Continuous Water-Quality and Suspended-Sediment Transport Monitoring in the San Francisco Bay, California, Water Years 2014–15

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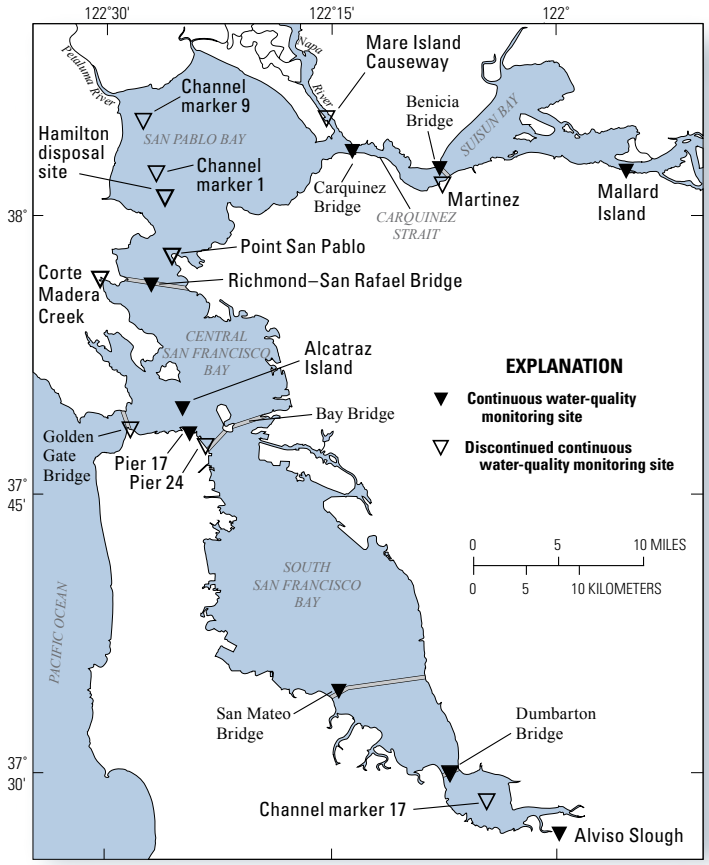
The U.S. Geological Survey (USGS) monitors water quality and suspended-sediment transport in the San Francisco Bay (bay) as part of a multi-agency effort to address management, water supply, and ecological concerns. The San Francisco Bay area is home to millions of people, and the bay teems both with resident and with migratory wildlife, plants, and fish. Freshwater mixes with salt water in the bay, which is subject both to riverine influences (floods, droughts, managed reservoir releases and freshwater diversions) and to marine influences (tides, waves, effects of salt water). To understand this environment, the USGS, along with its partners (see "Acknowledgements"), has been monitoring the bay's waters continuously since 1988. Several water-quality variables are of particular importance to State and Federal resource managers and are monitored at key locations throughout the bay (fig. 1). Salinity, which indicates the relative mixing of fresh and ocean waters in the bay, is derived from specific conductance measurements. Water temperature, along with salinity, affects the density of water, which controls gravity-driven circulation patterns and stratification in the water column. Turbidity, a measure of light scattered from suspended particles in the water, is used to estimate suspended-sediment concentration (SSC). Suspended sediment affects the bay in multiple ways: attenuation of sunlight in the water column, affecting phytoplankton growth; deposition on tidal marsh and intertidal mudflats, which can help sustain these habitats as sea level rises; deposition in ports and shipping channels, which can necessitate dredging; and often, adsorption of contaminants, affecting their distribution and concentrations in the environment. Dissolved oxygen concentration, essential to a healthy ecosystem and a fundamental indicator of water quality, is affected by water temperature, salinity, ecosystem metabolism, tidal currents, and wind. Tidal currents in the bay reverse four times a day, and wind direction and intensity typically vary on a daily cycle. Consequently, salinity, water temperature, SSC, and dissolved-oxygen concentration vary spatially and temporally throughout the bay. Therefore, continuous measurements are needed to observe these changes. The purpose of this fact sheet is to provide information about these variables, as well as internet links to access these continuous water-quality data collected by the USGS.



Base modified from U.S. Geological Survey and other Federal and State digital data, various scales; Albers Equal Area Conic projection, standard parallels are 29°30' N. and 45°30' N.; North American Datum of 1983.

Figure 1. San Francisco Bay study area, California.

Program Overview

Continuous water-quality measurements are, or have been, collected at several monitoring stations in the bay (fig. 1; table 1). Typically, instruments are suspended in the water from a stainless-steel cable that is anchored to the bottom (fig. 2) and are equipped with a variety of sensors. Data are recorded every 15 minutes and are retrieved either by cellular telemetry (yielding provisional data available within 1 hour of measurement) or during periodic site visits (yielding provisional data available within 1 week of the site visit). Biological growth, which can affect sensor readings, usually increases with time, and the affected data need to be revised or deleted. Every 2–5 weeks, each site is visited to clean and calibrate the instruments and retrieve data as needed. Water samples

are collected at the sensor depth to relate the turbidity data to SSC (fig. 3). For stations where water discharge is computed along with cross-sectionally averaged SSC, water discharge is measured by using a boat-mounted acoustic Doppler current profiler (Mueller and others, 2013), and water samples are collected periodically at points across the channel by the equal-discharge-increment method (fig. 4; U.S. Geological Survey, 2006). Suspended-sediment flux, in mass per unit time, is computed as the product of the water discharge and the channel-average SSC at the indicated cross section. Data are edited and reviewed before final approval. Further details about these methods are available at https://ca.water.usgs.gov/projects/baydelta (access the "Methods" section).

Specific-conductance, water-temperature and turbidity data are collected at two depths in the water column to help characterize the vertical variability. For stations in shallow water (Alviso Slough, Pier 17, and Alcatraz Island), data are collected only at one depth. Dissolved-oxygen data are only collected at Alviso Slough (table 1).

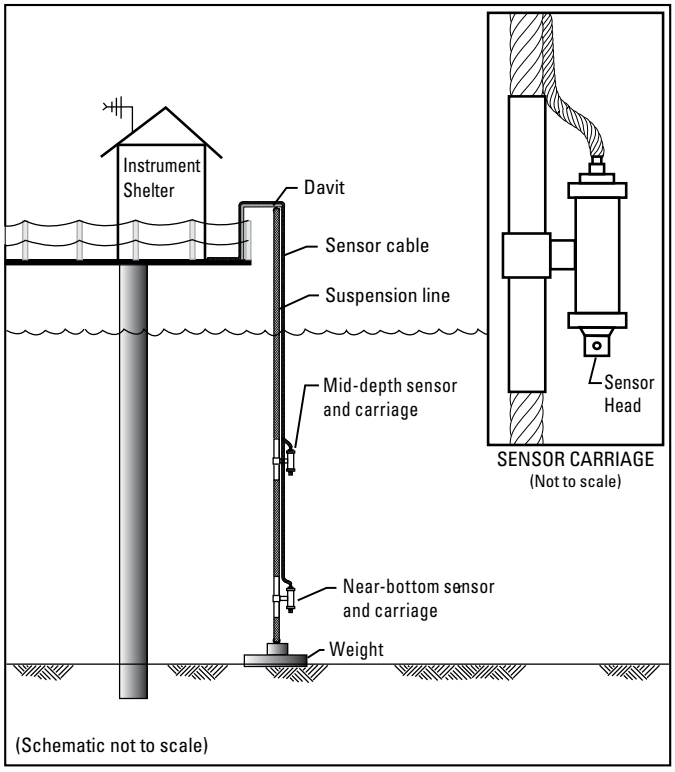


Figure 2. Typical monitoring installation, San Francisco Bay study.

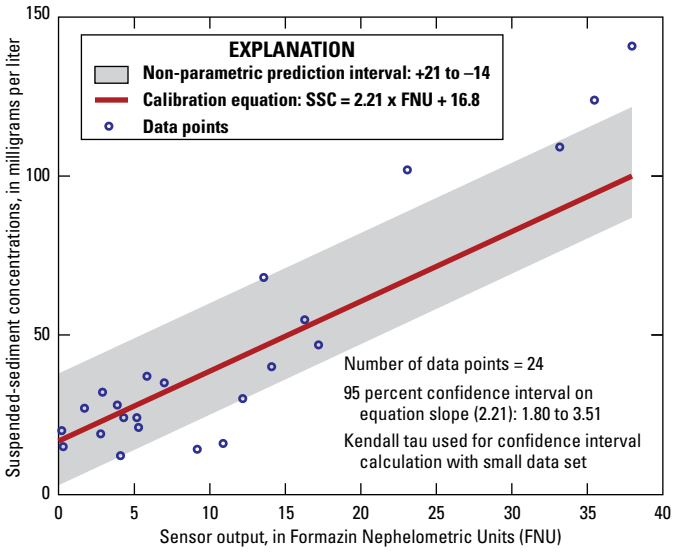


Figure 3. Example rating curve that relates turbidity to suspended-sediment concentrations (SSC) using the nonparametric repeated median method (Siegel, 1982). Output of an optical turbidity sensor is related to the SSC measured in water samples.

Figure 4. U.S. Geological Survey scientist collecting a suspended-sediment concentration sample with a depth-integrated sampler at South San Francisco Bay near the Dumbarton Bridge. Photograph taken by Greg Shellenbarger.

Figure 5. Biological fouling on water-quality instruments at the Richmond–San Rafael Bridge.

Instrument Specifications

Specific conductance (reported in microsiemens per centimeter at 25 degrees Celsius) and water temperature (reported in degrees Celsius) have been measured using the YSI, Inc., 6560 conductance/temperature sensor.[1] Two types of optical sensors have been used to measure turbidity: the DTS-12, manufactured by Forest Technology Systems, and model 6136, manufactured by YSI, Inc. Dissolved oxygen has been measured by the optical sensor model 6150, manufactured by YSI, Inc. Sensors manufactured by YSI, Inc., are installed on the 6920 multi-parameter water-quality instrument.

In a continuous water-quality monitoring program, potential sources of error include, but are not limited to, electronic drift, calibration errors, and biological fouling of sensors (fig. 5). Data corrections (necessary because of biological fouling or instrument electronic drift) have been applied to the affected periods of record following USGS guidelines (https://ca.water.usgs.gov/projects/baydelta).

Continuous water-quality and suspended-sediment transport data collected during water years 2014 and 2015 (October 2013–September 2015) are archived in the USGS National Water Information System and are available to the public at https://waterdata.usgs.gov/ca/nwis.

For additional information:
https://ca.water.usgs.gov/projects/baydelta/
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Siegel, A.R., 1982, Robust regression using repeated medians: Biometrika, v. 69, p. 242–244.

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[1]The use of firm, trade, and brand names in this report is for identification purposes only and does not constitute endorsement by the U.S. Government.

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Table 1. Continuous water-quality monitoring stations, Suisun Bay, San Pablo Bay, and Central and South San Francisco Bays, California, October 1, 2013–September 30, 2015.

[DO, dissolved oxygen; ft, feet; na, not applicable; NWIS, National Water Information System; Q, water discharge; SF, San Francisco; SpC, specific conductance; SSC, suspended-sediment concentration; SSF, suspended-sediment flux; T, water temperature; X, collected parameter; µS/cm, microsiemens per centimeter; °C, degrees Celsius; —, no data]

Measurement location		Water-quality parameter						Start of record (water year)	Remarks
		Specific conductance	Temperature	Turbidity	SSC	Q, SSF	Dissolved oxygen		
Alviso Slough near Alviso, 11169750									
Near bottom	Percent valid data*	82	89	78	—	—	88	2010	Highest SpC for period of record: September 12 and 13, 2015 (48,700 µS/cm).
Cross-section	—	—	—	—	X	X	na	2010	Q and SSF are not yet available from NWIS.
South SF Bay at Dumbarton Bridge, 373015122071000									
Upper	Percent valid data*	—	—	61	61	—	na	1993	Data are downloaded hourly using cellular telemetry.
Lower	Percent valid data*	—	—	64	64	—	na	1993	Dissolved-oxygen data collection was discontinued on October 1, 2014.
Cross-section	—	—	—	—	—	X	na	2009	Q and SSF data are not yet available from NWIS.
SF Bay at San Mateo Bridge near Foster City, 11162765									
Upper	Percent valid data*	86	94	—	—	—	na	1989	Data are downloaded hourly using cellular telemetry. Highest SpC for period of record: September 9, 2014 (51,100 µS/cm). Highest T for period of record: August 7, 2015 (24.0 °C).
Lower	Percent valid data*	63	88	—	—	—	na	1989	Highest SpC for period of record: September 20, 21, 23–26, 2014 (51,300 µS/cm). Highest T for period of record: July 27, 2014 (23.9 °C). Dissolved-oxygen data collection was discontinued October 1, 2014.
SF Bay at Pier 17, 374811122235001									
Near bottom	Percent valid data*	79	85	81	81	—	na	2014	Highest SpC for period of record: July 8, 9, 11, 13, 2014 (49,900 µS/cm). Highest T for period of record: August 29, 2015 (20.4 °C). Data are downloaded hourly using cellular telemetry. Dissolved-oxygen data collection was discontinued October 1, 2014.
SF Bay at Alcatraz Island, 374938122251801									
Mid-depth	Percent valid data*	85	98	72	72	—	na	2003	Data are downloaded hourly using cellular telemetry. Highest SpC for period of record: August 29, 2008 (49,300 µS/cm). Highest T for period of record: July 26, 2014, August 28, 2015 (20.1 °C).
SF Bay at Richmond–San Rafael Bridge, 375607122264701									
Upper	Percent valid data*	87	87	84	84	—	na	2006	Highest SpC for period of record: June 14, 2004 (51,000 µS/cm). Highest T for period of record: August 17, 2015 (21.9 °C).
Lower	Percent valid data*	92	95	77	77	—	na	2006	Highest SpC for period of record: July 12, 2014 (50,100 µS/cm). Highest T for period of record: August 16 and 17, 2015 (21.1 °C). Dissolved-oxygen data collection was discontinued October 1, 2014.

Table 1. Continuous water-quality monitoring stations, Suisun Bay, San Pablo Bay, and central and south San Francisco Bays, California, October 1, 2013–September 30, 2015.—Continued

[DO, dissolved oxygen; ft, feet; na, not applicable; NWIS, National Water Information System; Q, water discharge; SF, San Francisco; SpC, specific conductance; SSC, suspended-sediment concentration; SSF, suspended-sediment flux; T, water temperature; X, collected parameter; µS/cm, microsiemens per centimeter; °C, degrees Celsius; —, no data]

Measurement location		Water-quality parameter						Start of record (water year)	Remarks
		Specific conductance	Temperature	Turbidity	SSC	Q, SSF	Dissolved oxygen		
Carquinez Strait at Carquinez Bridge, 11455820									
Upper	Percent valid data*	64	66	—	—	—	na	1998	Highest SpC for period of record: October 9, 2014, October 16, 2015 (43,400 µS/cm).
Lower	Percent valid data*	68	69	—	—	—	na	1999	Highest SpC for period of record: August 29, September 3, 2015 (44,400 µS/cm).
Suisun Bay at Benicia Bridge, 11455780									
Upper	Percent valid data*	93	98	81	81	—	na	2001	Data are downloaded hourly using cellular telemetry. Highest SpC for period of record: July 31, 2015 (38,700 µS/cm).
Lower	Percent valid data*	92	96	85	85	—	na	2001	Highest SpC for period of record: October 14, 2014 (40,100 µS/cm). Dissolved-oxygen data collection was discontinued October 1, 2014.
Suisun Bay at Mallard Island, 11185185									
Upper	Percent valid data*	—	—	95	95	—	na	1994	Data are downloaded hourly using cellular telemetry. Upper sensor attached to a float to maintain a constant depth below water surface of 3.3 ft.
Lower	Percent valid data*	—	—	98	98	—	na	1994	—

*Percentage of valid data represents the number of valid data points for water years 2014 and 2015 divided by the maximum theoretical number of data points (96 points is the maximum number of data points for a 15-minute time series of measurements).