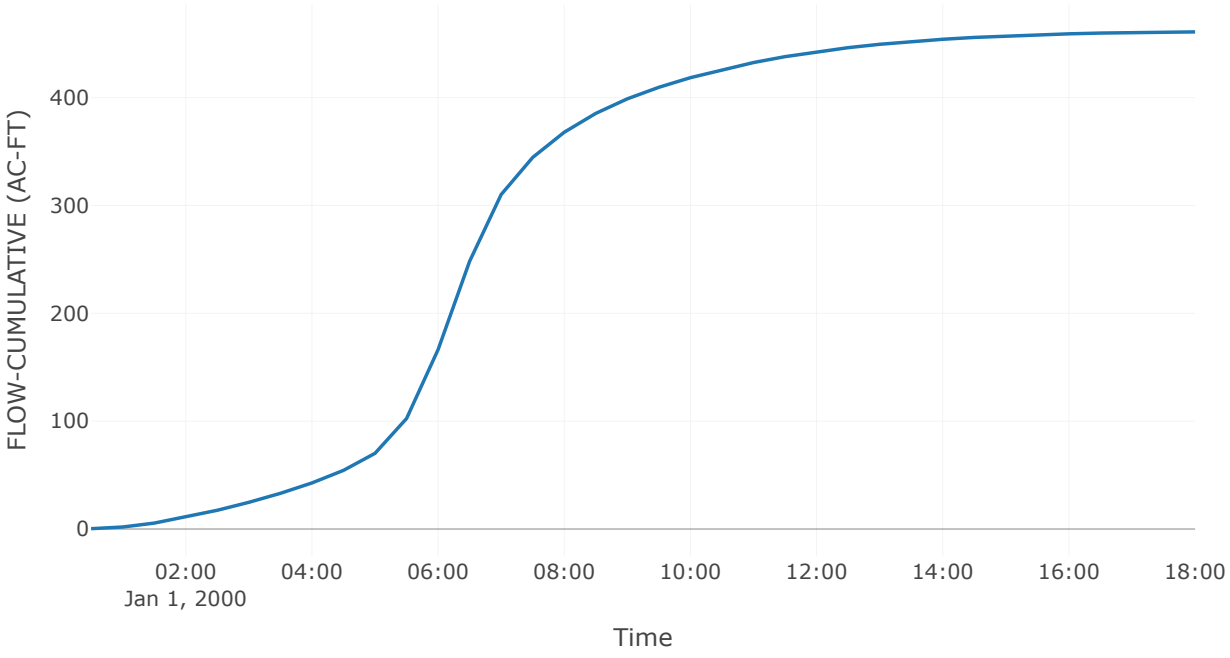
Transform: User - Specified S - Graph	
S - graph	Combined S - Graph
Lag Method	Specified
Lag	1.37

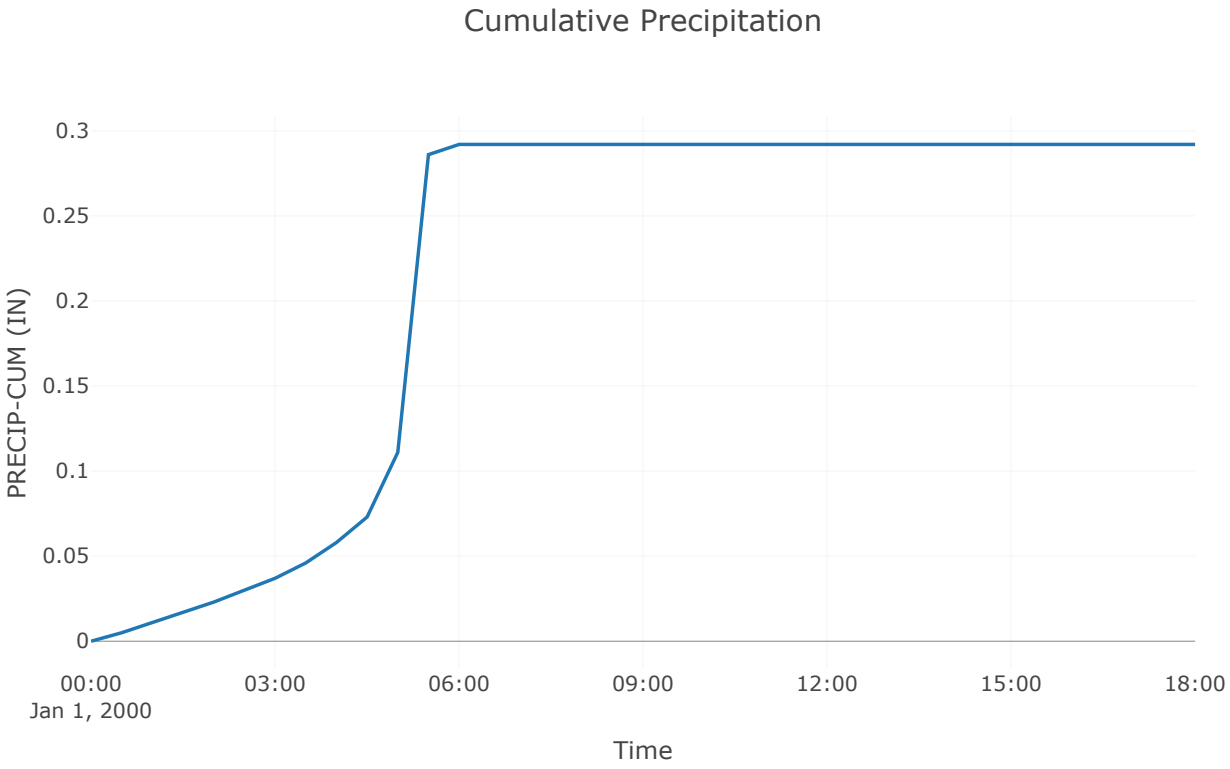
Results: Basin-2	
Peak Discharge (CFS)	1983.13
Time of Peak Discharge	01Jan2000, 06:30
Volume (IN)	0.29
Precipitation Volume (AC - FT)	460.97
Loss Volume (AC - FT)	0
Excess Volume (AC - FT)	460.97
Direct Runoff Volume (AC - FT)	460.97
Baseflow Volume (AC - FT)	0

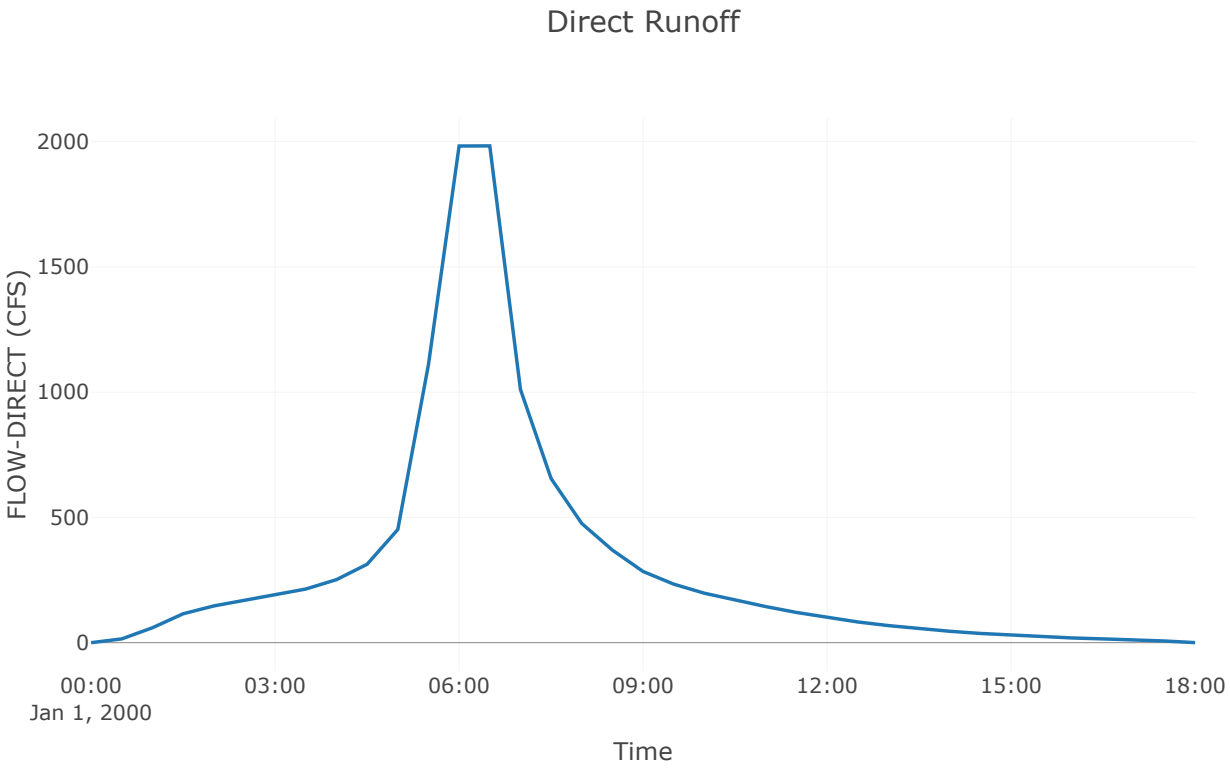
Precipitation and Outflow



Cumulative Outflow




Cumulative Precipitation
PRECIP-CUM (IN)
0.3
0.25
0.2
0.15
0.1
0.05
0
00:00
Jan 1, 2000
03:00
06:00
09:00
12:00
15:00
18:00
Time


Direct Runoff
FLOW-DIRECT (CFS)
2000
1500
1000
500
0
00:00
Jan 1, 2000
03:00
06:00
09:00
12:00
15:00
18:00
Time

Project: Basin2
Simulation Run: 06h 100yr
Simulation Start: 31 December 1999, 24:00
Simulation End: 1 January 2000, 18:00

HMS Version: 4.9
Executed: 04 October 2022, 23:05

Global Parameter Summary - Subbasin

Area (MI^2)

Element Name	Area (MI^2)
Basin - 2	29.6

Transform: User - Specified S - Graph

Element Name	S - graph	Lag Method	Lag
Basin - 2	Combined S - Graph	Specified	1.37

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Basin - 2	29.6	6716.57	01Jan2000, 06:00	0.98

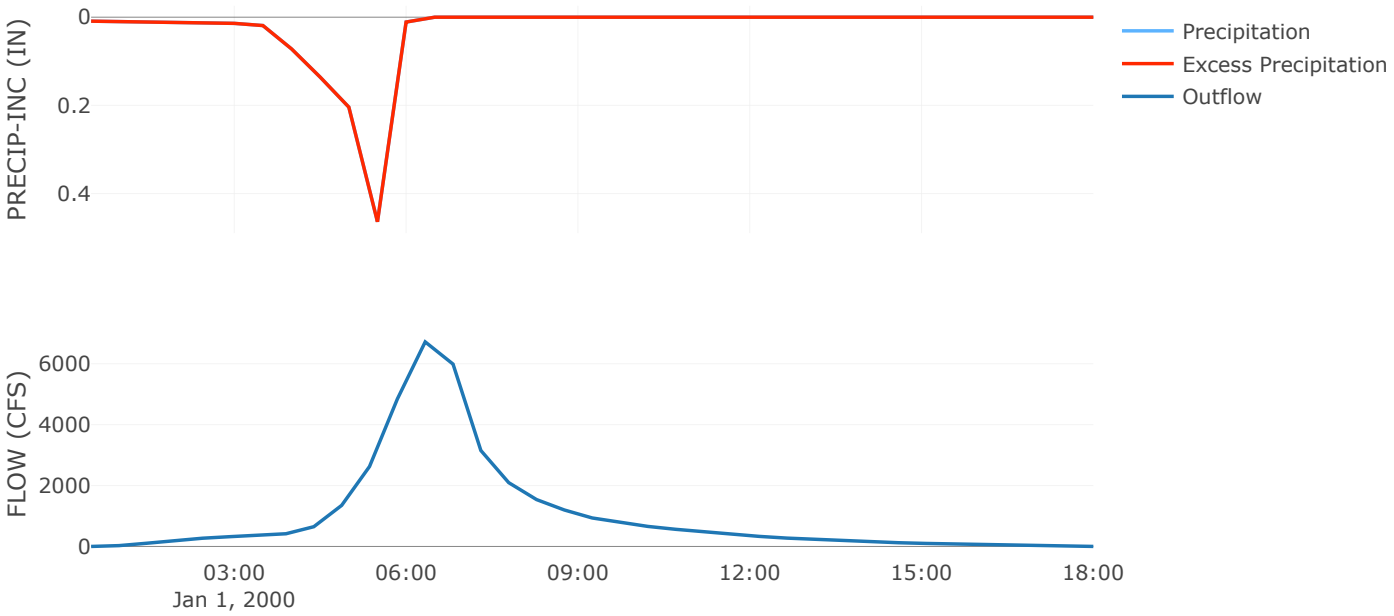
Subbasin: Basin-2

Area (MI^2) : 29.6

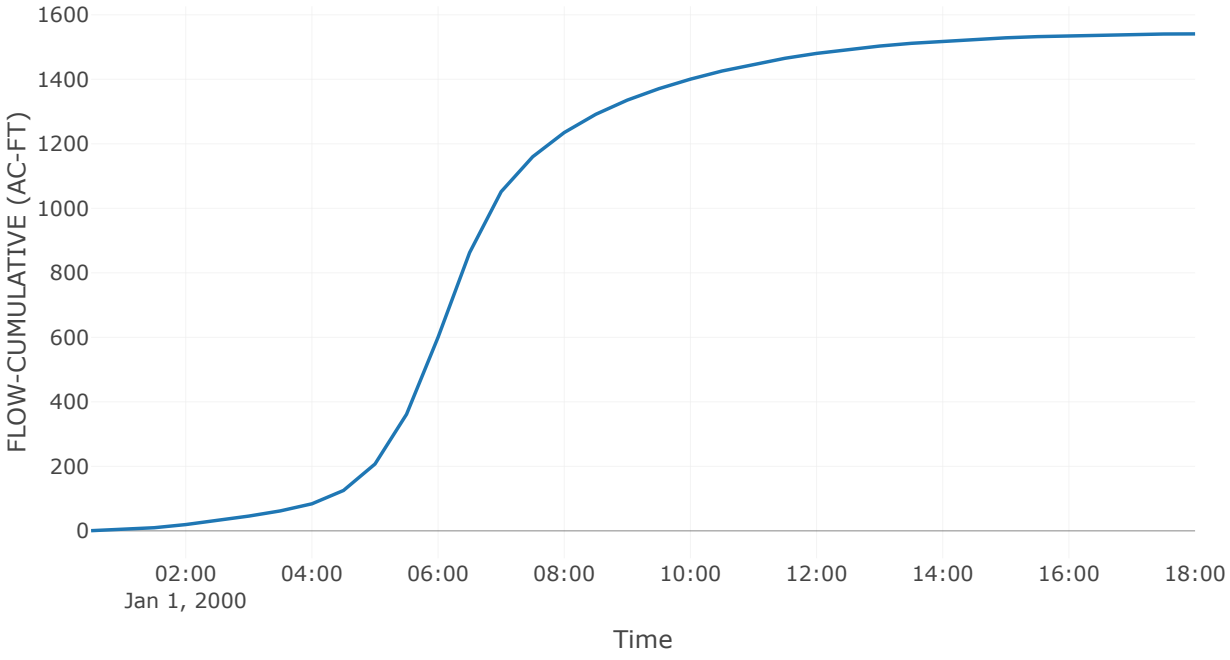
Transform: User - Specified S - Graph	
S - graph	Combined S - Graph
Lag Method	Specified
Lag	1.37

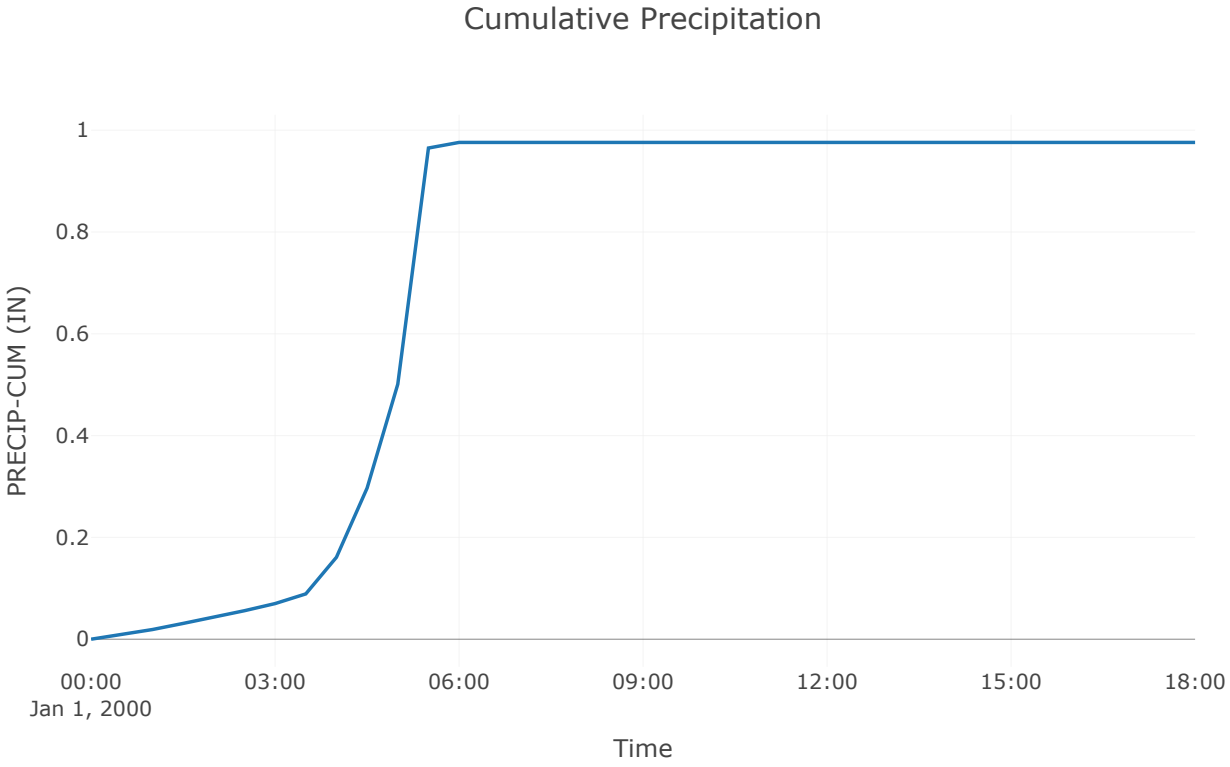
Results: Basin-2	
Peak Discharge (CFS)	6716.57
Time of Peak Discharge	01Jan2000, 06:00
Volume (IN)	0.98
Precipitation Volume (AC - FT)	1540.78
Loss Volume (AC - FT)	0
Excess Volume (AC - FT)	1540.78
Direct Runoff Volume (AC - FT)	1540.77
Baseflow Volume (AC - FT)	0

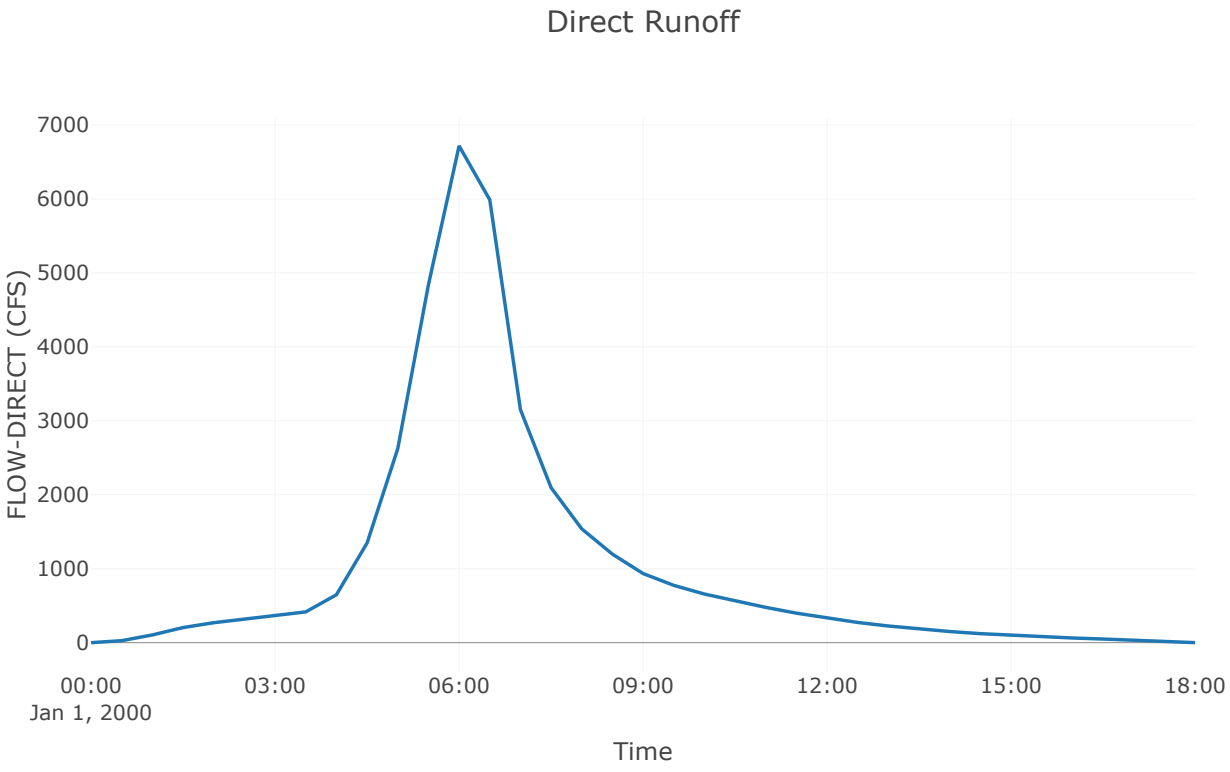
Precipitation and Outflow



Cumulative Outflow




Cumulative Precipitation
PRECIP-CUM (IN)
1
0.8
0.6
0.4
0.2
0
00:00
Jan 1, 2000
03:00
06:00
09:00
12:00
15:00
18:00
Time


Direct Runoff
FLOW-DIRECT (CFS)
7000
6000
5000
4000
3000
2000
1000
0
00:00
Jan 1, 2000
03:00
06:00
09:00
12:00
15:00
18:00
Time

Project: Basin2
Simulation Run: 24h 10yr
Simulation Start: 31 December 1999, 24:00
Simulation End: 2 January 2000, 06:00

HMS Version: 4.9
Executed: 04 October 2022, 23:05

Global Parameter Summary - Subbasin

Area (MI^2)

Element Name	Area (MI^2)
Basin - 2	29.6

Transform: User - Specified S - Graph

Element Name	S - graph	Lag Method	Lag
Basin - 2	Combined S - Graph	Specified	1.37

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Basin - 2	29.6	409.86	01Jan2000, 14:30	0.21

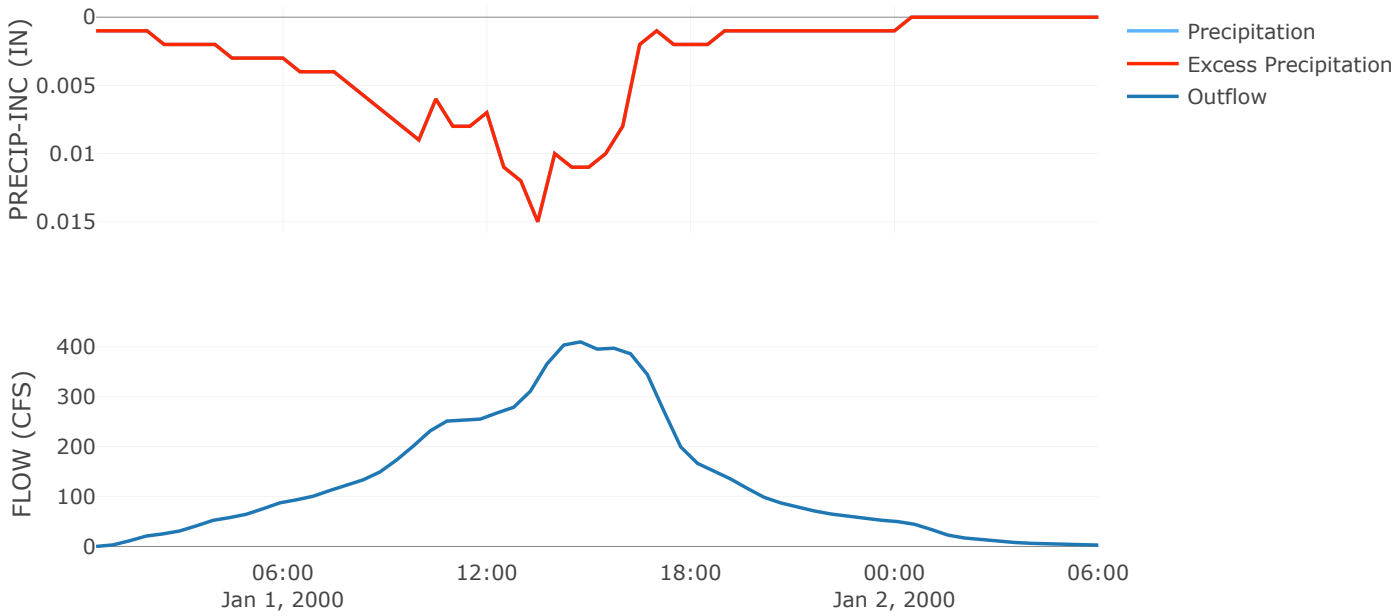
Subbasin: Basin-2

Area (MI^2) : 29.6

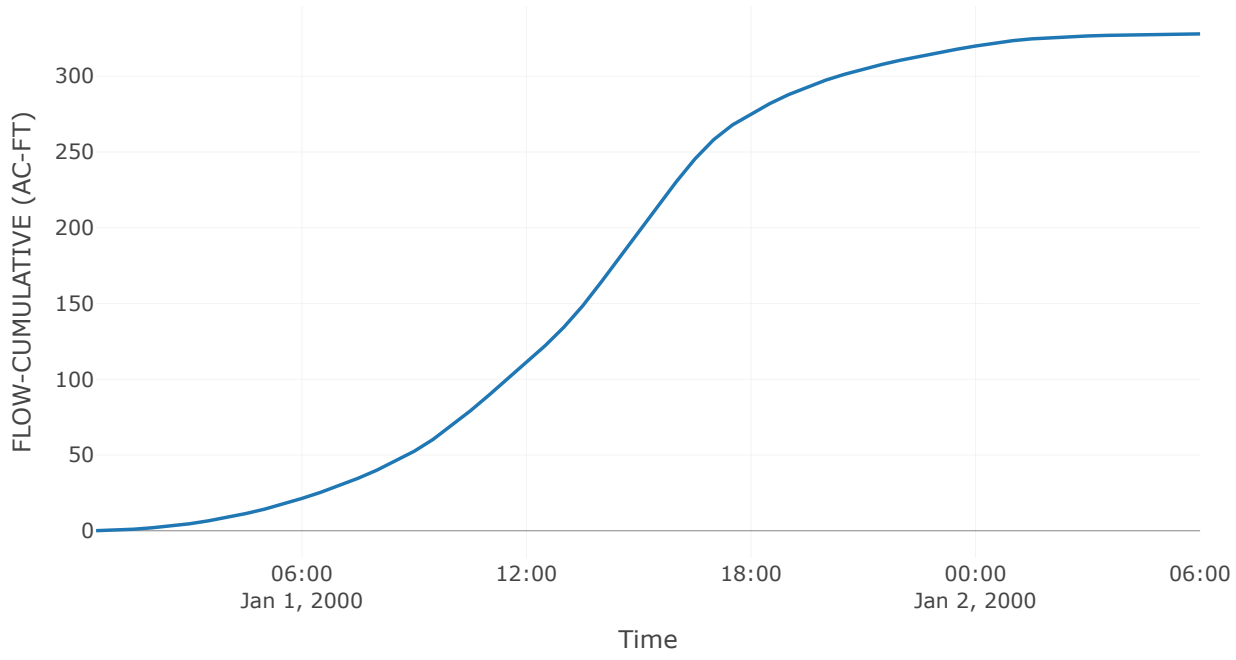
Transform: User - Specified S - Graph	
S - graph	Combined S - Graph
Lag Method	Specified
Lag	1.37

Results: Basin-2	
Peak Discharge (CFS)	409.86
Time of Peak Discharge	01Jan2000, 14:30
Volume (IN)	0.21
Precipitation Volume (AC - FT)	328.36
Loss Volume (AC - FT)	0
Excess Volume (AC - FT)	328.36
Direct Runoff Volume (AC - FT)	327.94
Baseflow Volume (AC - FT)	0

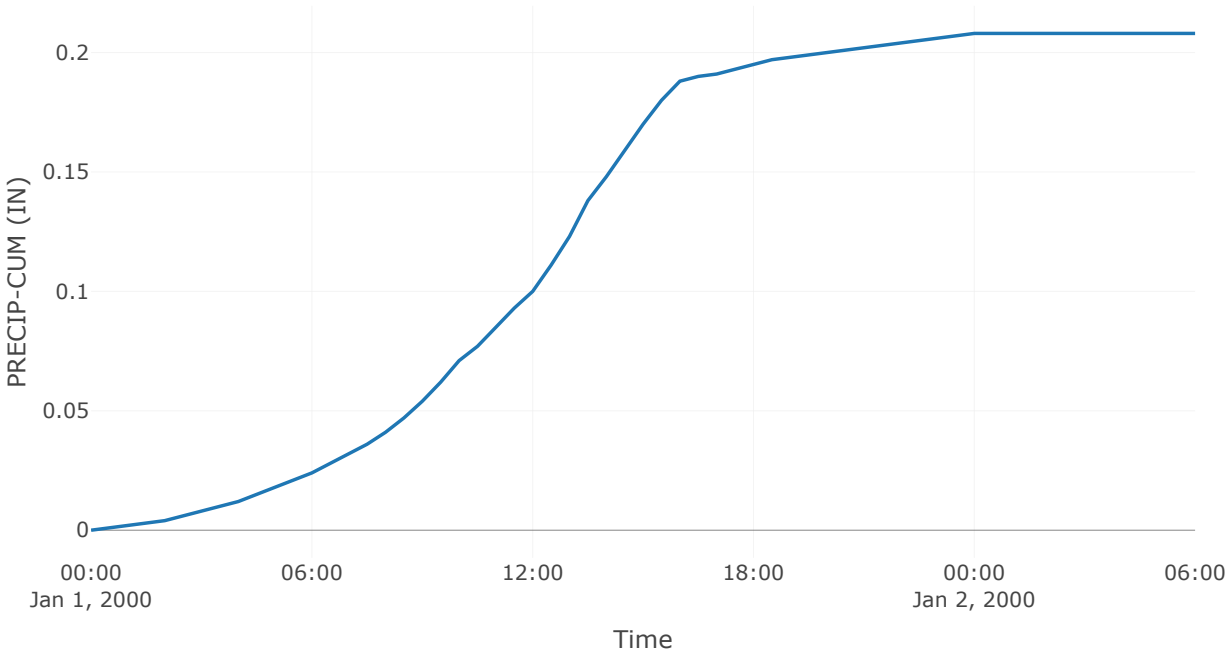
Precipitation and Outflow



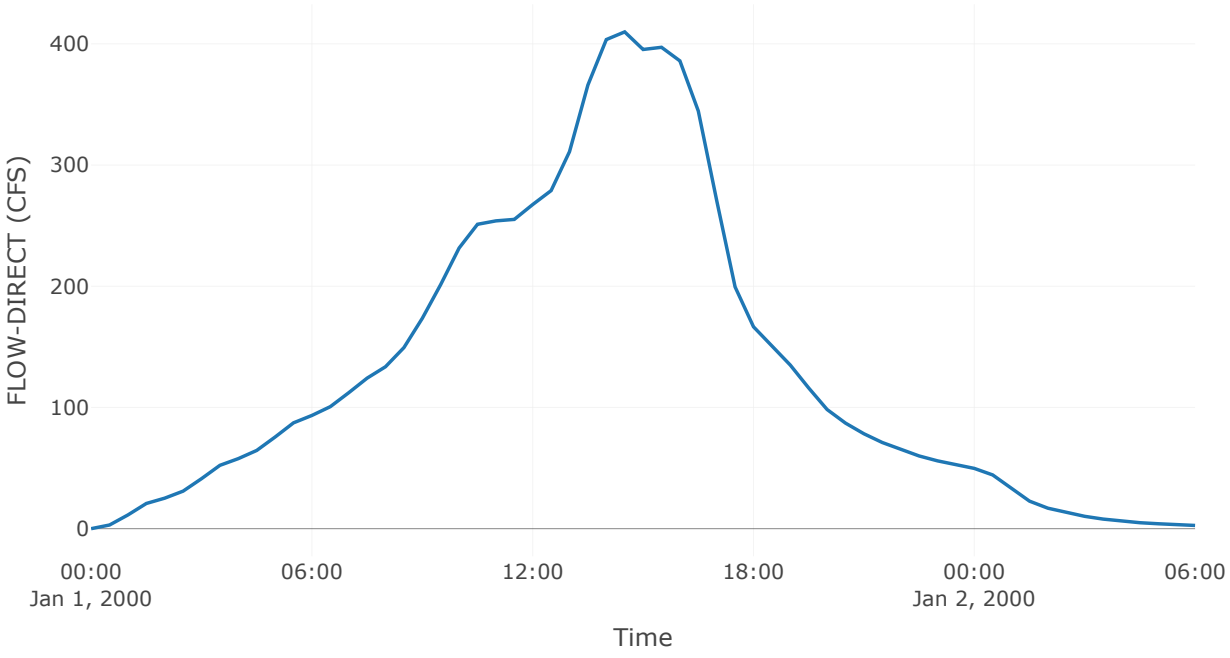
Cumulative Outflow



Cumulative Precipitation



Direct Runoff



Project: Basin2
Simulation Run: 24hr 100yr
Simulation Start: 31 December 1999, 24:00
Simulation End: 2 January 2000, 06:00

HMS Version: 4.9
Executed: 04 October 2022, 23:05

Global Parameter Summary - Subbasin

Area (MI^2)

Element Name	Area (MI^2)
Basin - 2	29.6

Transform: User - Specified S - Graph

Element Name	S - graph	Lag Method	Lag
Basin - 2	Combined S - Graph	Specified	1.37

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Basin - 2	29.6	2841.95	01Jan2000, 14:30	0.89

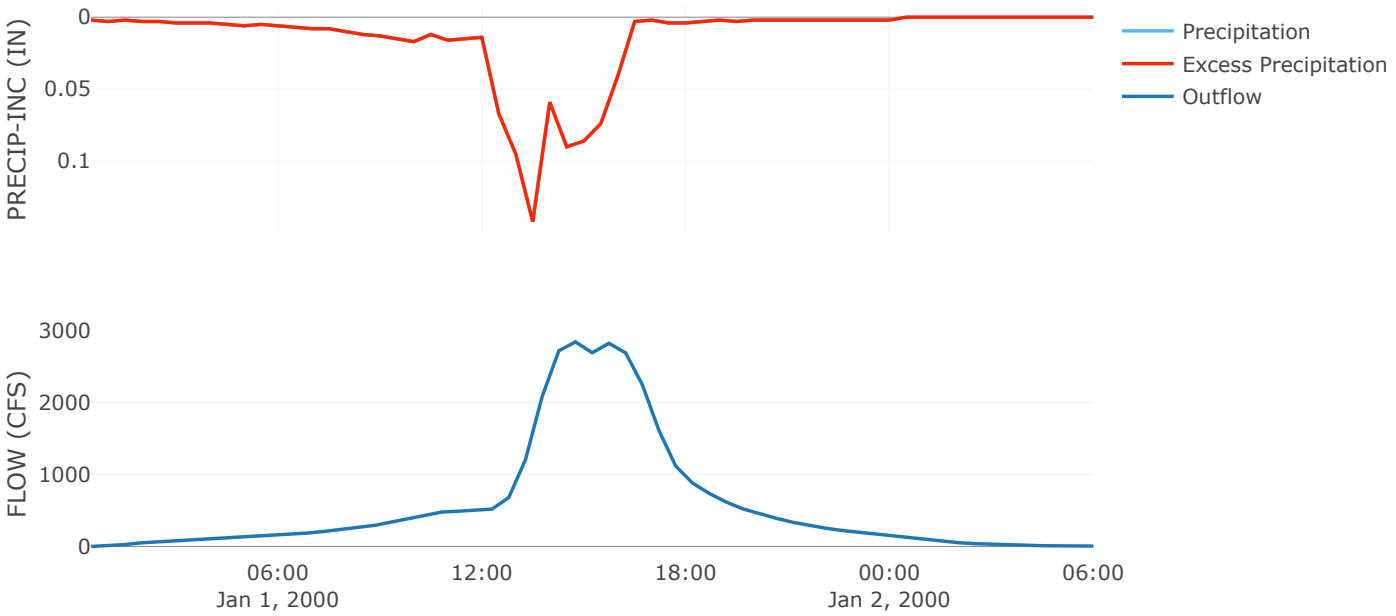
Subbasin: Basin-2

Area (MI^2) : 29.6

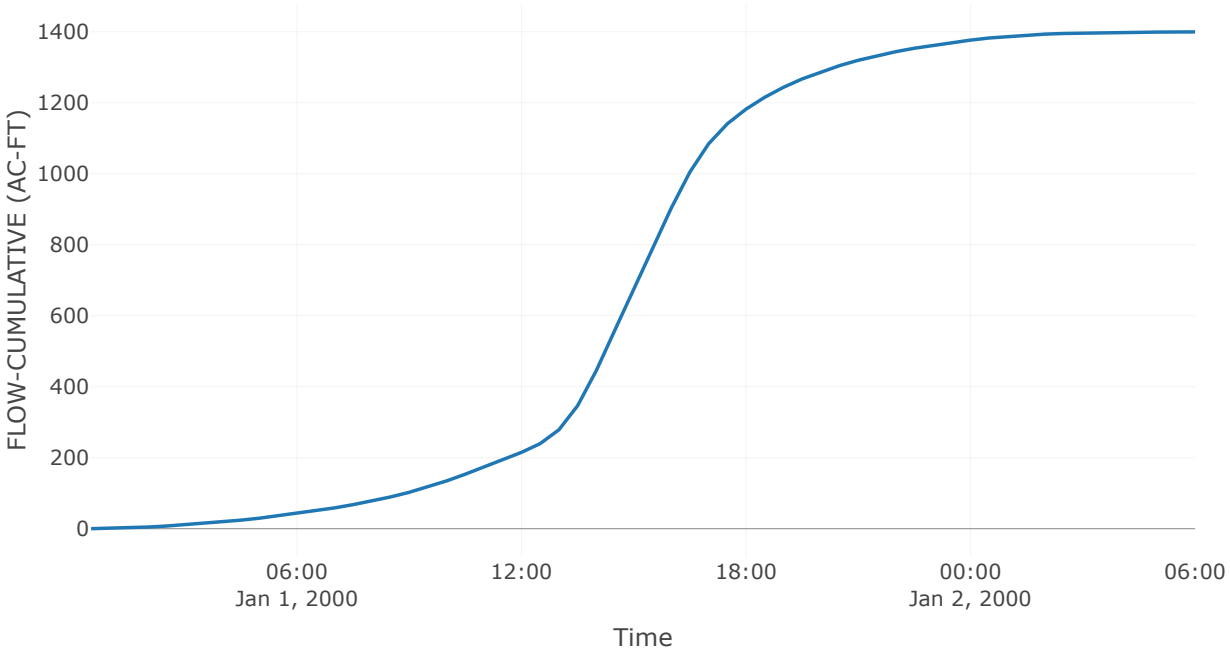
Transform: User - Specified S - Graph	
S - graph	Combined S - Graph
Lag Method	Specified
Lag	1.37

Results: Basin-2	
Peak Discharge (CFS)	2841.95
Time of Peak Discharge	01Jan2000, 14:30
Volume (IN)	0.89
Precipitation Volume (AC - FT)	1400.28
Loss Volume (AC - FT)	0
Excess Volume (AC - FT)	1400.28
Direct Runoff Volume (AC - FT)	1399.42
Baseflow Volume (AC - FT)	0

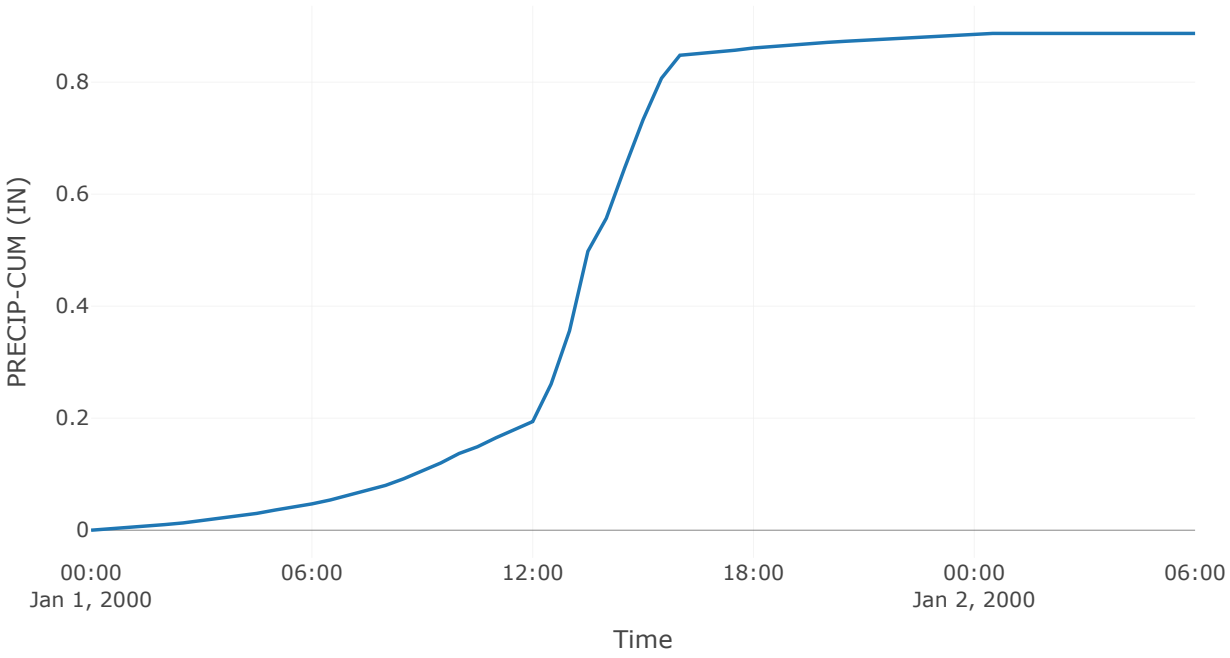
Precipitation and Outflow



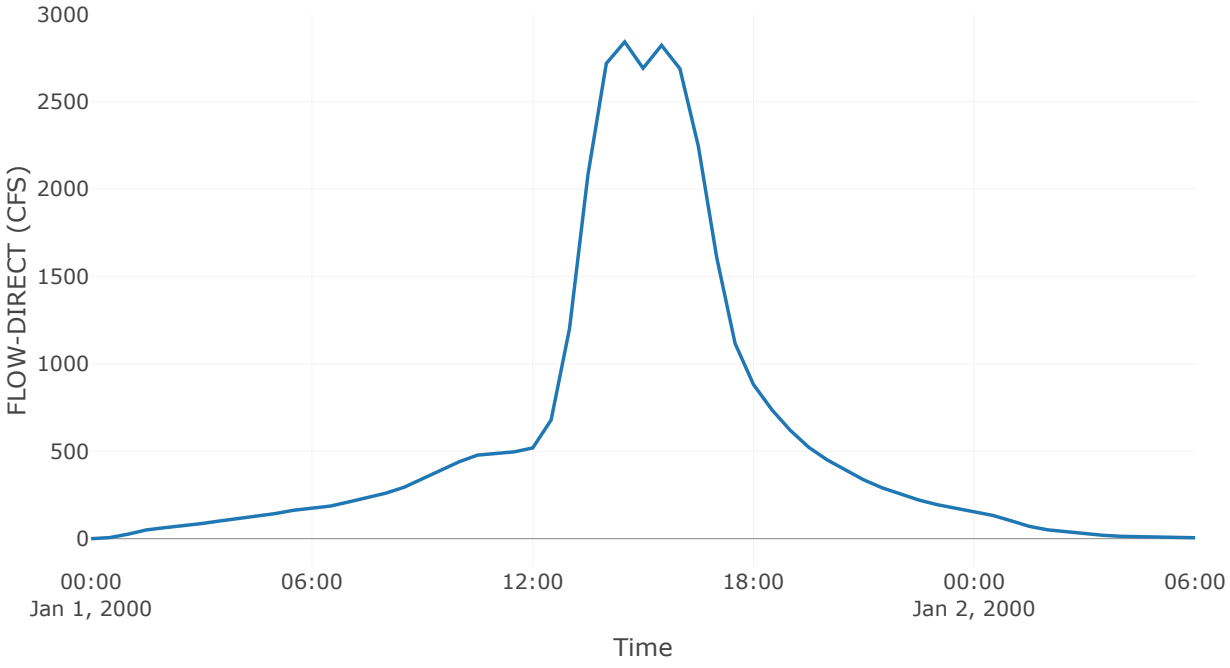
Cumulative Outflow



Cumulative Precipitation



Direct Runoff



Project: Basin3
Simulation Run: 03h 10yr
Simulation Start: 31 December 1999, 24:00
Simulation End: 1 January 2000, 24:00

HMS Version: 4.9
Executed: 04 October 2022, 23:17

Global Parameter Summary - Subbasin

Area (MI^2)

Element Name	Area (MI^2)
Basin - 3	162.6

Transform: User - Specified S - Graph

Element Name	S - graph	Lag Method	Lag
Basin - 3	Combined S - Graph	Specified	2.65

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Basin - 3	162.6	7193.13	01Jan2000, 04:30	0.26

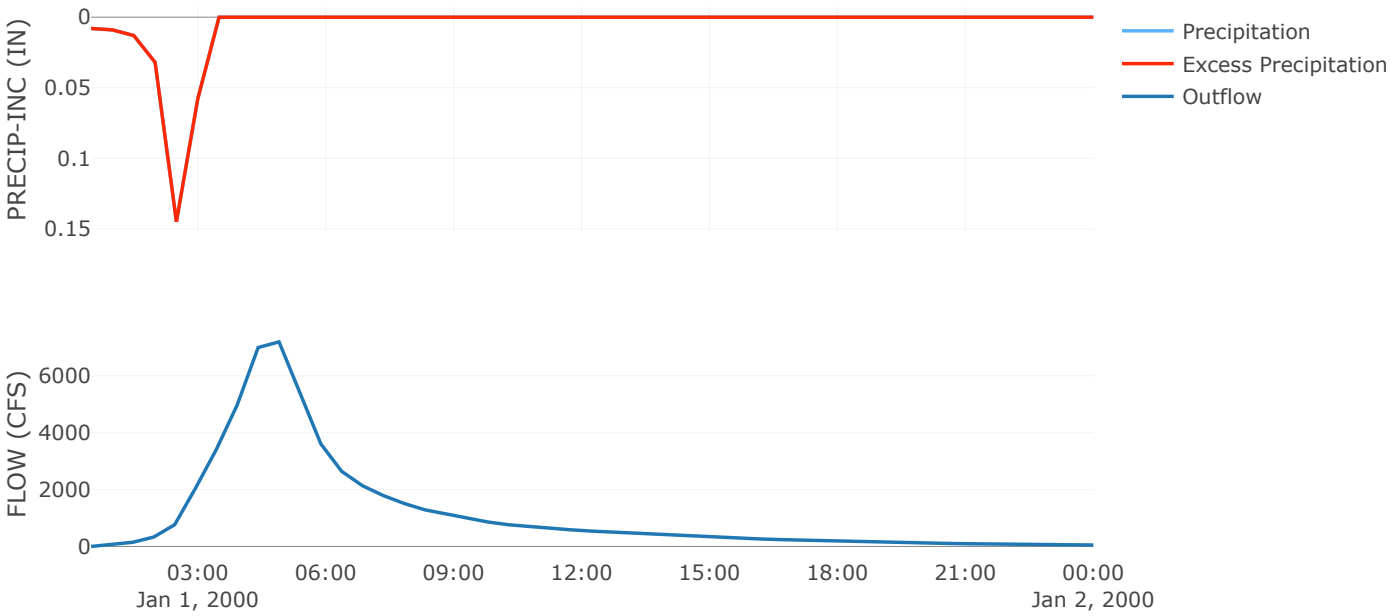
Subbasin: Basin-3

Area (MI^2) : 162.6

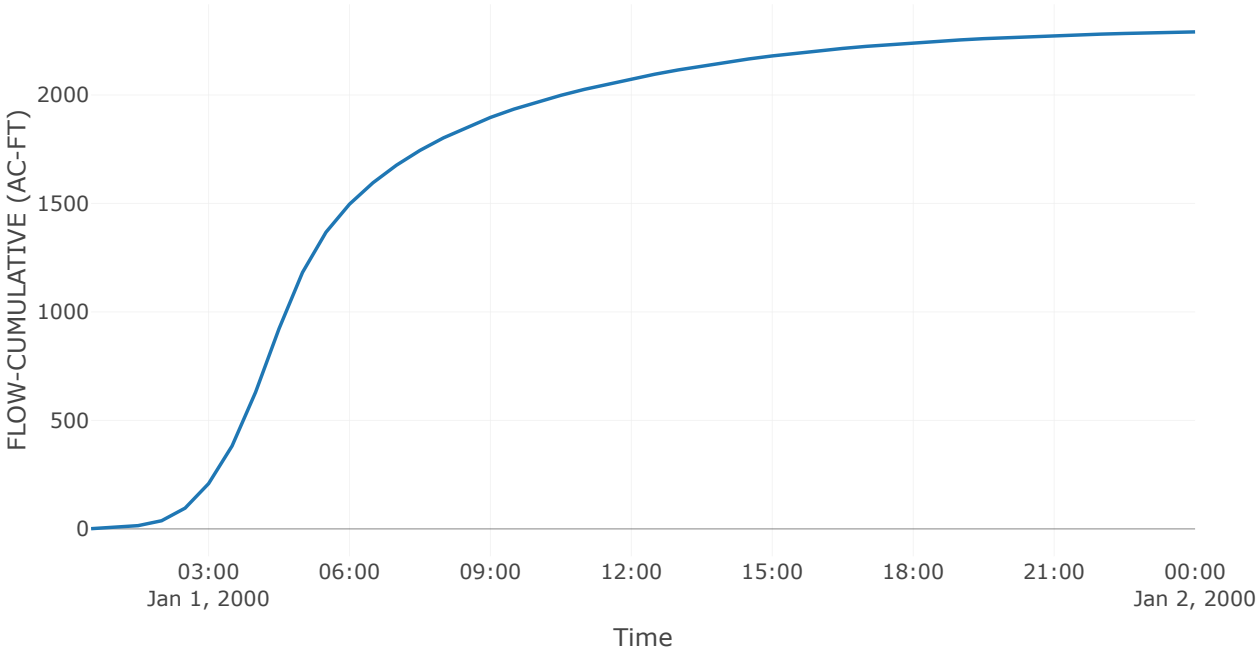
Transform: User - Specified S - Graph	
S - graph	Combined S - Graph
Lag Method	Specified
Lag	2.65

Results: Basin-3	
Peak Discharge (CFS)	7193.13
Time of Peak Discharge	01Jan2000, 04:30
Volume (IN)	0.26
Precipitation Volume (AC - FT)	2298.08
Loss Volume (AC - FT)	0
Excess Volume (AC - FT)	2298.08
Direct Runoff Volume (AC - FT)	2290.69
Baseflow Volume (AC - FT)	0

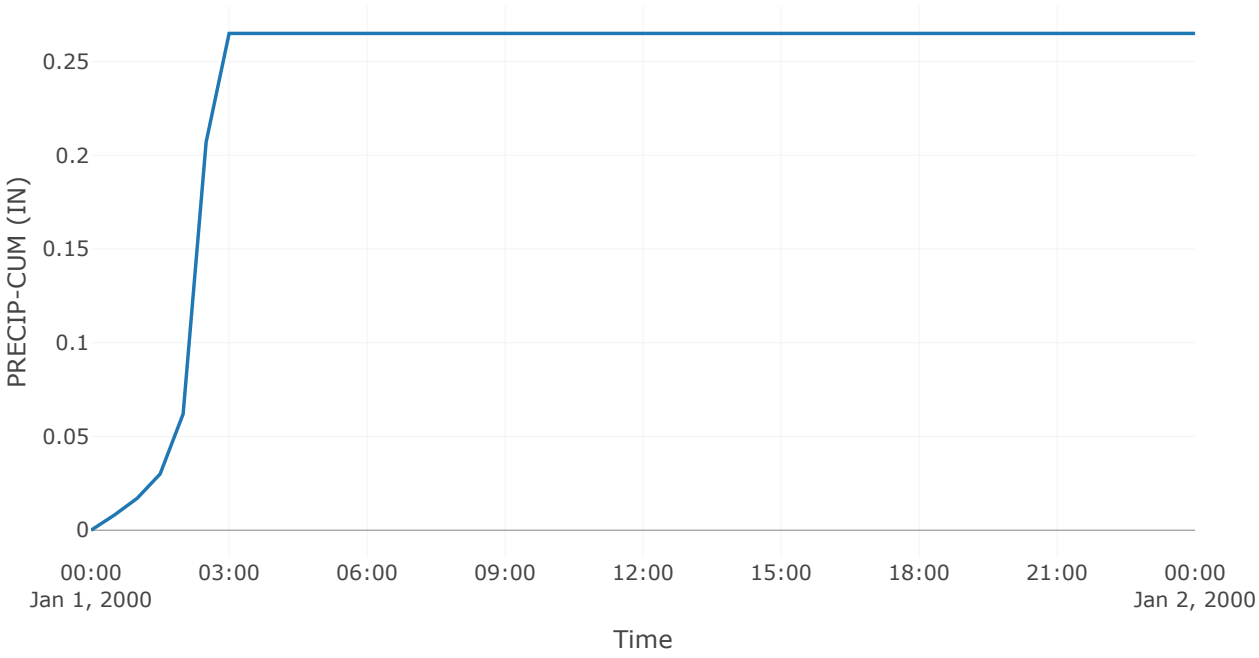
Precipitation and Outflow



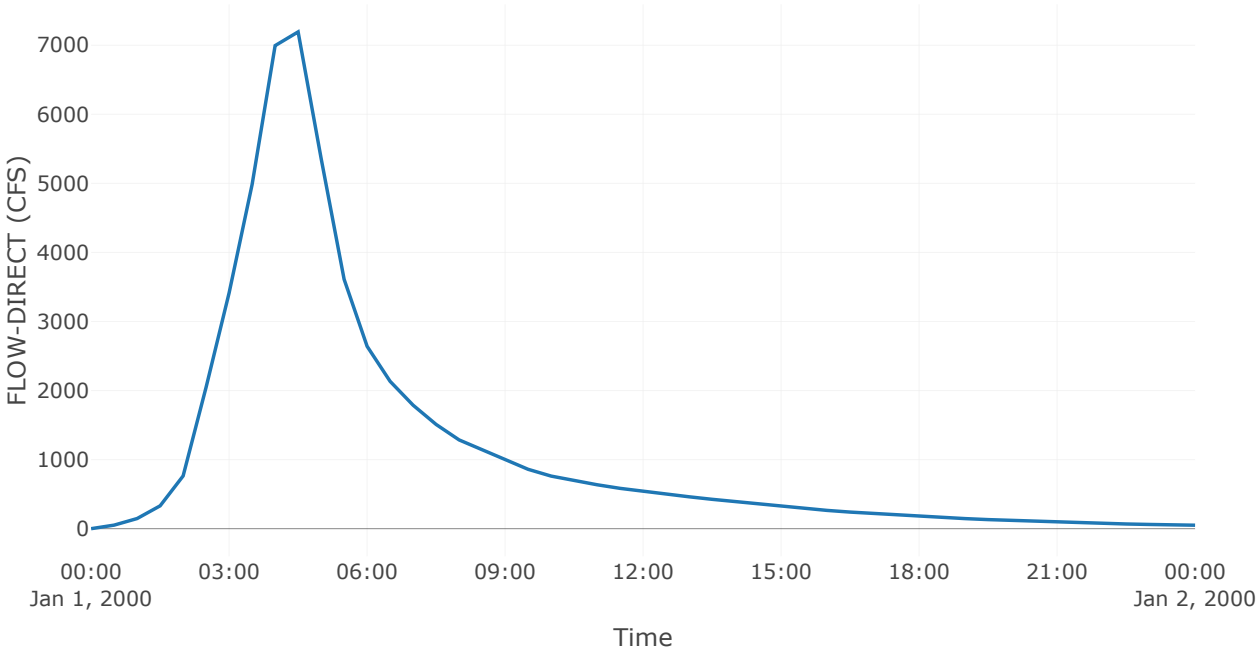
Cumulative Outflow



Cumulative Precipitation



Direct Runoff



Project: Basin3
Simulation Run: 03h 100yr
Simulation Start: 31 December 1999, 24:00
Simulation End: 1 January 2000, 24:00

HMS Version: 4.9
Executed: 04 October 2022, 23:17

Global Parameter Summary - Subbasin

Area (MI^2)

Element Name	Area (MI^2)
Basin - 3	162.6

Transform: User - Specified S - Graph

Element Name	S - graph	Lag Method	Lag
Basin - 3	Combined S - Graph	Specified	2.65

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Basin - 3	162.6	24443.57	01Jan2000, 04:00	0.96

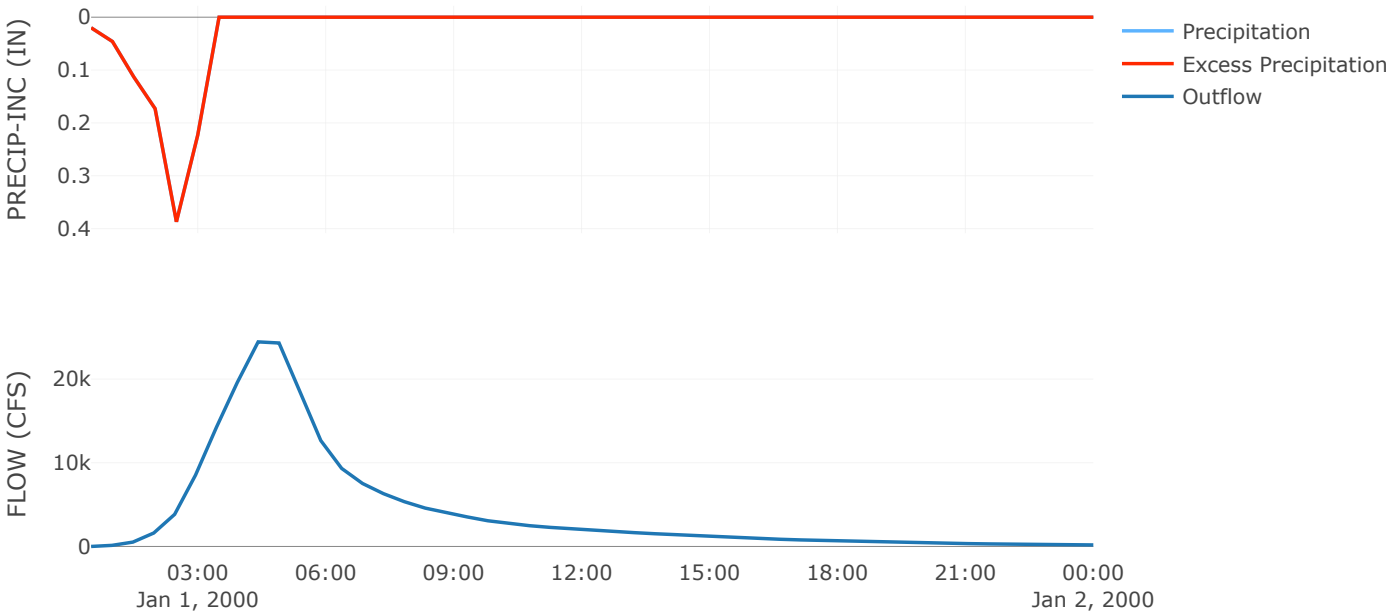
Subbasin: Basin-3

Area (MI^2) : 162.6

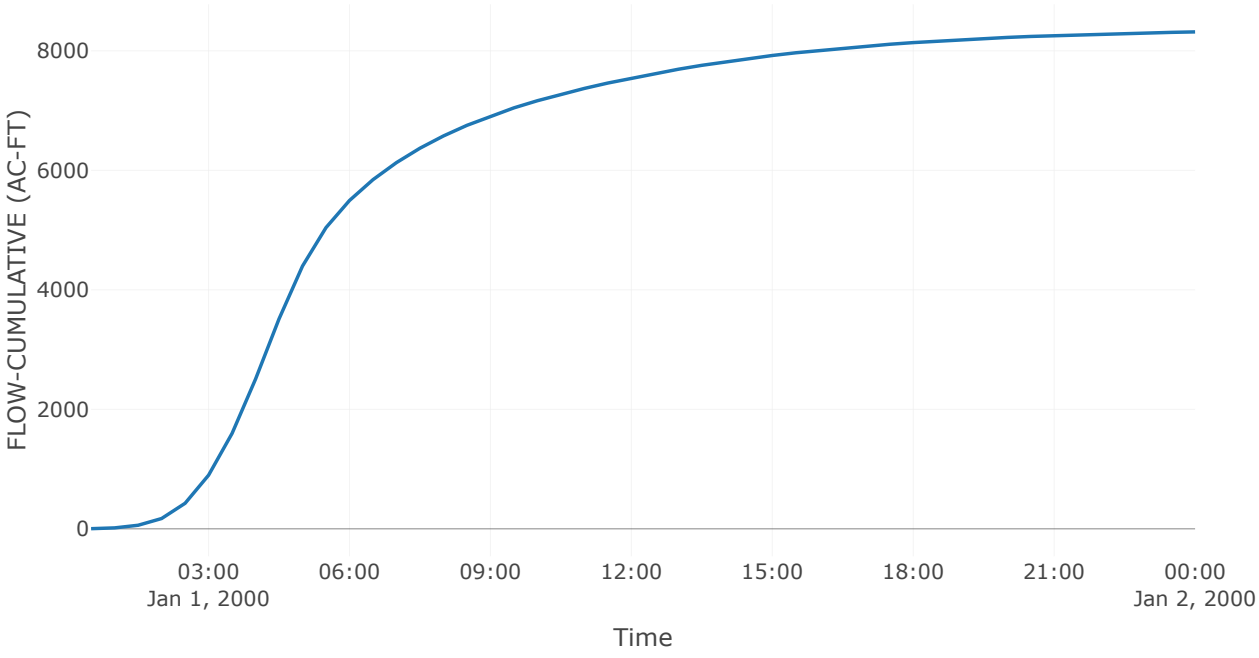
Transform: User - Specified S - Graph	
S - graph	Combined S - Graph
Lag Method	Specified
Lag	2.65

Results: Basin-3	
Peak Discharge (CFS)	24443.57
Time of Peak Discharge	01Jan2000, 04:00
Volume (IN)	0.96
Precipitation Volume (AC - FT)	8342.46
Loss Volume (AC - FT)	0
Excess Volume (AC - FT)	8342.46
Direct Runoff Volume (AC - FT)	8316.97
Baseflow Volume (AC - FT)	0

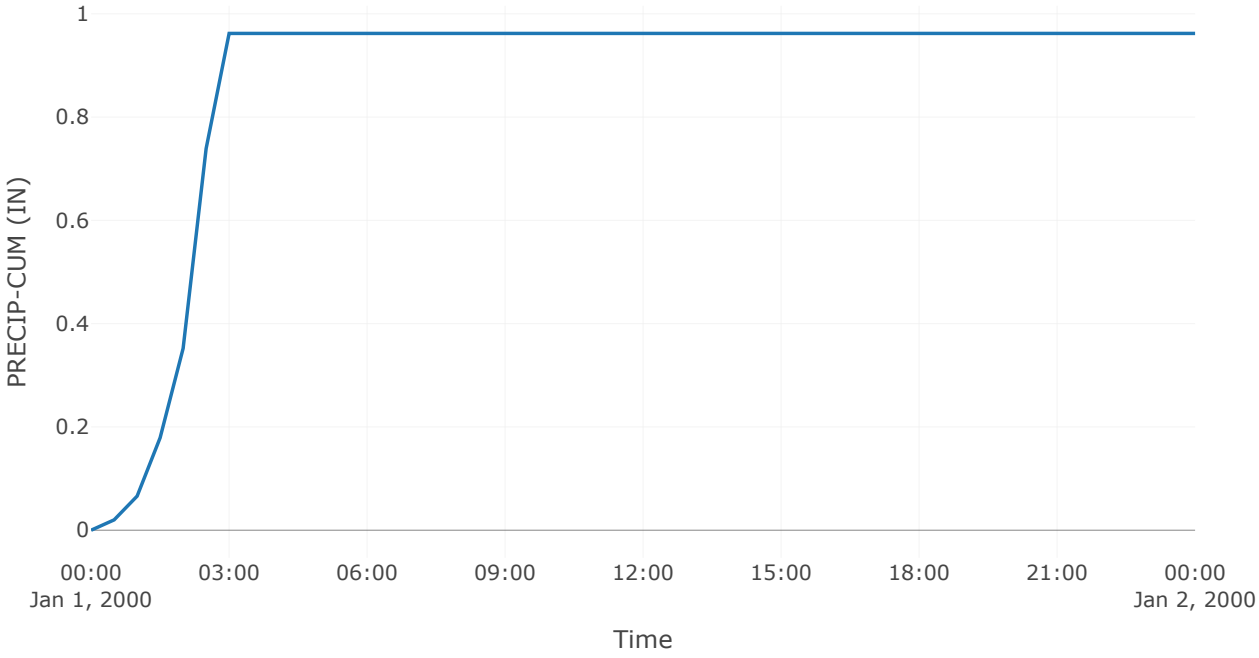
Precipitation and Outflow



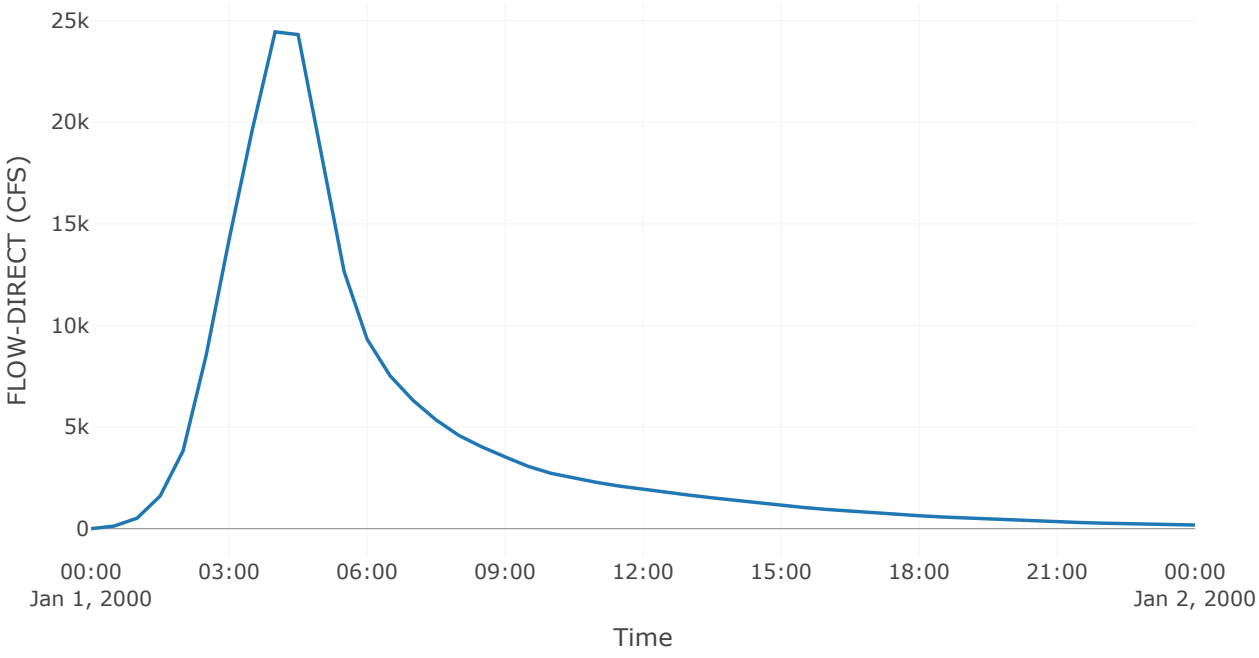
Cumulative Outflow



Cumulative Precipitation



Direct Runoff



Project: Basin3
Simulation Run: 06h 10yr
Simulation Start: 31 December 1999, 24:00
Simulation End: 2 January 2000, 08:00

HMS Version: 4.9
Executed: 04 October 2022, 23:17

Global Parameter Summary - Subbasin

Area (MI^2)

Element Name	Area (MI^2)
Basin - 3	162.6

Transform: User - Specified S - Graph

Element Name	S - graph	Lag Method	Lag
Basin - 3	Combined S - Graph	Specified	2.65

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Basin - 3	162.6	7128.96	01Jan2000, 07:00	0.28

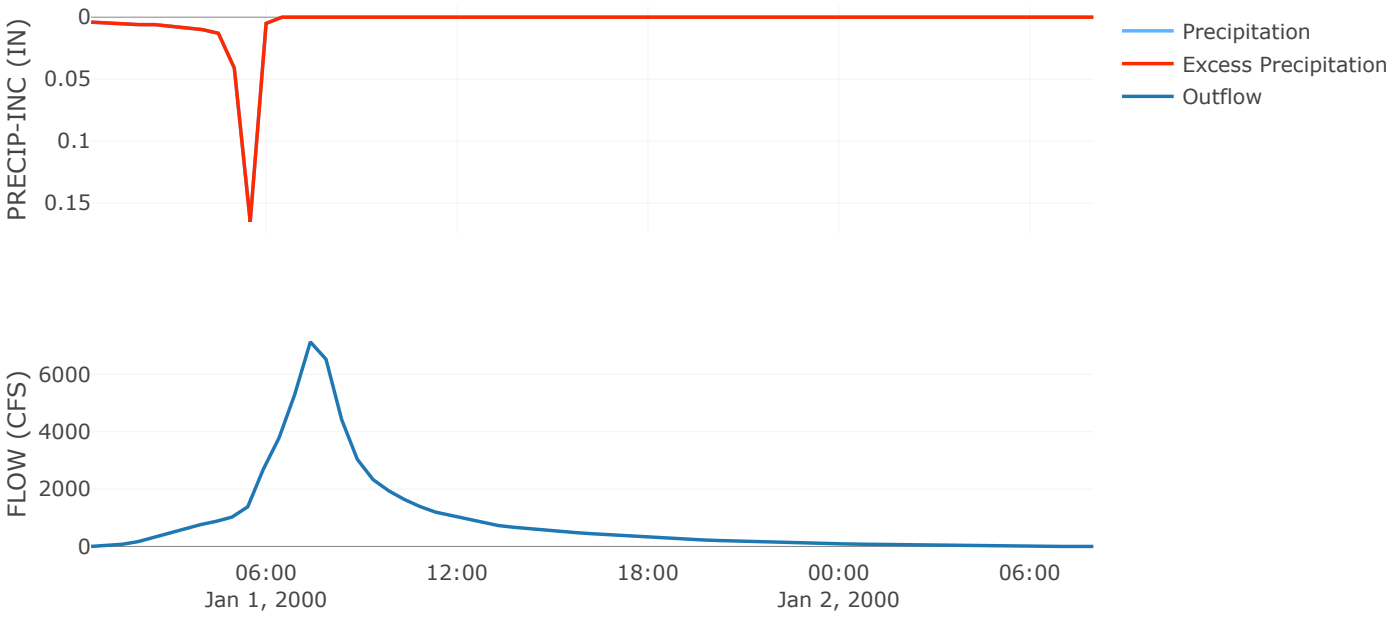
Subbasin: Basin-3

Area (MI^2) : 162.6

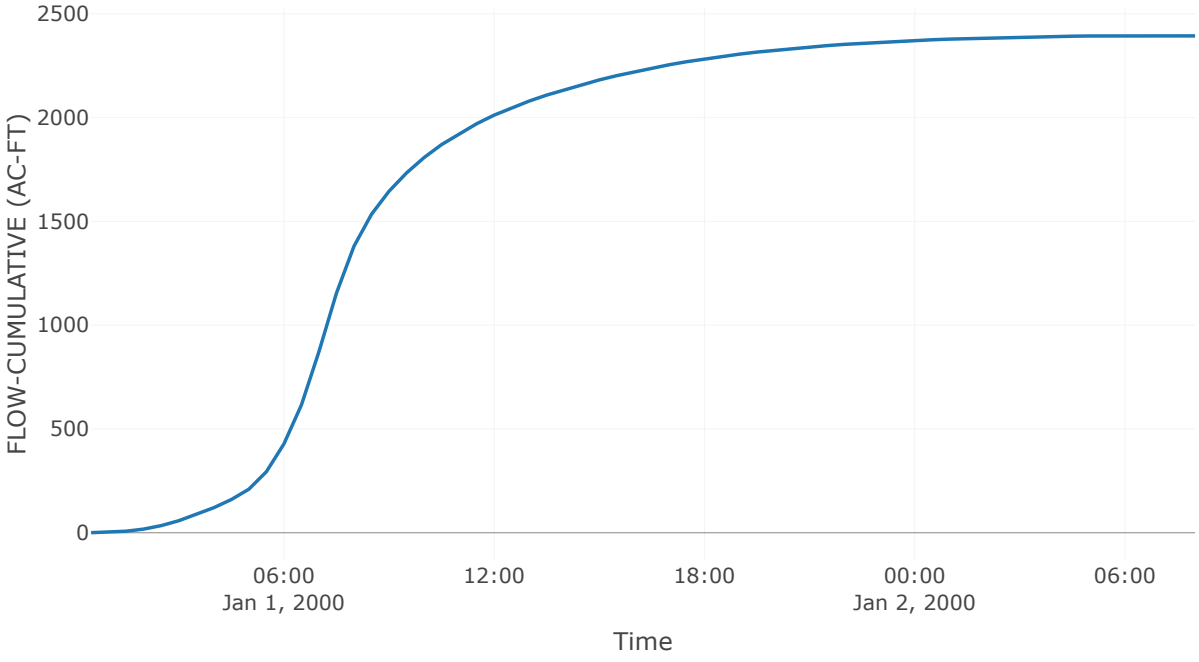
Transform: User - Specified S - Graph	
S - graph	Combined S - Graph
Lag Method	Specified
Lag	2.65

Results: Basin-3	
Peak Discharge (CFS)	7128.96
Time of Peak Discharge	01Jan2000, 07:00
Volume (IN)	0.28
Precipitation Volume (AC - FT)	2393.47
Loss Volume (AC - FT)	0
Excess Volume (AC - FT)	2393.47
Direct Runoff Volume (AC - FT)	2393.47
Baseflow Volume (AC - FT)	0

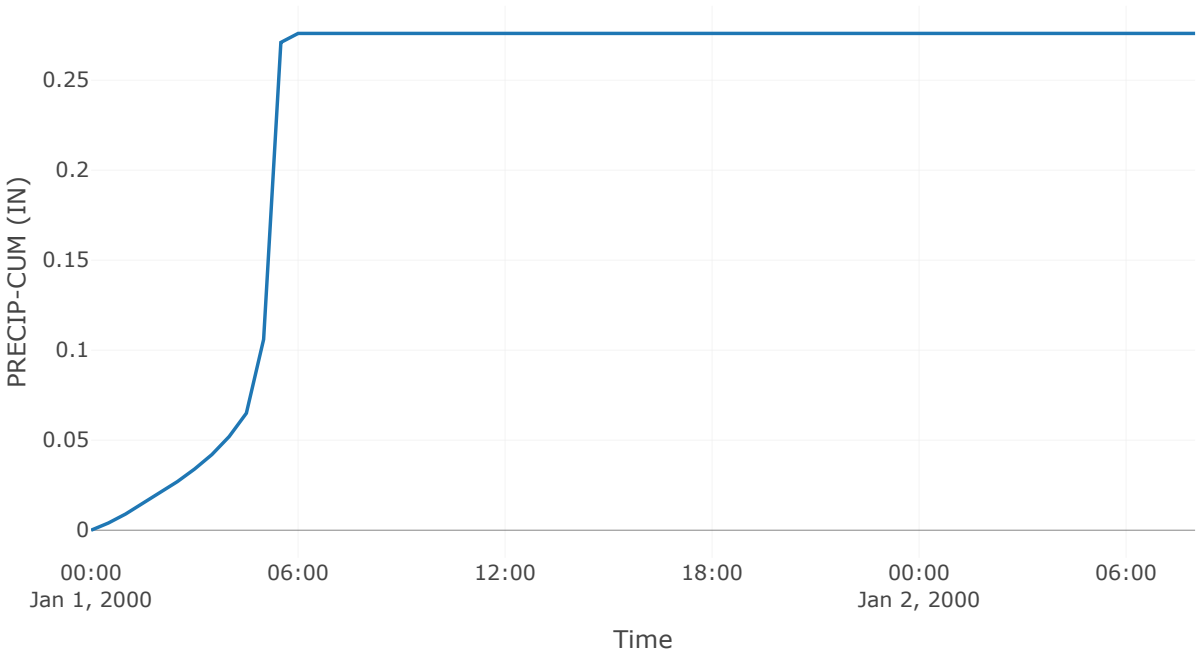
Precipitation and Outflow



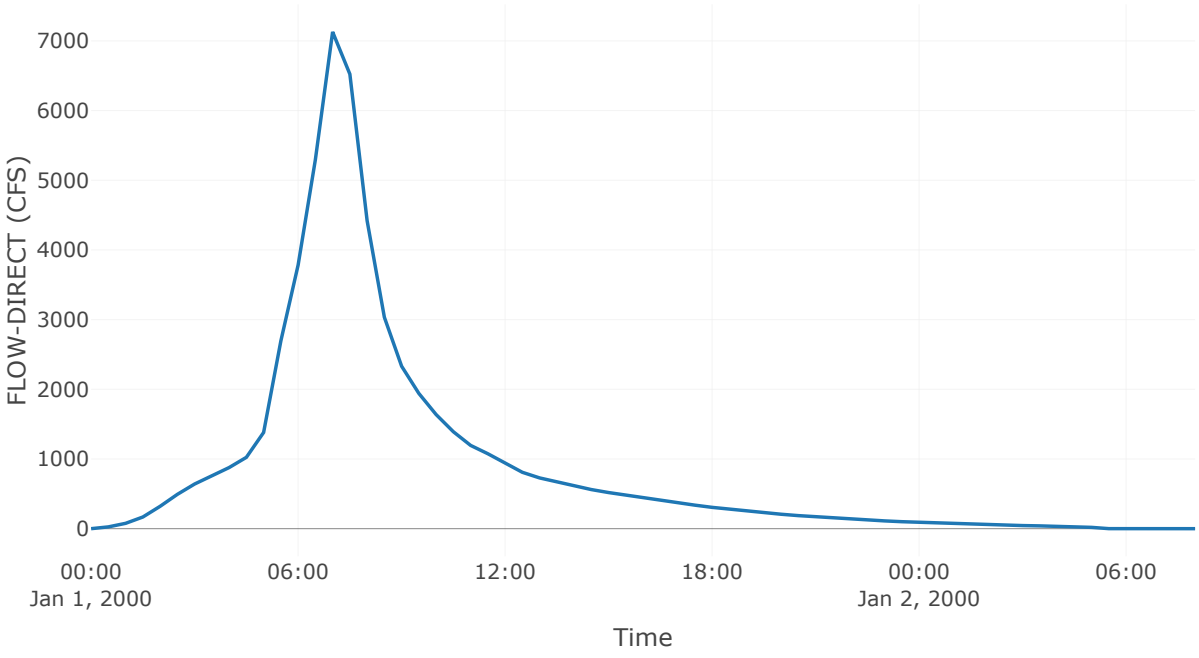
Cumulative Outflow



Cumulative Precipitation



Direct Runoff



Project: Basin3
Simulation Run: 06h 100yr
Simulation Start: 31 December 1999, 24:00
Simulation End: 2 January 2000, 08:00

HMS Version: 4.9
Executed: 04 October 2022, 23:17

Global Parameter Summary - Subbasin

Area (MI^2)

Element Name	Area (MI^2)
Basin - 3	162.6

Transform: User - Specified S - Graph

Element Name	S - graph	Lag Method	Lag
Basin - 3	Combined S - Graph	Specified	2.65

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Basin - 3	162.6	23402.75	01Jan2000, 07:00	0.92

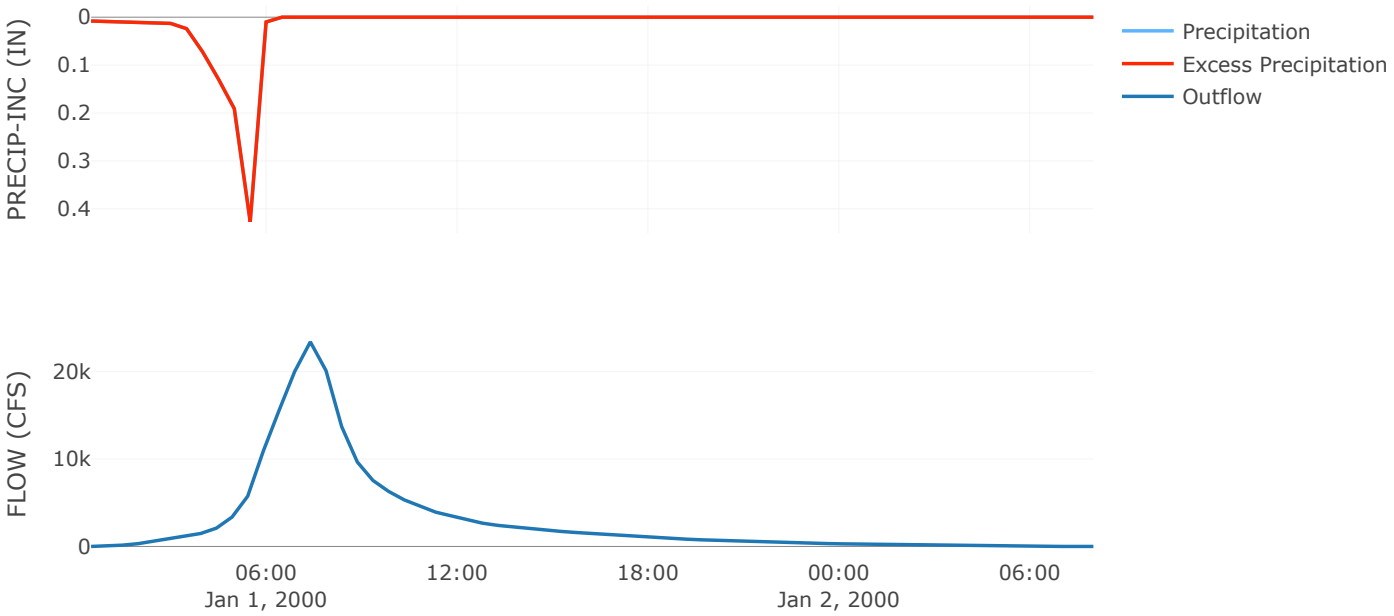
Subbasin: Basin-3

Area (MI^2) : 162.6

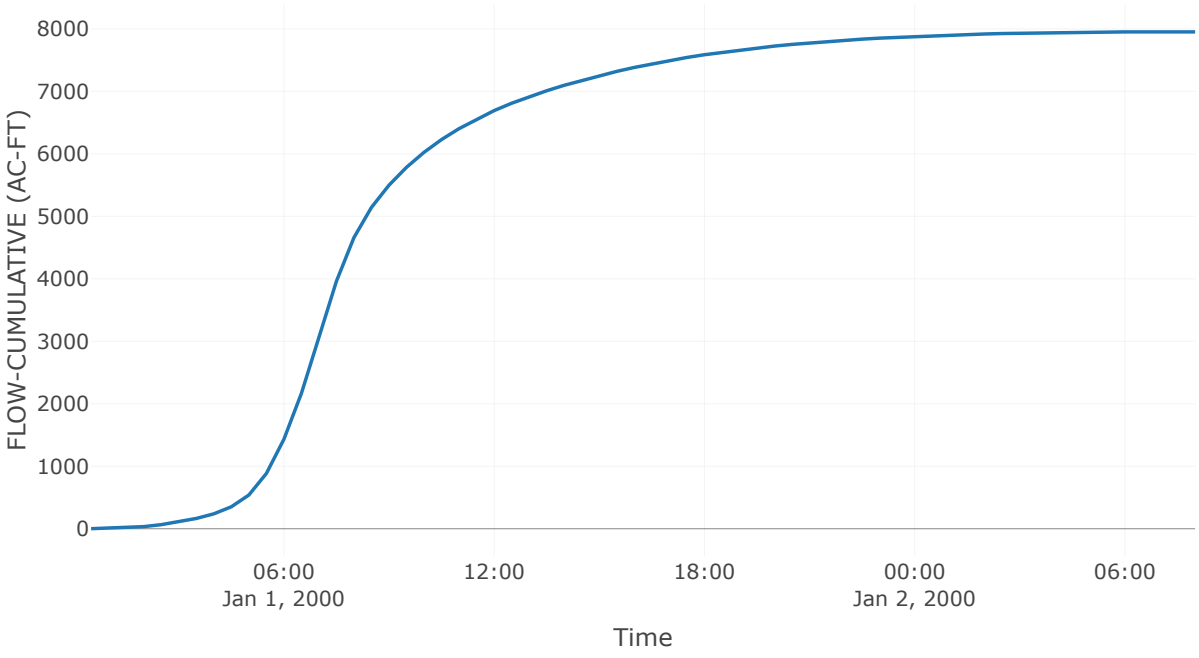
Transform: User - Specified S - Graph	
S - graph	Combined S - Graph
Lag Method	Specified
Lag	2.65

Results: Basin-3	
Peak Discharge (CFS)	23402.75
Time of Peak Discharge	01Jan2000, 07:00
Volume (IN)	0.92
Precipitation Volume (AC - FT)	7952.22
Loss Volume (AC - FT)	0
Excess Volume (AC - FT)	7952.22
Direct Runoff Volume (AC - FT)	7952.22
Baseflow Volume (AC - FT)	0

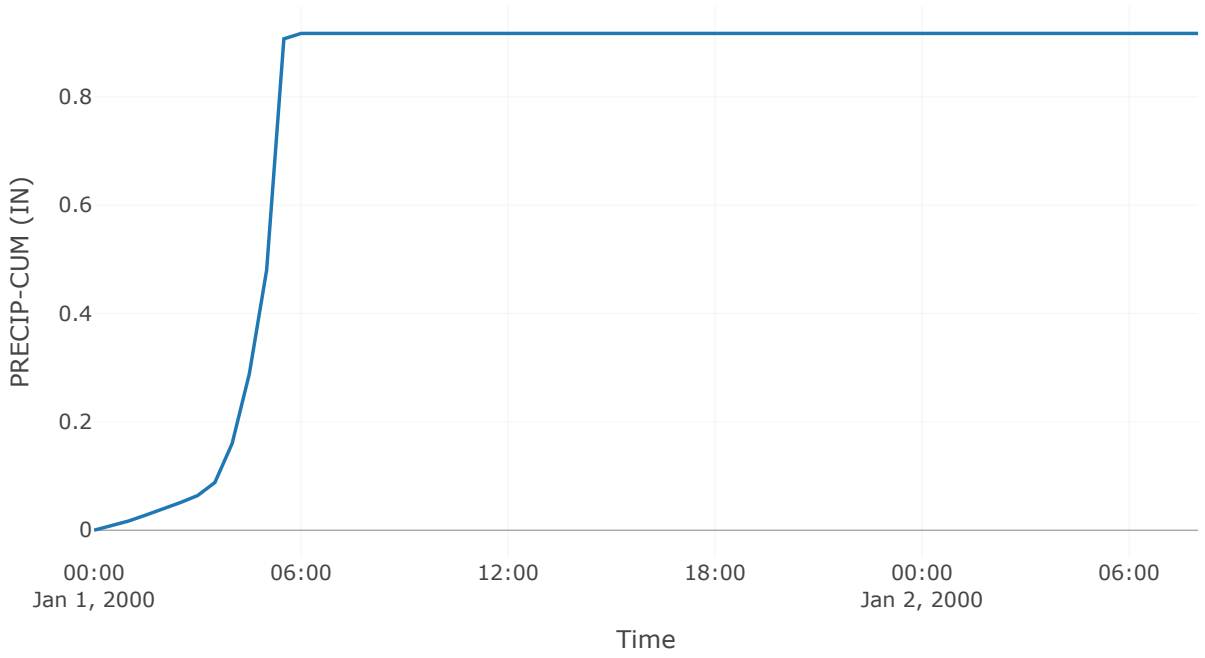
Precipitation and Outflow



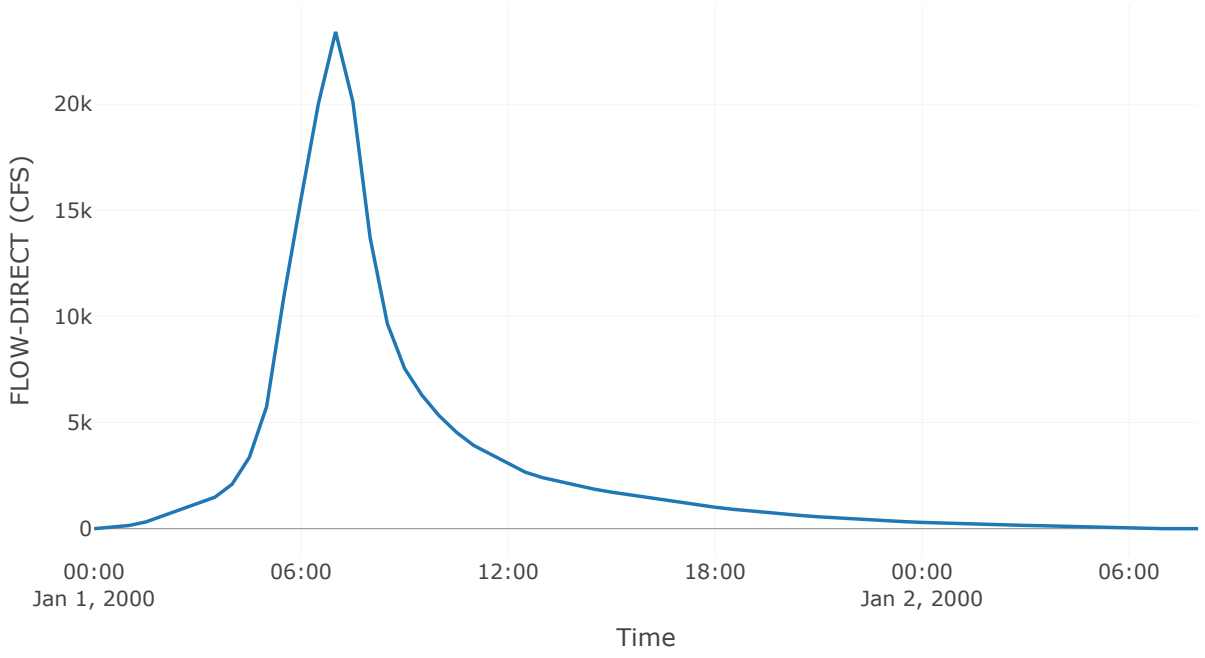
Cumulative Outflow



Cumulative Precipitation



Direct Runoff



Project: Basin3
Simulation Run: 24h 10yr
Simulation Start: 31 December 1999, 24:00
Simulation End: 2 January 2000, 20:00

HMS Version: 4.9
Executed: 04 October 2022, 23:17

Global Parameter Summary - Subbasin

Area (MI^2)

Element Name	Area (MI^2)
Basin - 3	162.6

Transform: User - Specified S - Graph

Element Name	S - graph	Lag Method	Lag
Basin - 3	Combined S - Graph	Specified	2.65

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Basin - 3	162.6	2177.57	01Jan2000, 15:30	0.21

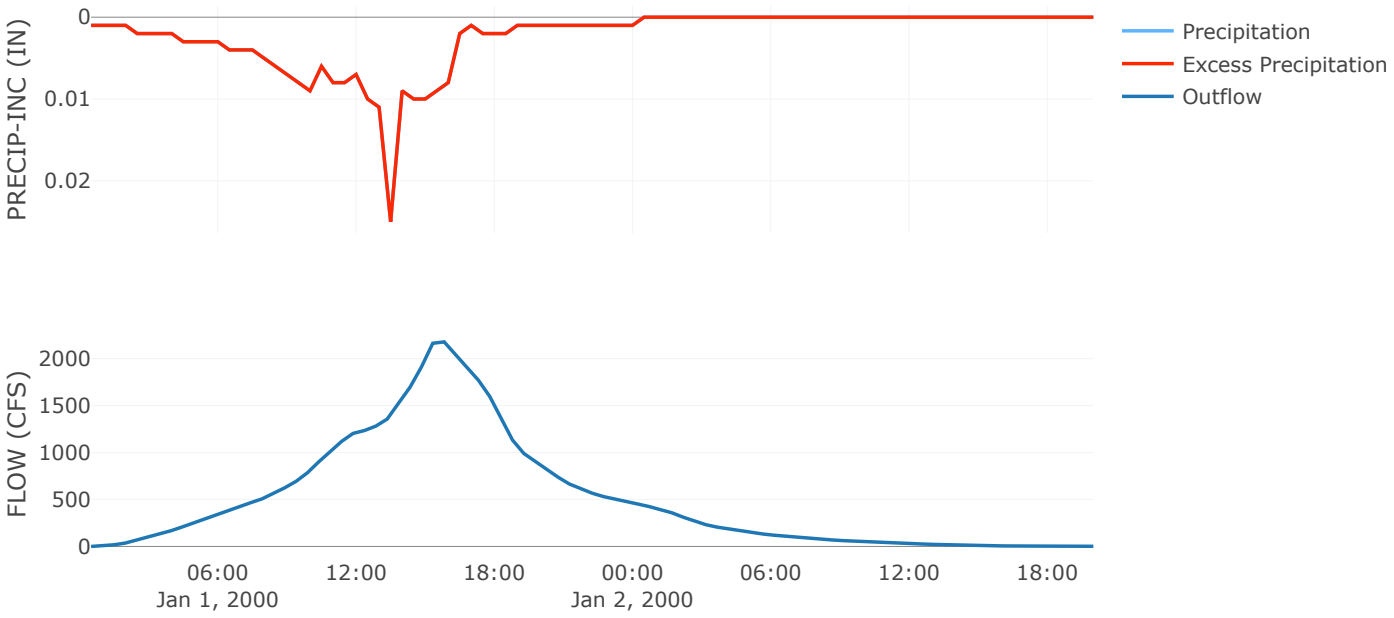
Subbasin: Basin-3

Area (MI^2) : 162.6

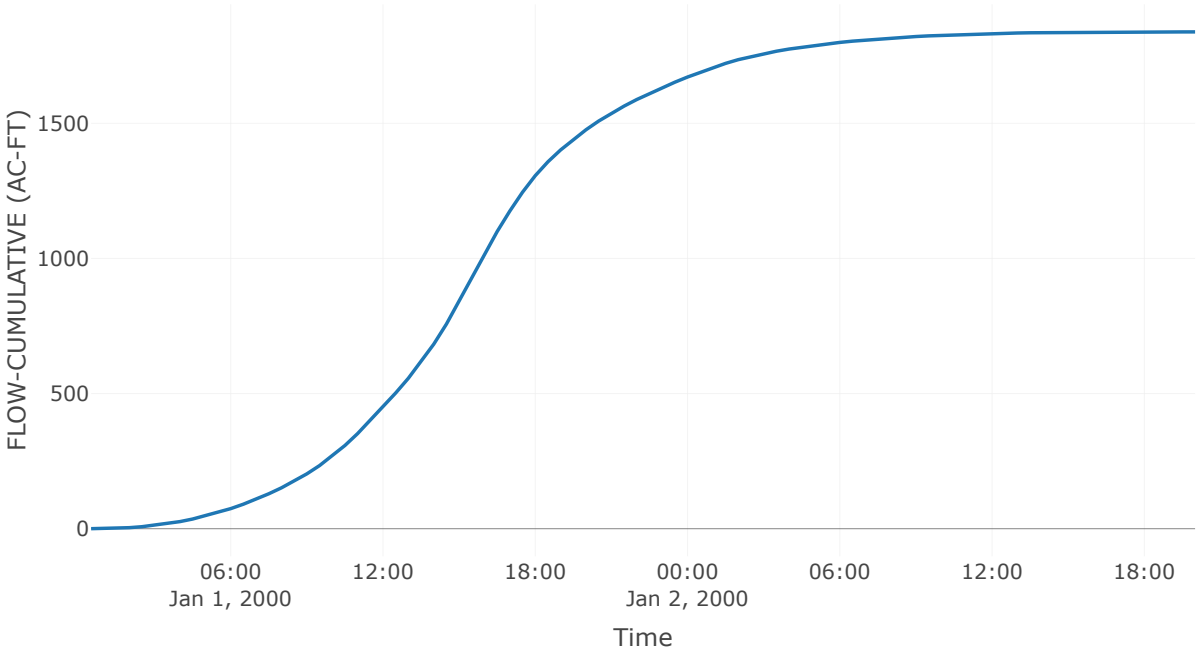
Transform: User - Specified S - Graph	
S - graph	Combined S - Graph
Lag Method	Specified
Lag	2.65

Results: Basin-3	
Peak Discharge (CFS)	2177.57
Time of Peak Discharge	01Jan2000, 15:30
Volume (IN)	0.21
Precipitation Volume (AC - FT)	1838.46
Loss Volume (AC - FT)	0
Excess Volume (AC - FT)	1838.46
Direct Runoff Volume (AC - FT)	1838.25
Baseflow Volume (AC - FT)	0

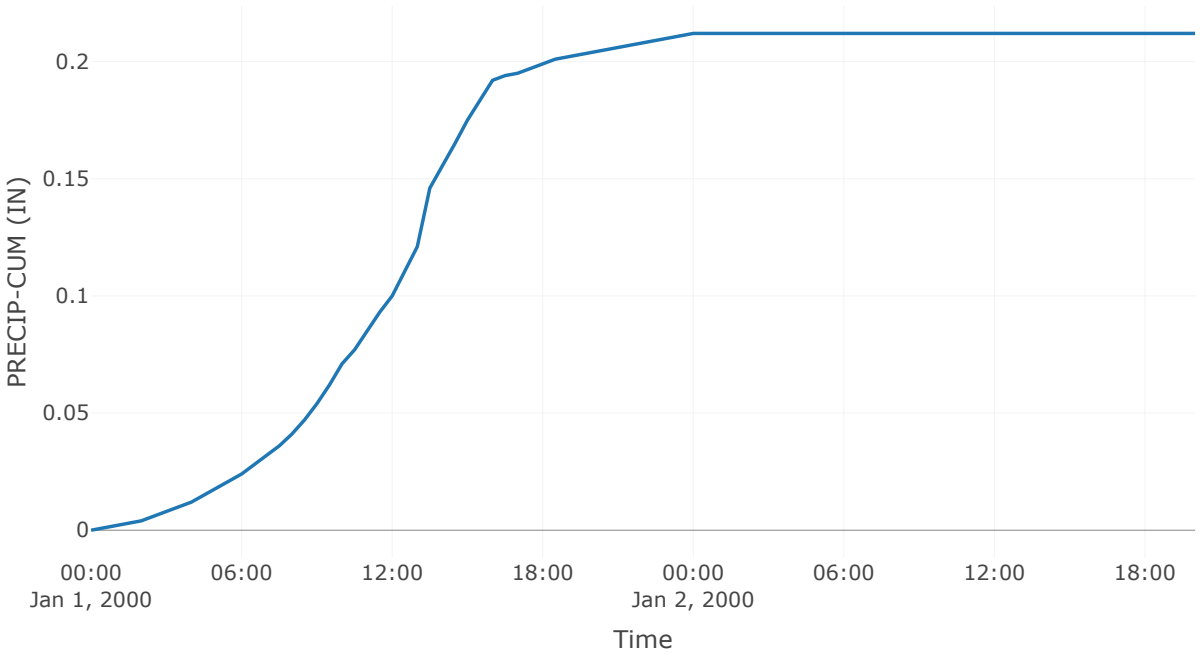
Precipitation and Outflow



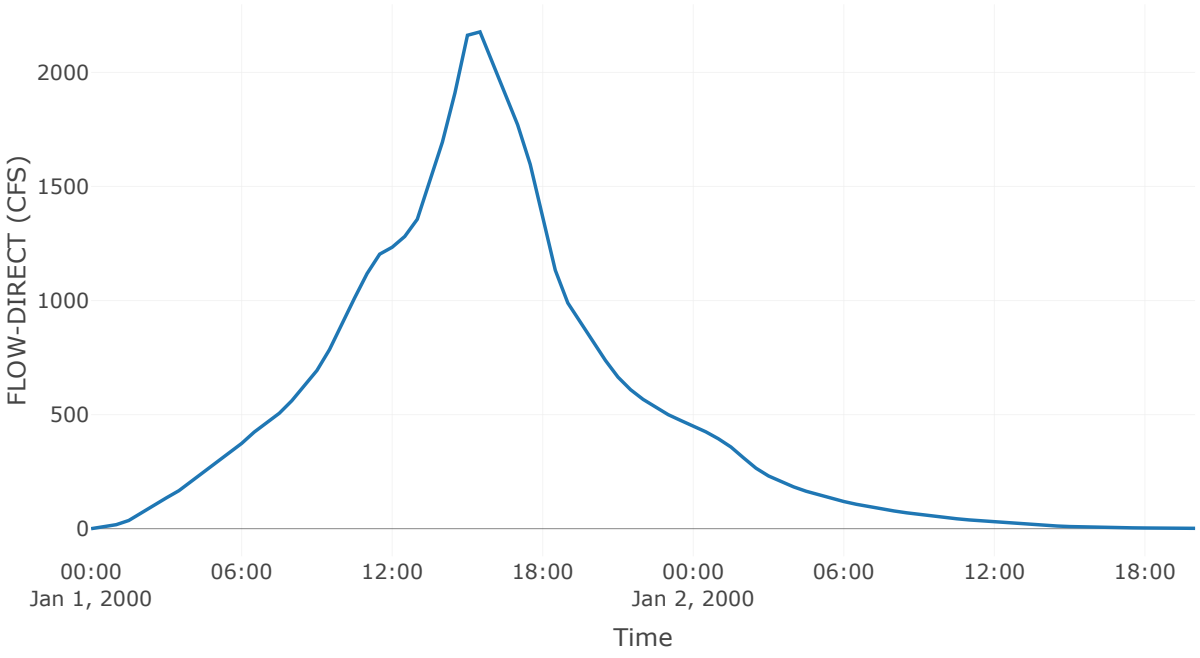
Cumulative Outflow



Cumulative Precipitation



Direct Runoff



Project: Basin3
Simulation Run: 24hr 100yr
Simulation Start: 31 December 1999, 24:00
Simulation End: 2 January 2000, 20:00

HMS Version: 4.9
Executed: 04 October 2022, 23:17

Global Parameter Summary - Subbasin

Area (MI^2)

Element Name	Area (MI^2)
Basin - 3	162.6

Transform: User - Specified S - Graph

Element Name	S - graph	Lag Method	Lag
Basin - 3	Combined S - Graph	Specified	2.65

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Basin - 3	162.6	13790.85	01Jan2000, 15:30	0.95

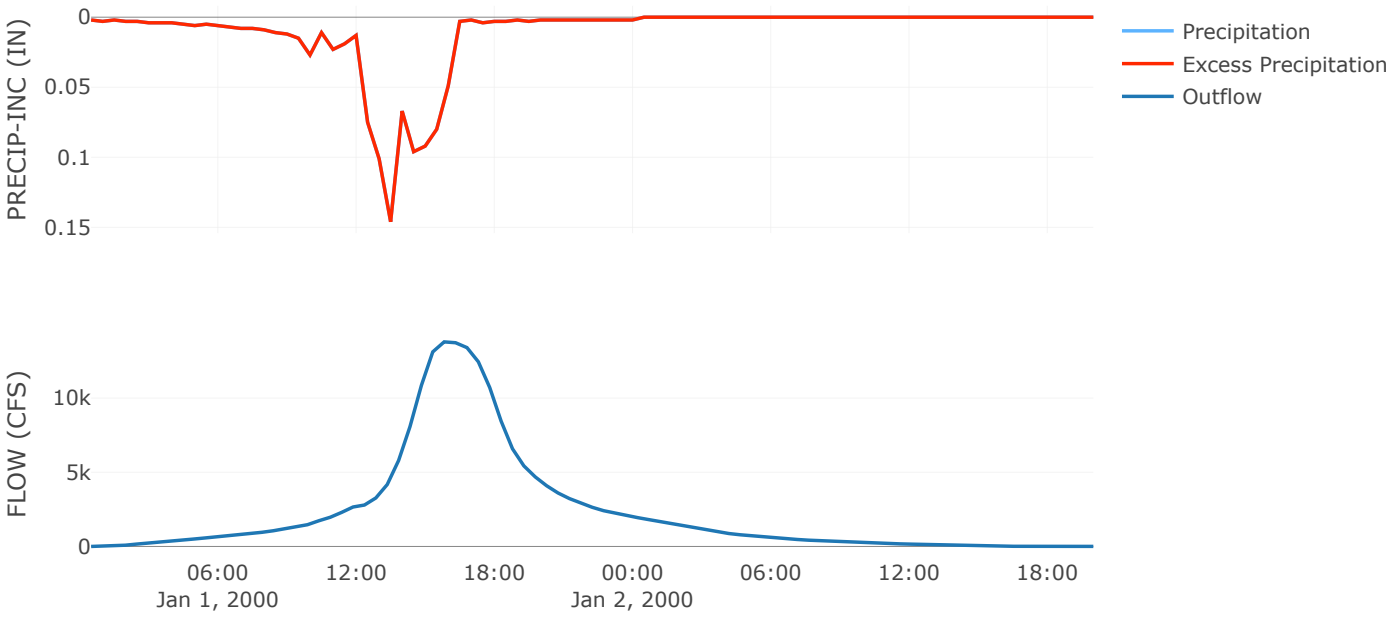
Subbasin: Basin-3

Area (MI^2) : 162.6

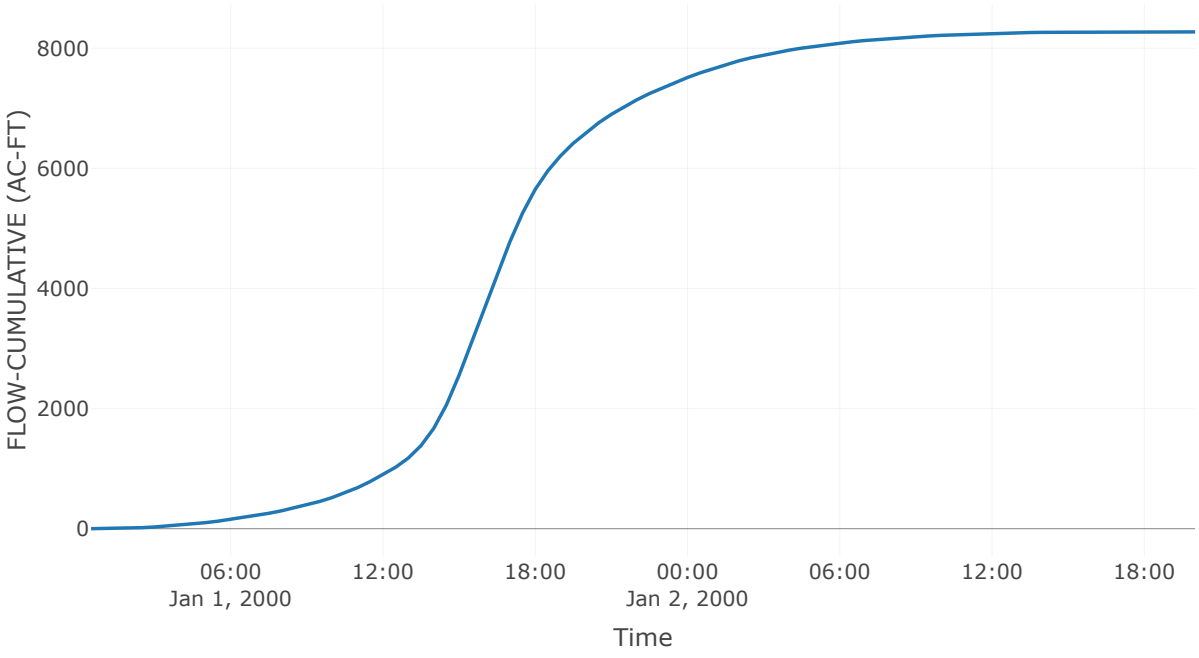
Transform: User - Specified S - Graph	
S - graph	Combined S - Graph
Lag Method	Specified
Lag	2.65

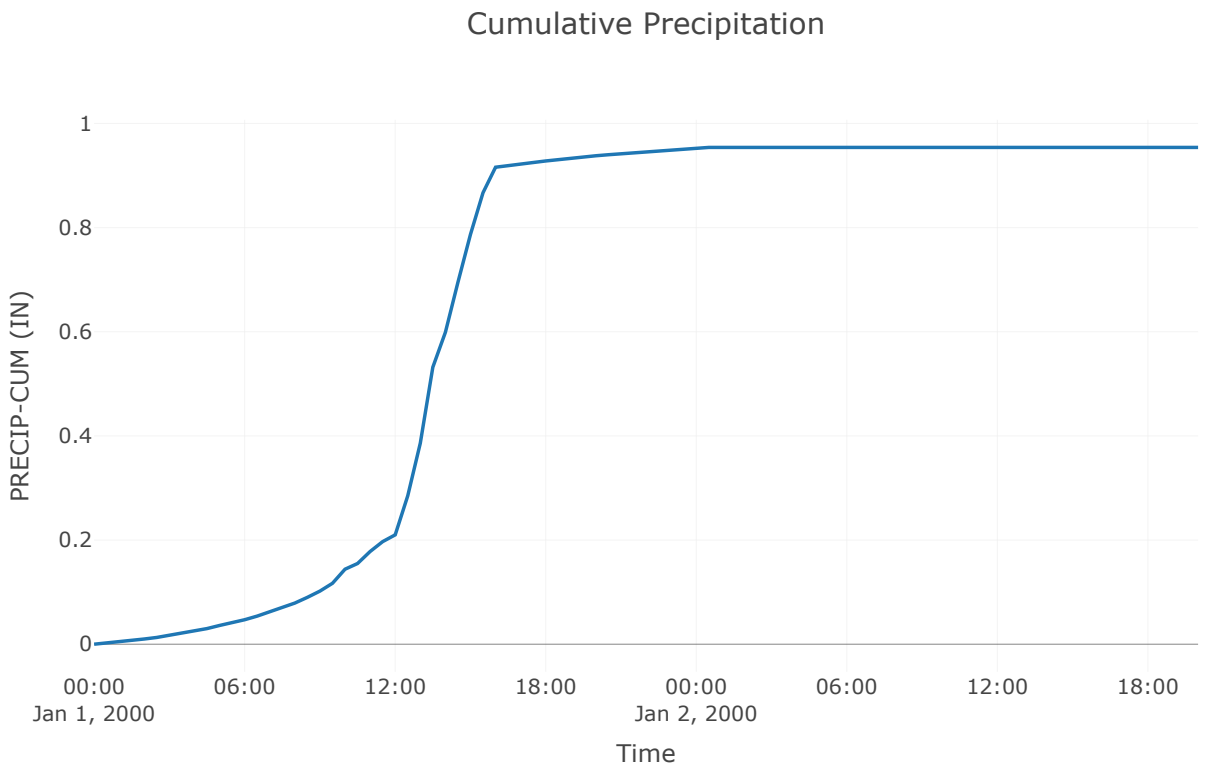
Results: Basin-3	
Peak Discharge (CFS)	13790.85
Time of Peak Discharge	01Jan2000, 15:30
Volume (IN)	0.95
Precipitation Volume (AC - FT)	8273.09
Loss Volume (AC - FT)	0
Excess Volume (AC - FT)	8273.09
Direct Runoff Volume (AC - FT)	8272.65
Baseflow Volume (AC - FT)	0

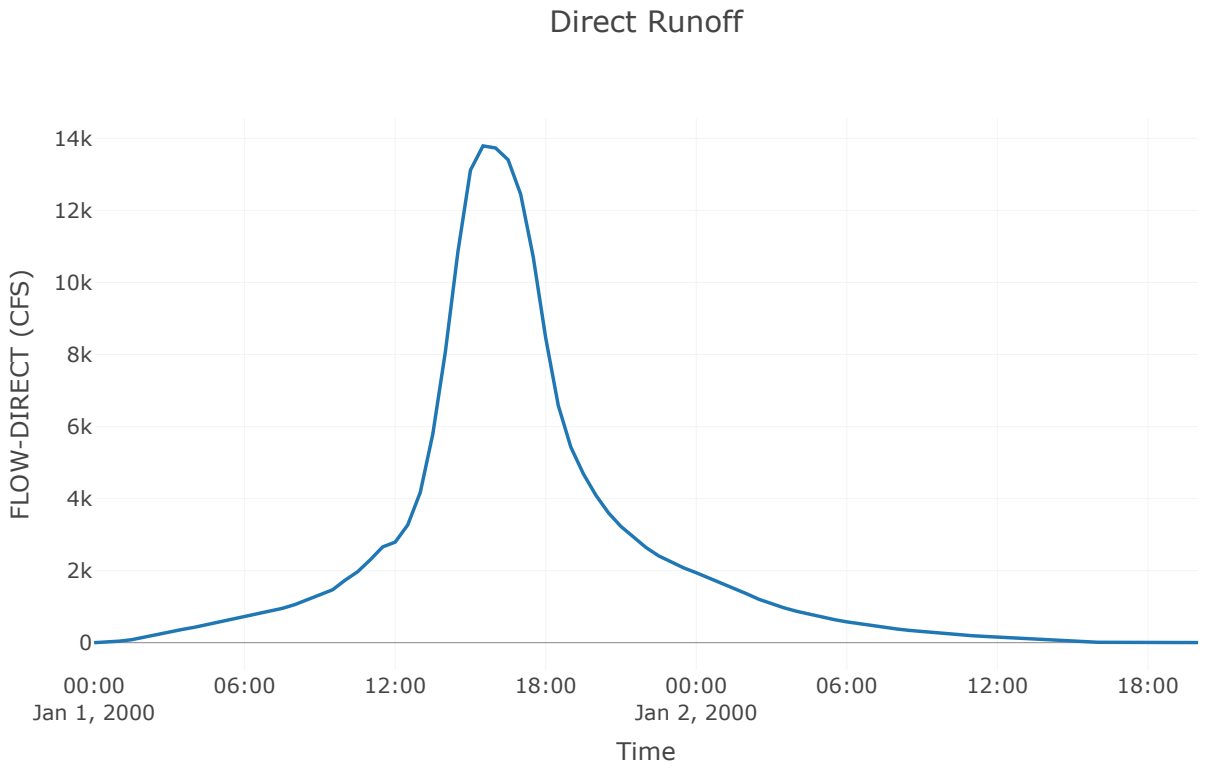
Precipitation and Outflow



Cumulative Outflow




Cumulative Precipitation
PRECIP-CUM (IN)
1
0.8
0.6
0.4
0.2
0
00:00
Jan 1, 2000
06:00
12:00
18:00
00:00
Jan 2, 2000
06:00
12:00
18:00
Time


Direct Runoff
FLOW-DIRECT (CFS)
14k
12k
10k
8k
6k
4k
2k
0
00:00
Jan 1, 2000
06:00
12:00
18:00
00:00
Jan 2, 2000
06:00
12:00
18:00
Time

Appendix H
Scour Calculations

Equations from Evaluating Scour at Bridges, Fifth Edition (FHA 2012)

The HEC-18 equation is:

$$\frac{y_s}{y_1} = 2.0\, K_1\, K_2\, K_3 \left(\frac{a}{y_1}\right)^{0.65} Fr_1^{0.43} \qquad (7.1)$$

In terms of y_s/a, Equation 7.1 is:

$$\frac{y_s}{a} = 2.0\, K_1\, K_2\, K_3 \left(\frac{y_1}{a}\right)^{0.35} Fr_1^{0.43} \qquad (7.3)$$

where:

- y_s = Scour depth, ft (m)
- y_1 = Flow depth directly upstream of the pier, ft (m)
- K_1 = Correction factor for pier nose shape from Figure 7.3 and Table 7.1
- K_2 = Correction factor for angle of attack of flow from Table 7.2 or Equation 7.4
- K_3 = Correction factor for bed condition from Table 7.3
- a = Pier width, ft (m)
- L = Length of pier, ft (m)
- Fr_1 = Froude Number directly upstream of the pier = $V_1/(gy_1)^{1/2}$
- V_1 = Mean velocity of flow directly upstream of the pier, ft/s (m/s)
- g = Acceleration of gravity (32.2 ft/s^2) (9.81 m/s^2)

Table 7.1. Correction Factor, K_1, for Pier Nose Shape.

Shape of Pier Nose	K_1
(a) Square nose	1.1
(b) Round nose	1.0
(c) Circular cylinder	1.0
(d) Group of cylinders	1.0
(e) Sharp nose	0.9

Table 7.2. Correction Factor, K_2, for Angle of Attack, 2, of the Flow.

Angle	L/a=4	L/a=8	L/a=12
0	1.0	1.0	1.0
15	1.5	2.0	2.5
30	2.0	2.75	3.5
45	2.3	3.3	4.3
90	2.5	3.9	5.0

Angle = skew angle of flow
L = length of pier

Table 7.3. Increase in Equilibrium Pier Scour Depths, K_3, for Bed Condition.

Bed Condition	Dune Height ft	K_3
Clear-Water Scour	N/A	1.1
Plane bed and Antidune flow	N/A	1.1
Small Dunes	10 > H ≥ 2	1.1
Medium Dunes	30 > H ≥ 10	1.2 to 1.1
Large Dunes	H ≥ 30	1.3

Table H. Scour Potential Scenarios

y_1 (ft)	V_1 (ft/s)	Fr_1	a (ft)	K_1	K_2	K_3	Scour Depth, y_s (ft)
0.5	0.5	0.12	0.25	1.0	1.0	1.1	0.3
0.5	2	0.50	0.25	1.0	1.0	1.1	0.5
2.5	2	0.22	0.25	1.0	1.0	1.1	0.6
2.5	4	0.45	0.25	1.0	1.0	1.1	0.9
5	2	0.16	0.25	1.0	1.0	1.1	0.7
5	4	0.32	0.25	1.0	1.0	1.1	1.0