(1.) Data collection methods:

Station frequency and type:

Discrete water quality monitoring stations were created in compliance with Water Right Decision D-1379 and are now mandated by Water Right Decision D-1641. Discrete water quality sampling occurs once a month at each monitoring station. From 1975 to 1994, however, sampling occurred twice a month, typically on a seasonal basis starting in Spring and ending in Fall. Stations that are accessed by research vessel (e.g., boat) are referred to as “mid-channel stations” and those that are accessed by vehicle (e.g., truck or van) are referred to as “shore-based stations”.

Field Data:

The EMP collects both surface and bottom discrete water quality field measurements during high slack tide using a multiparameter instrument (see methods table for models used for the duration of the sampling period). Surface measurements are collected one meter below the surface of the water and bottom measurements are collected one meter above the bottom of the channel. At each mid-channel station, the multiparameter instrument is placed over the side of the research vessel and lowered into the water using a winch crane. The instrument is directly connected to an onboard computer by a 30-meter cable. Once the instrument is equilibrated to the local conditions, the surface and bottom water quality measurements are recorded onto field data sheets, then the instrument is returned onboard the vessel. At shore-based stations, the multiparameter instrument is either placed directly in the water or into a bucket filled with water collected at the station. The surface and bottom water quality measurements are then recorded onto field data sheets once the instrument is equilibrated to the local conditions.

Light extinction measurements are made by lowering a light meter into the water and recording depth and light measurements to establish a curve of light extinction. The depth at which only 1% of the surface light intensity remains is read from the curve and recorded. A Secchi disk is also used to determine water clarity and light penetration by lowering the disk into the water in a shaded area and recording the measurement when the black and white quadrants of the disk become indistinguishable. Visual observations of both presence and density of the blue-green cyanobacteria, *Microcystis aeruginosa*, are made at each station and given a qualitative score ranging from 1 (no *Microcystis*) to 5 (continuous colonies of *Microcystis* forming mats/scum).

Laboratory Data:

The research vessels used to collect samples from mid-channel stations are equipped with wet laboratories for onboard processing of water samples. Water is collected using a flow-through system whereby it is pumped into the laboratory from a fixed intake located one meter below the water’s surface. For shore-based stations, water is collected either from a Van Dorn water sampler or via a submersible pump. For both mid-channel and shore-based stations, water is collected into a churn splitter and homogenized before being dispensed into sample collection bottles. Samples of dissolved nutrients are filtered using mixed cellulose ester filters (diameter = 47 mm, pore size = 0.45 µm). Samples of chlorophyll *a* and pheophytin *a* are collected on a glass fiber filter (diameter = 47 mm, effective pore size = 1.0 µm). Historically, samples of dissolved organic carbon were passed through glass fiber filters (diameter = 47 mm, effective pore size = 1.0 µm) that have been combusted for 1 hour at 450 ºC. Starting in December 2020, the EMP switched to using mixed cellulose ester filters (diameter = 47 mm, pore size = 0.45 µm) to process dissolved organic carbon samples.

Entrapment Zone:

The EMP began sampling the Entrapment Zone (EZ) stations in 1996 to document the environmental conditions and geographic variability of the low salinity zone. This zone is sampled once a month at two “floating” stations, which represent the upper (upstream) and lower (downstream) boundaries, called EZ2 and EZ6, respectively. Station EZ2 is located where the bottom specific conductance falls within 10% of 2,000 µS/cm and station EZ6 is located where the bottom specific conductance falls within 10% of 6,000 µS/cm. When dry conditions reduce the freshwater flows into the San Francisco Estuary, saline water from the Pacific Ocean intrudes further into the estuary and causes the low salinity zone to travel upstream where it is split by the Sacramento and San Joaquin Rivers. Such conditions create two geographically disparate low salinity zones. Under these conditions, the stations EZ2-SJR and EZ6-SJR are sampled in the San Joaquin River in addition to stations EZ2 and EZ6, which are sampled in the Sacramento River.

Vessel Use:

Sampling typically occurred on research vessels from the California Department of Water Resources or United States Bureau of Reclamation. From DWR, the RV San Carlos (1975-2016) and RV Sentinel (2017-2020) were primarily used. From USBR, RV Compliance and RV Endeavor were utilized when DWR vessels were unavailable.

Standard operating procedures for field collection methods are available upon request (email data contact).

(2.) Datasheet:

Copies of field data sheets are available upon request. Please email data contact.

(3.) Instruments and equipment:

Field Instrumentation:

See IEP\_EMP\_DWQN\_metadata\_methods.pdf

Light Extinction: A Whitney LMT-8A Light Meter was used to measure the depth at which sunlight is extinguished to 1% of surface intensity from 1975 – 1986.

Secchi: A 20 cm inch diameter plastic disc with alternate black and white quadrants was used to measure water transparency from 1975 – 2020.

*Microcystis aeruginosa*: *Microcystis* qualitative scores were recorded startingin August 2015. The qualitative score isa visual observation ranging from (1) meaning absent, (2) low-widely scattered colonies, (3) Medium-adjacent colonies, (4) High-contiguous to (5) Very High- concentration of contiguous colonies forming mats/scum.

Surface and bottom turbidity data collected during the period of record is reported in two different units. Nephelometric Turbidity Units (NTU) were used from January 1975 - December 2018 for shore-based stations and from January 1975 – June 2019 for mid-channel stations. Formazin Nephelometric Units (FNU) were used starting in January 2019 for shore-based stations and July 2019 for mid-channel stations. This change in reporting units is based on recommendations from the instrument manufacturer and has no impact on the raw measurements nor does it affect the comparability of the dataset.

Chlorophyll fluorescence data collected from field instrumentation during the period of record is not included in this data set, but is available upon request (email data contact).

(4.) Analysis and methods (standard operating procedures):

Laboratory Analysis Methods:

See IEP\_EMP\_DWQN\_metadata\_methods.pdf

Analyses were performed by CDWR’s Bryte Laboratory for most of the period of record. From October – March 2020, however, analyses (except for chlorophyll and pheophytin) were performed by Test America Laboratory. Historically, it was common for Bryte Laboratory to use Department-approved procedures that deviated from the standard or EPA methods. These approved deviations were associated with sample preservation techniques and are indicated by an asterisk (\*) in the methods table. Bryte Laboratory stopped using modified versions of these methods in November 2020. For more information on this, please email the data contact.

Copies of written standard operating procedures for all laboratory analysis methods are available upon request (email data contact).

(5.) Project history (change in methods and locations):

Stations:

At the start of the program in 1975, there were 27 discrete water quality monitoring stations sampled monthly. These stations mostly remained unchanged from 1975-1994, though a small number of stations were added or discontinued, while others were replaced by nearby stations. When a station replacement occurred, an “A” was typically added to the end of the old station name to create the new station name (e.g., station C3 was replaced by the nearby station C3A). However, stations D41 and D41A are an exception to this and are two independent locations. At the end of 1995, sampling was discontinued at 11 stations, leaving 15 remaining stations. Beginning in 1996, EMP implemented a revised compliance monitoring program, which combined the water quality, phytoplankton, benthic, and zooplankton samplings programs previously undertaken by DWR/USBR and the California Department of Fish and Wildlife (CDFW) independently. This led to the acquisition of the CDFW stations, which are indicated by the prefix “NZ”. By 2017, the station list had increased to 26 stations sampled monthly, with 13 of those included in the original station list at the start of the program. Most changes made to the station list over the period of record were to either obtain better access, maintain consistency between program elements, and/or to pair discrete water quality data with data from other elements, such as continuous water quality or zooplankton data.

Data:

In the earlier years of the program, comprehensive nutrient sampling occurred monthly at all stations. This continued until 1995 when six of the 15 stations remaining were reduced to chlorophyll *a* and pheophytin *a* sampling only. Starting in 2016, the EMP began reinstating the comprehensive sampling at these chlorophyll *a* and pheophytin *a*-only stations. By February 2017, the full suite of water quality analytes was collected at every station. Regarding field data, surface measurements were reported from the start of the program, but it wasn’t until 2017 (January for mid-channel stations and February for shore-based stations) when bottom measurements were reported for the first time. There are only three months during the entire period of record in which no data was collected at any station, which were in January 1980, from reasons that were undocumented, and April and May 2020 due to the COVID-19 pandemic. There are a few instances during the period of record when some stations were sampled, but not all, which was due to unsafe conditions caused by hazardous air quality and the COVID-19 pandemic.

From 1975-2020, the following laboratory analytes were added to the sampling list: dissolved ammonia (1979), dissolved chloride (1980), total dissolved solids (1997), total suspended solids (1997), volatile suspended solids (1997), total organic carbon (2011), dissolved organic carbon (2011), dissolved calcium (2011), dissolved bromide (2019), and total alkalinity (2019). From 1975 - 2020, the following laboratory analytes were dropped from the sampling list: total ammonia (1978), total organic nitrogen (1979), and total chloride (1980).

From 1975 - 2020, the following field parameters were added to the sampling list: wind direction (1984), field notes (1996), weather observations (1996), GPS coordinates for EZ stations (2004), a rating score for the blue-green algae, *Microcystis aeruginosa* (2015), and near bottom measurements (2017), dissolved oxygen in percent saturation (2019). From 1975 - 2020, the following field parameters were dropped from the sampling list: 1% light depth (1996) and wind direction (1999).

Collection Methods:

At each discrete monitoring station, the EMP collects water quality and biological (phytoplankton and zooplankton) samples concurrently. At most stations, samples for discrete water quality are collected prior to beginning the zooplankton sampling, which is conducted by towing collection nets upstream from the station at a constant velocity. At four stations—D28A, D26, D8, and D4—water quality samples were historically collected midway through the zooplankton tow. Results of an internal study conducted in March 2016, however, found no significant differences in water quality parameters at the beginning tow and mid-tow locations for these four stations. As a result, all water quality samples are now collected before beginning the zooplankton tow as of June 2016.

Dissolved oxygen (DO) was historically measured from a Winkler titration method. As the ease and accuracy of electronic DO sensors increased, the EMP conducted an internal study to assess any potential differences between DO measured by a multiparameter sonde and Winkler titration. No significant differences were found, and the EMP discontinued the use of Winkler titrations in June 2016. DO is now measured solely using a multiparameter sonde.

Sample water from shore-based stations was historically collected via a pump system that was permanently installed at each station. During prolonged droughts, however, the EMP determined that this fixed intake produced unreliable data when water levels were low. As a result, the EMP began using a Van Dorn water sampler to collect samples at these stations starting in May 2016.

The EMP has been sampling dissolved organic carbon (DOC) since January 2011 and has historically used a 1.0 μm glass fiber filter combusted at 400° Celsius for one hour to process DOC samples. However, the EPA method 415.3 for DOC sampling requires that the sample be passed through a 0.45 μm filter prior to analysis. As a result, the EMP switched to a 0.45 μm mixed cellulose ester membrane filter for DOC sampling in December 2020. This filter type proved to be a reliable option for departmental water quality sampling in a study done by the DWR Quality Assurance Program, as it did not add or remove analytes in blank samples. A separate internal study conducted in 2018 found that the differences between DOC samples processed with a combusted 1.0 μm glass fiber filter and a 0.45 μm mixed cellulose ester membrane filter were similar to the differences found between replicate samples. This indicates that the historical DOC data collected by the EMP is comparable to the data collected after making the switch to the 0.45 μm filter.

(6.) QA/QC:

Field data sheets are error checked by hand at the end of each sampling run by the water quality field leads. Field data for each run is then entered into CDWR’s Field and Laboratory Management System (FLIMS) where it is housed while the laboratory data is being analyzed. After the laboratory data has been analyzed, it is merged with the field data and uploaded into the Water Data Library. Both field and laboratory data are then exported into an Excel file from the Water Data Library and verified with the field data sheets by the EMP quality assurance lead.

Instruments used to collect and analyze water quality data are calibrated and maintained following the manufacturer’s guidelines. The multiparameter instruments are calibrated with known standards prior to field runs and verified with another calibrated instrument during sampling. After returning from the field, the instruments are checked with the same calibration standards to ensure the instrument held its calibration. Since October 2018, the EMP started assigning a drift rating to each sensor on the instrument based on calculations made from the post-field calibration check results. These ratings follow an acceptance criteria developed from the USGS Wagner method to validate the data collected in the field and are available upon request (email data contact).

To create this data set, annual discrete water quality data files were exported from the CDWR’s Water Data Library (WDL) from 1975-2020 and then merged to create one large data set. The data was then checked for accuracy using the associated field data sheets as a reference. Blank and duplicate data was collected during this period of record, but was removed from this data set, as its primary use is for internal QA/QC checks. The EMP also conducted heavy metal and pesticide monitoring historically, but this data was not included in this data set because it was separate from the mandate.

(7.) Contractor Information:

All water quality sampling was conducted by staff from IEP’s Environmental Monitoring Program (EMP) primarily from the California Department of Water Resources and the United States Bureau of Reclamation with assistance from the California Department of Fish and Wildlife.

(8.) External review process:

An IEP Project Work Team reviewed the EMP’s sampling procedures during 2001-2002 and a summary report and recommendations was created in 2003.