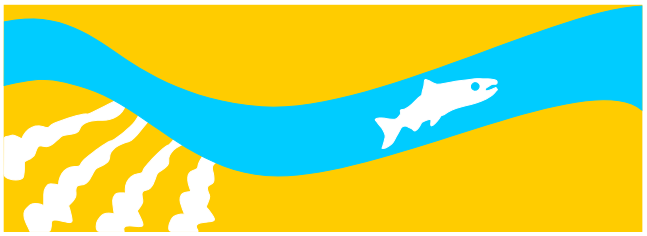
Study

Floodplain Infiltration Data Collection and Modeling

SAN JOAQUIN RIVER
RESTORATION PROGRAM



December 2013

1.0 Statement of Need

The San Joaquin River Restoration Program (SJRRP) is a comprehensive long-term effort to restore flows to 153 miles of the San Joaquin River from Friant Dam to the confluence of Merced River and restore a self-sustaining Chinook salmon fishery in the river while reducing or avoiding adverse water supply impacts from Restoration Flows. To restore a self-sustaining Chinook salmon fishery, the SJRRP will implement a combination of channel and structural projects along the San Joaquin River, restore an annual flow regime through water releases from Friant Dam, and reintroduce fish to the system. To inform channel and structural projects, habitat productivity and salmonid duration of occupation, which can be tied to the duration and depth of flows on the floodplain, should be studied. The depth and duration of flow on a floodplain is dependent on the flow hydrographs, floodplain grading and connectivity, water table elevation, floodplain soil hydraulic conductivity, and evaporation.

This study plan describes the methodology for better defining flow residence time on the floodplain. Through this study, a model will be developed that predicts inundation duration for a given flow rate and groundwater elevation for floodplains along the San Joaquin River Restoration Area. This document details the data collection that will be conducted, project timeline, project budget, and deliverables.

1.1 Anticipated Outcomes

The proposed study is intended to better quantify floodplain inundation duration by improving the knowledge of the hydraulic conductivity of floodplain soils through collecting field data. The outcome of this study will be to better inform Reclamation as to which site locations along the San Joaquin River will be suitable for conducting the floodplain production study for Reaches 2B and 4B.

1.2 Methods

Site selection criteria were developed to capture the spatial variability of hydraulic conductivity with a feasible sample density. Since the San Joaquin River Restoration Area encompasses 153 miles of the San Joaquin River and infiltration testing can be very time intensive, site selection criteria were developed to reduce the numbers of samples while still capturing the variation of infiltration along the reaches. Relevant existing soil hydraulic conductivity data and floodplain inundation were used to make informed decisions on the location of the sample sites.

Soil hydraulic conductivity is the rate in which water can flow through a soil profile. The rate is impacted by soil texture, pore connectivity, percent organic matter, bulk density, water temperature and viscosity, water and soil salinity, and landscape slope. The Natural Resources Conservation Service (NRCS) has performed soil surveys over much

of the United States and the results are housed in the Soil Survey Geographical Database (SSURGO) (Soil Survey Staff, NRCS, 2013). The SSURGO database provides a qualitative rating of hydraulic conductivity called the hydrologic soil group (HSG). The grouping is based on the premise that soils found within a climatic region will have the same infiltration responses when they have similar depth-to-restrictive layer or water table ratio, transmission rate of water, texture, structure, and degree of swelling when saturated (NRCS, 2007). Table 1 shows the four groups and their associated saturated hydraulic conductivity.

Table 1.
NRCS Hydrologic Soil Group Classifications

Soil Property	HSG A	HSG B	HSG C	HSG D
Saturated Hydraulic Conductivity	>5.67in/hr	≤5.67 to >1.42 in/hr	≤1.42 to >0.14 in/hr	≤0.14in/hr

Key:
HSG = Hydrologic Soil Groups
in/hr = inches per hour
NRCS = Natural Resources Conservation Service

The HSG of the San Joaquin River Restoration Area was determined from the NRCS Soil Data Viewer Version 6.0 (NRCS, 2011) (Figure 1). Soil Data Viewer is a tool built as an extension to ArcMap (ESRI, 2011) that allows users to create soil-based thematic maps. Soil Data Viewer data is populated from SSURGO (Soil Survey Staff, NRCS, date unknown).

Soil hydraulic conductivity is highly variable because soils are heterogeneous and anisotropic, which results in nonuniform conditions over large areas. Therefore, a high level of precision in hydraulic conductivity estimation is not obtainable; however, efforts should be made to provide high accuracy when testing. The HSG map in conjunction with the inundation grids were used to select sampling sites. Priority was given to locations where there were there were large areas of the same HSGs so that the majority of the study area would be analyzed. This study will assume that the soil hydraulic conductivity is the same for a given HSG.

In 2012, the U.S. Department of the Interior, Bureau of Reclamation (Reclamation) completed a report titled Hydraulic Studies for Fish Habitat Analysis for the San Joaquin River (SJRRP, 2012) that modeled inundation depths and extents for various discharges from Reach 1B to Reach 5. The inundation grid of 2,000 cubic feet per second (cfs) was used to select sample sites because it will be the most frequently released Restoration Flow.

Sample sites were selected by the HSG and the inundation mapping. Initially, there were 17 sample locations along the San Joaquin River (Table 2 and Figure 2). Reclamation's Technical Services Center (TSC) will coordinate with the Floodplain Production Study team to sample the test sites for their study, which is scheduled to begin field studies in February 2014.

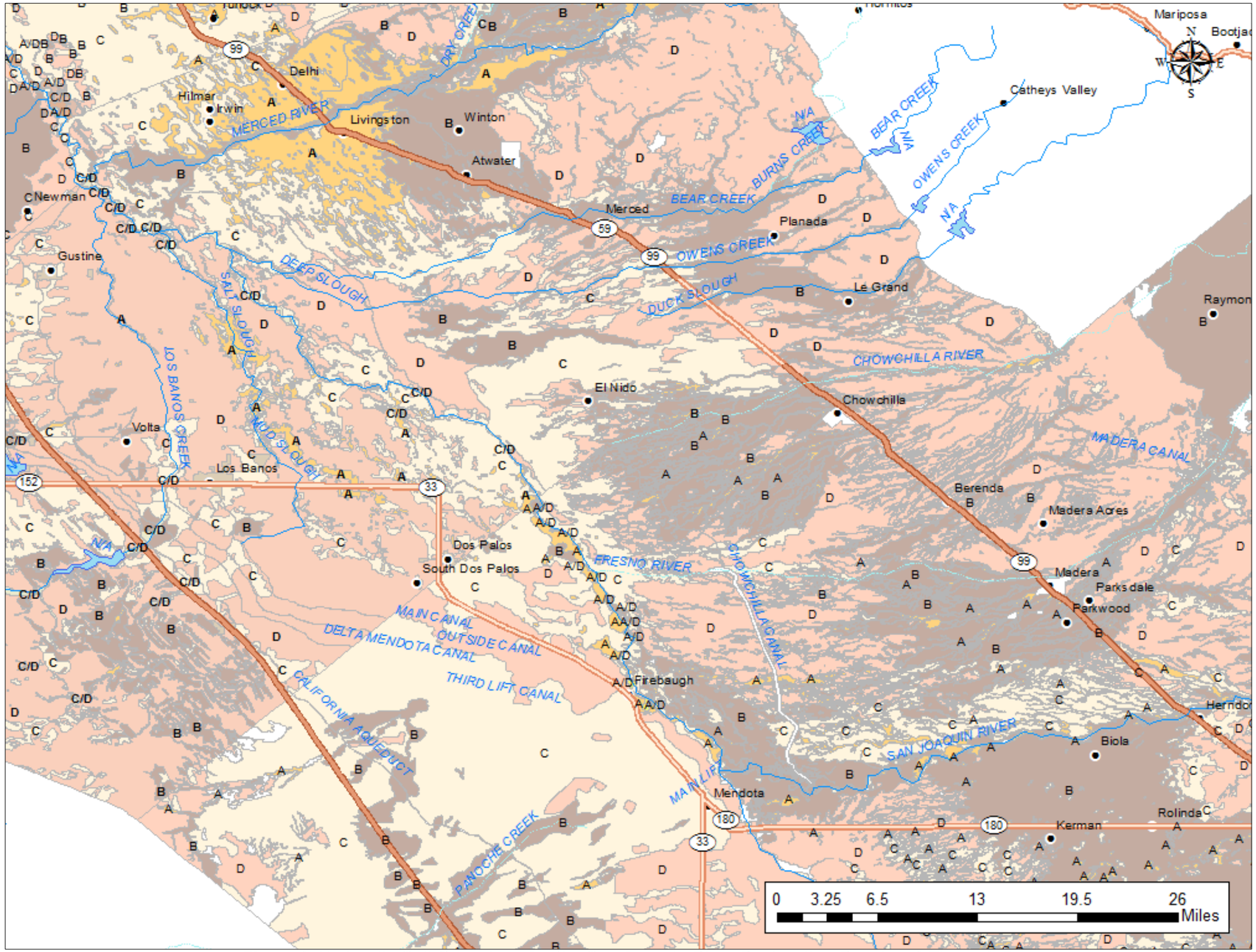


Figure 1. Hydraulic Soil Groupings for the San Joaquin River Restoration Reaches 1 Through 5

This page left blank intentionally.

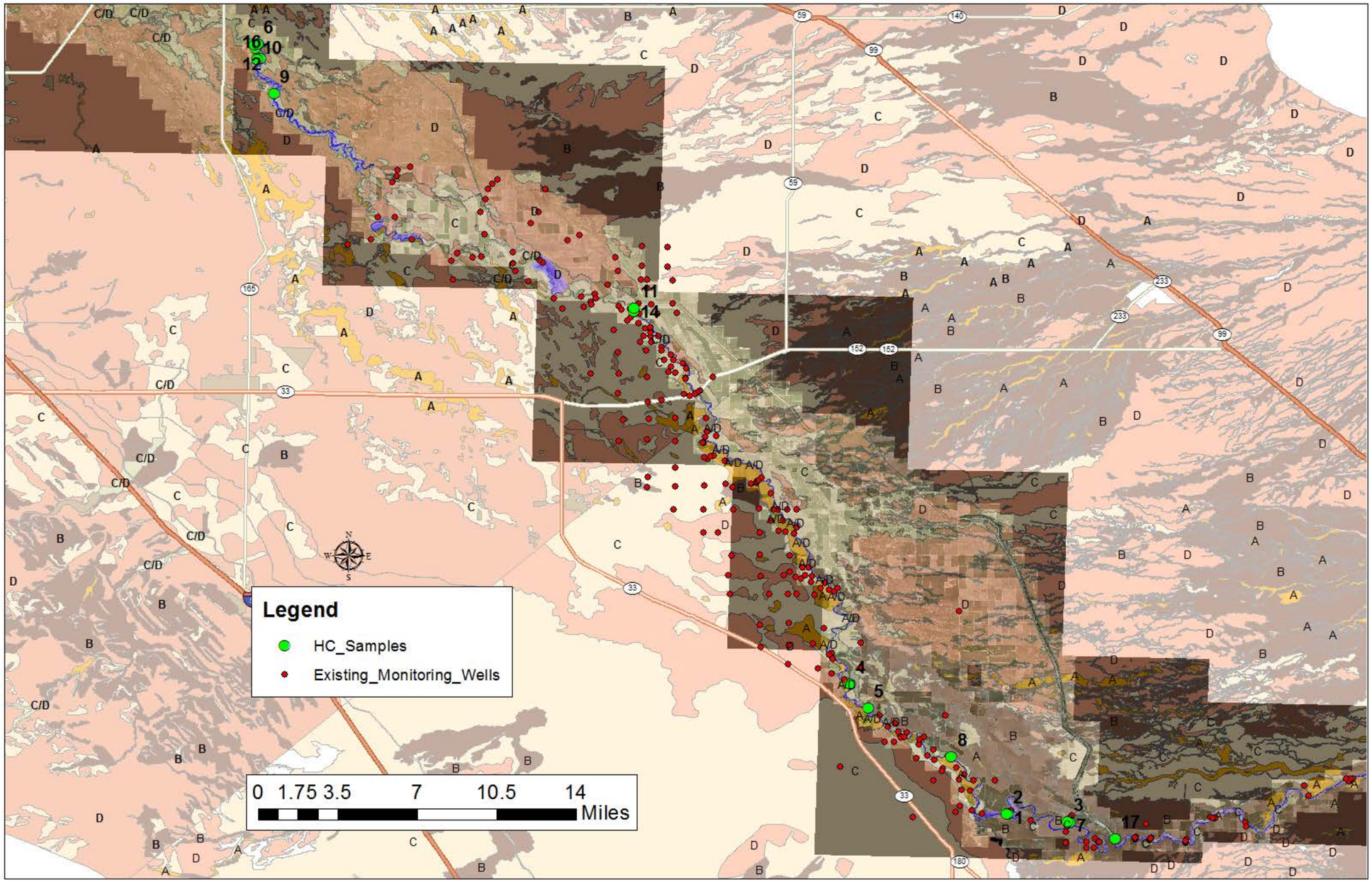


Figure 2. Hydraulic Conductivity Sampling Locations and Monitoring Well Locations along the San Joaquin River Restoration Reaches

This page left blank intentionally.

Table 2.
Hydraulic Conductivity Sample Locations

Sample ID	Hydraulic Soil Type	X (feet)[1]	Y (feet)[1]
1	A	6605430	1745150
2	A	6605140	1745230
3	A	6616490	1743370
4	A/D	6575870	1775400
5	A/D	6579210	1769780
6	B	6465830	1924090
7	B	6616940	1743200
8	B	6594720	1758450
9	C	6468810	1912650
10	C	6465620	1920640
11	C	6535610	1862720
12	C/D	6465330	1923210
13	C/D	6465170	1924080
14	C/D	6535630	1861950
15	D	6465830	1924090
16	D	6466270	1920790
17	D	6625320	1739450

Notes: 1. Coordinates are in North American Datum (NAD) 1983 State Plane California III Federal Information Processing Standard (FIPS) 0403 Feet

1.2.1 Data Collection

Floodplain inundation is dependent on several factors, specifically surface water stage and flow from the existing network, groundwater elevation, and floodplain hydraulic conductivity. Stream flow data will be obtained at five sites by the U.S. Geological Survey (USGS) (Table 3), Reclamation-gaged sites, and the California Department of Water Resources (DWR) stream gages. There are several groundwater monitoring wells that have been established throughout the San Joaquin River Restoration Area, and that data will be obtained from Reclamation's Fresno Area Office. Site-specific hydraulic conductivity will be collected in January 2014.

Table 3.
USGS Gage Stations in the San Joaquin River Restoration Area

Gage Number	Gage Name
11260815	San Joaquin River near Stevinson, CA
11260001	San Joaquin River and Chamberlain Sl near Nido, CA
11260000	San Joaquin River near El Nido, CA
11256000	San Joaquin River near Dos Palos, CA
11254000	San Joaquin River near Mendota, CA

Key: CA = California; USGS = U.S. Geological Survey

The hydraulic conductivity of a soil is dependent on the vertical (K_v) and horizontal (K_h) hydraulic conductivity. Data will be collected to determine both K_v and K_h. The most accurate testing of K_v is performed with a ring permeameter test. This test will be conducted on the 17 selected sites. The following materials are required to perform one double-ring permeameter test:

- Two steel rings
- One Marrient tank
- Two Pressure transducers
- Two-foot by four-foot board
- Sledge hammer
- Fifty-gallon water tank

Testing of K_h is dependent on the height of the water table. When the water table is within 3 feet of the surface, a bail-out test will be performed. The following equipment is needed to perform a bail-out test:

- Three-inch-diameter auger with three 1.5-meter extensions handles
- Graduated cylinder (10,000 milliliter)
- Tripod
- Measuring tape
- One hole scratcher
- Bailer or pump
- Burlap

- Perforated case or wire-wound well screen

If the water table is deeper than 3 feet, a shallow well pump-in test will be conducted to determine K_h. The following equipment is required to perform a pump-in test:

- Water supply tank truck of at least 350 gallons
- Fifty-gallon calibrated head tank
- Heavy-duty hose tape
- Constant-level float valve (carburetor) set up to regulate a constant head

1.2.2 Model Development

A simple spreadsheet model will be created to determine the floodplain inundation duration. The model will incorporate stream flow, evaporation from California Irrigation Management Information System (CIMIS) stations (Table 4), groundwater monitoring well elevations, and soil hydraulic conductivity parameters. The model will use Darcy's equation during low water table conditions and bank storage equations developed at Reclamation for high water table conditions to determine inundation duration.

Table 4.
CIMIS Stations to be Used to Determine Evaporation Along the San Joaquin River Restoration Reaches

Number ID	Station
145	Madera
7	Firebaugh/Telles
105	Westlands
124	Panoche
56	Los Banos
92	Kesterson

1.3 Budget and Schedule

Both K_v and K_h data collection will be conducted at the same time. The sampling effort will take 10 days with four people in the field. Data collection will be completed in January 2014 and the draft report will be completed by March 2014. Table 5 provides the budget request for the work performed and includes 2 days for peer review. The peer reviewer will be internal and will be scheduled by a qualified infiltration modeler and soil sampler. Limitations and/or data gaps that affect model uncertainty will be included in the model report.

Table 5.
Infiltration Analysis for the San Joaquin Floodplain Budget

Task	SL 2 (days)	SL 3 (Days)	SL 2 (8240) (days)	Labor $	Non-labor $	Total $
Hydraulic Conductivity Data Collection	10	21	10	$32,392	$10,000	$42,392
Data Synthesis/ Model Development			15	$10,680		$10,680
Report			5	$3,560		$3,560
Peer Review		2		$1,744		$1,744
					Grand Total	$68,376

1.4 References

Environmental Systems Research Institute (ESRI). 2011. ArcGIS Desktop: Release 10. Redlands, California: Environmental Systems Research Institute.

ESRI. *See* Environmental Systems Research Institute.

Natural Resource Conservation Service (NRCS). 2007. National Engineering Handbook Part 630 Hydrology Chapter 7. United States Department of Agriculture.

NRCS. *See* Natural Resource Conservation Service.

San Joaquin River Restoration Program (SJRRP). 2012. Hydraulic Studies for Fish Habitat Analysis. Denver, Colorado.

SJRRP. *See* San Joaquin River Restoration Program.

Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Soil Survey Geographic (SSURGO) Database for [Merced County, Califonia]. NRCS, Soil Data Mart. Retrieved September 25, 2013. Available at: <http://soildatamart.nrcs.usda.gov>.