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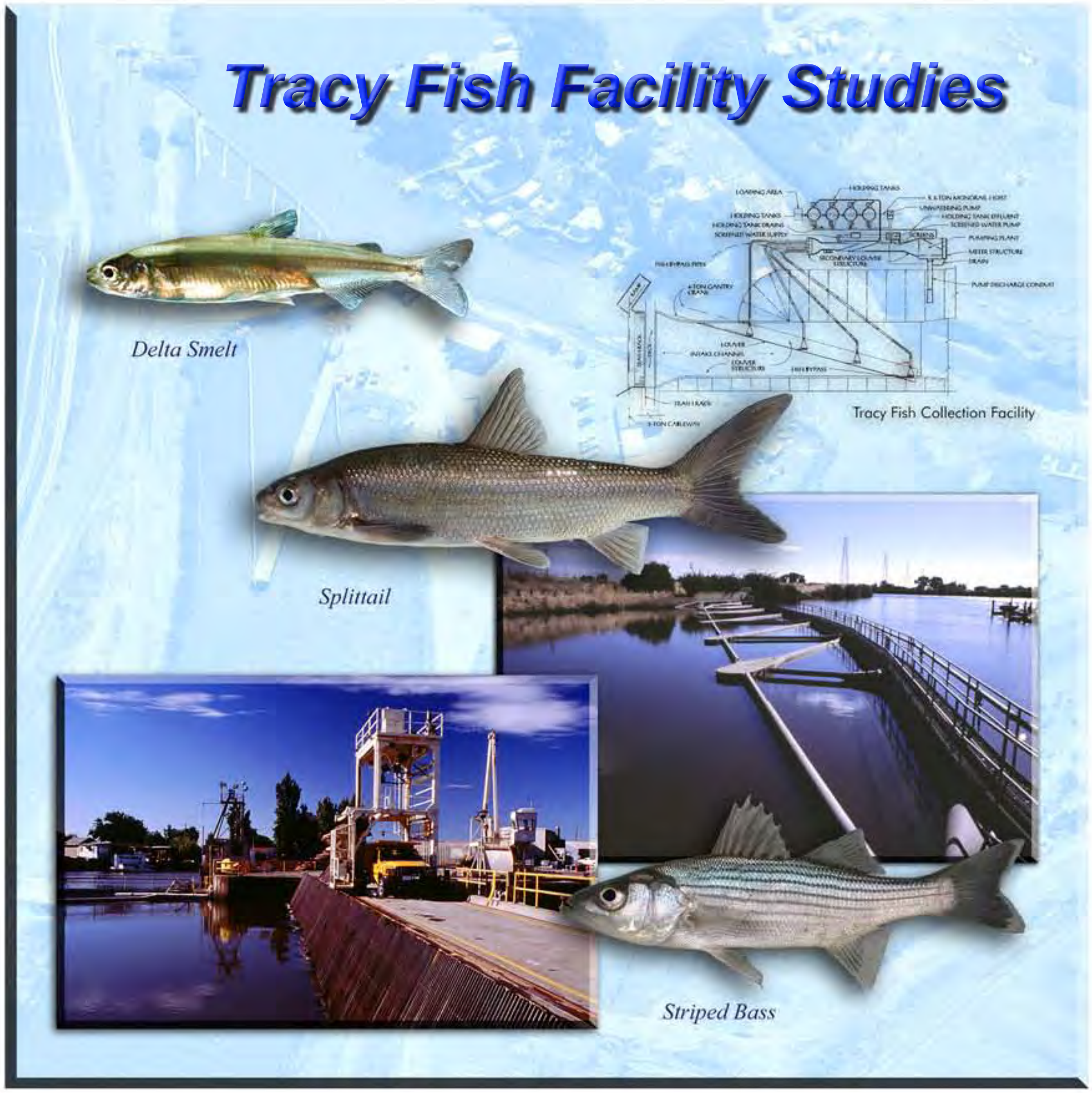

Semi-Continuous Water Quality Measurements at the Tracy Fish Collection Facility: 7-Year Summary

Volume 37

U.S. Department of the Interior
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14. ABSTRACT
Water quality variables temperature, hydrogen-ion concentration (pH), dissolved oxygen, conductivity, oxidation-reduction potential, and turbidity were measured at 30-minute intervals using calibrated recording multiprobes installed in the intake channel of the Bureau of Reclamation's Tracy Fish Collection Facility (TFCF), located near Tracy, California, in the southern region of the Sacramento-San Joaquin River Delta. This report summarizes validated data from April 1, 2000 through February 15, 2007. The water quality data were archived in a relational data base that combined water quality with data for meteorology, hydrology, tides, export pumping at a nearby Federal pumping plant, fish salvage, and temporary barrier installation and removal schedules. Median values and ranges for this period of record were 17.4 degrees Celsius (5.41 to 29.0 °C) for temperature, 366 microSiemens per centimeter (119 to 1,220 µS/cm) for conductivity, 7.46 milligrams per liter (0.10 to 12.5 mg/L) for dissolved oxygen, 339 millivolts (100 to 575 mV) for redox potential, 7.70 (6.28 to 8.65) for pH, and 13.2 Nephelometric turbidity units (0.10 to >200 NTU) for turbidity. Dissolved oxygen was below the critical value of 5 mg/L (50 percent saturation) for Chinook salmon 2.6 percent of the time (65 out of 2,512 days), usually during the summer. Besides regional climate, runoff hydrology, and daily tidal fluctuations, the most significant influence on water quality appears to be the status of nearby temporary channel barriers and the operation of the Delta Cross Channel gates near Walnut Grove, California. When temporary barriers are installed and the Cross Channel gates are open from April through October, daily variations and maximum conductivity are much lower than when higher conductivity water from the San Joaquin River flows relatively unimpeded to the TFCF.

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Tracy Fish Collection Facility, Tracy Fish Facility Improvement Program, TFCF, TFFIP, semi-continuous, water quality, multiprobe, sonde, dissolved oxygen, DO, pH, temperature, conductivity, EC, turbidity, data base

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Tracy Fish Facility Studies
California

Semi-Continuous Water Quality Measurements at the Tracy Fish Collection Facility: 7-Year Summary

Volume 37

by

Doug Craft[1], Maria Del Hoyo[2], Ron Housewright[2], and John Fields[2]

September 2008

U.S. Department of the Interior
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Tracy Fish Facility Improvement Program

Ron Silva, Manager

Tracy Series Editor

Donald E. Portz, Ph.D.
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Cover

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EXECUTIVE SUMMARY

The Tracy Fish Collection Facility (TFCF), Tracy, California, is the Bureau of Reclamation's (Reclamation's) fish salvage facility located at the head of the intake canal for the C.W. "Bill" Jones Pumping Plant (BJPP – formerly Tracy Pumping Plant). The TFCF removes entrained fish from Old River water before it is pumped into the Delta Mendota Canal by the BJPP. These facilities are located in the southern riverine estuary region of the Sacramento-San Joaquin River Delta (south Delta) that flows into San Francisco Bay in northern California, and were built in the 1950s as part of the Federal Central Valley Project. Since 1992, applied research and investigations to improve fish salvage at the TFCF have been funded by the Central Valley Project Improvement Act and guided by the Tracy Fish Facility Improvement Program (TFFIP). The purpose of this TFFIP project was to provide reliable baseline water quality data from the TFCF to aid Reclamation fishery scientists and engineers performing experimental work at the TFCF, and to contribute reliable data for the Interagency Ecological Program and other researchers involved in water management and fish salvage in the Central Valley of California.

This is the fifth Tracy Series report summarizing water quality data at the TFCF (Craft, *et al.*, 2000, 2002, 2003, 2004), and this report summarizes semi-continuous water quality data measured at 30-minute intervals using calibrated recording multiprobes (sondes) from April 1, 2000 through February 15, 2007, a 6.9-year period of record containing over 120,000 observations. The Hydrolab and YSI water quality sondes were installed in the intake channel of the TFCF behind the trash rack, and were cleaned and calibrated on a biweekly schedule by personnel from the MP Regional Office, Sacramento, California, following established quality assurance and quality control procedures. The variables measured in the Old River intake channel at the TFCF included temperature (T, measured in degrees Celsius, °C), pH (measured in standard units, su), dissolved oxygen (DO, measured in milligrams per liter, mg/L), electrical conductivity (EC, measured in microSiemens per centimeter, µS/cm), oxidation-reduction (or redox) potential (Eh, measured in millivolts, mV), and turbidity (measured in nephelometric turbidity units, NTU). The water quality data are posted on the Tracy research website at: http://www.usbr.gov/pmts/tech_services/tracy_research/data/WaterQualityData.html.

Water Quality Data Summaries

Table ES-1 provides a summary of valid data, statistics, and percentiles for the entire 6.9-yr period of record (POR) for each the water quality variables. Because several of the variables were not normally distributed, rank-based summaries of percentiles and the median are presented in addition to mean and standard deviation. Figures ES-1 through ES-6 graph median and the 16th and 84th percentile data by month of year for water quality variables. The 16th to 84th percentile is an approximation of the ± 1 standard deviation associated with the 68-percent confidence interval. Refer to Appendix 3 for histograms that provide a more detailed view of the water quality variable distributions, and Appendix 4 for a detailed statistical and percentile summary of the data by month of year.

TABLE ES-1.—Overall summary of data, statistics, and percentiles for the 6.9-yr record of water quality data at the Tracy Fish Collection Facility, summarized by water quality variable.

	T, °C	EC, µS/cm	DO, mg/L	pH, su	Eh, mV	Turbidity, NTU
Valid Data Points	106,285	105,240	105,878	101,052	92,077	105,845
Total Missing Data Points	14,267	15,312	14,674	19,500	28,475	14,707
Subtotal Censored	334	1,379	741	5,567	14,542	774
Subtotal Sonde Malfunction	13,933	13,933	13,933	13,933	13,933	13,933
Mean	17.1	390	7.68	7.47	354	20.7
Standard Deviation	5.44	157	1.57	0.287	102	29.0
Standard Error of Mean	0.0167	0.483	0.00482	0.000902	0.335	0.0892
Range	23.6	1100	10.25	2.37	475	200
Minimum	5.41	119	2.28	6.28	100	0.1
Maximum	29.0	1220	12.51	8.65	575	200
Percentiles						
0.1th	5.82	123	0.230	6.75	119	<0.500
2.5th	8.26	143	4.58	6.93	185	1.00
16th	10.6	243	6.24	7.21	255	3.80
25th	11.9	277	6.72	7.29	272	6.10
Median (50th)	17.4	366	7.70	7.46	339	13.2
75th	22.2	483	8.75	7.63	426	24.9
84th	23.5	528	9.25	7.74	473	31.7
97.5th	25.6	777	10.6	8.13	562	97.3
99.9th	28.3	1060	11.7	8.52	575	>200

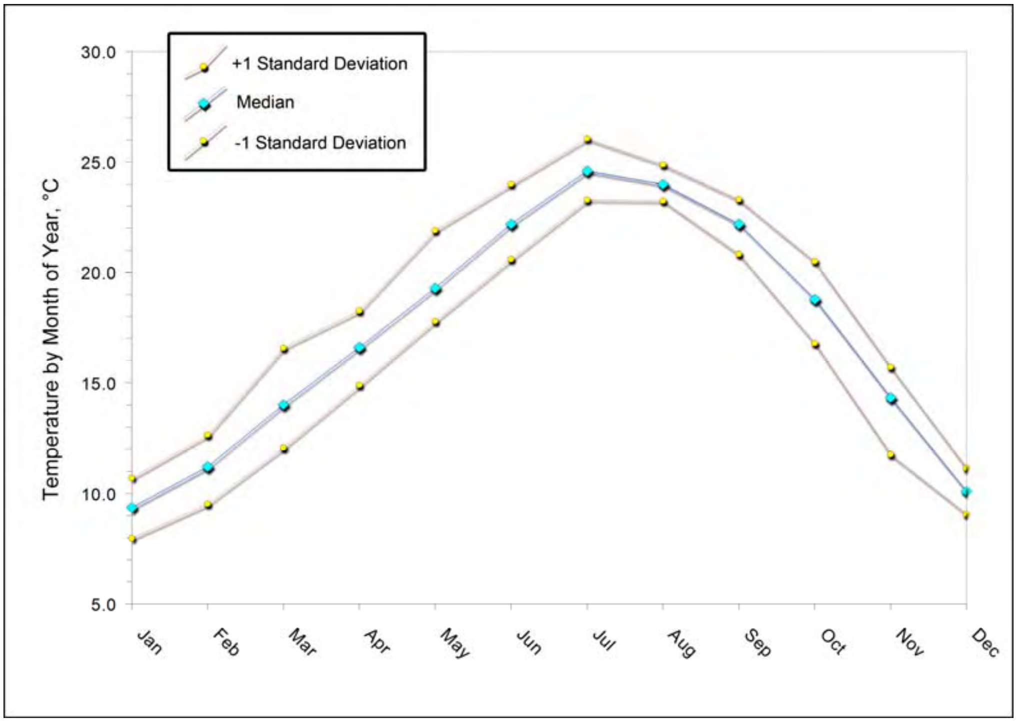

FIGURE ES-1.—Median monthly water temperature in °C (centerline) at the Tracy Fish Collection Facility with 84th percentile (upper line) and 16th percentile (lower line) plotted to approximate 68-percent confidence intervals (± 1 standard deviation).

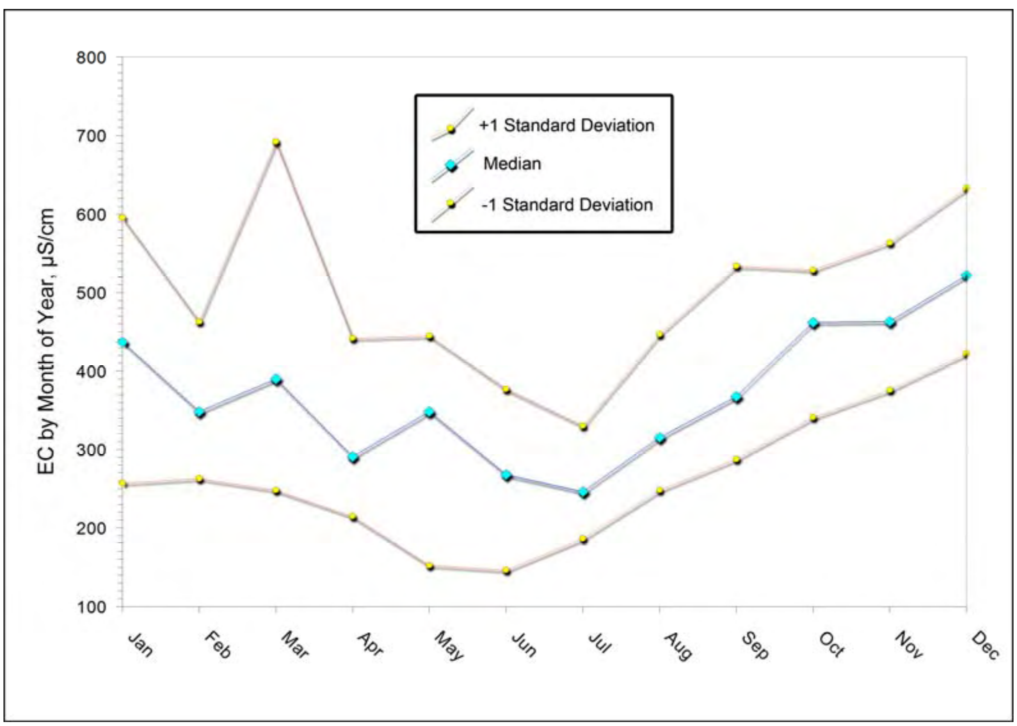

FIGURE ES-2.—Median monthly electrical conductivity (EC) in µS/cm (centerline) at the Tracy Fish Collection Facility with 84th percentile (upper line) and 16th percentile (lower line) plotted to approximate 68-percent confidence intervals (± 1 standard deviation).

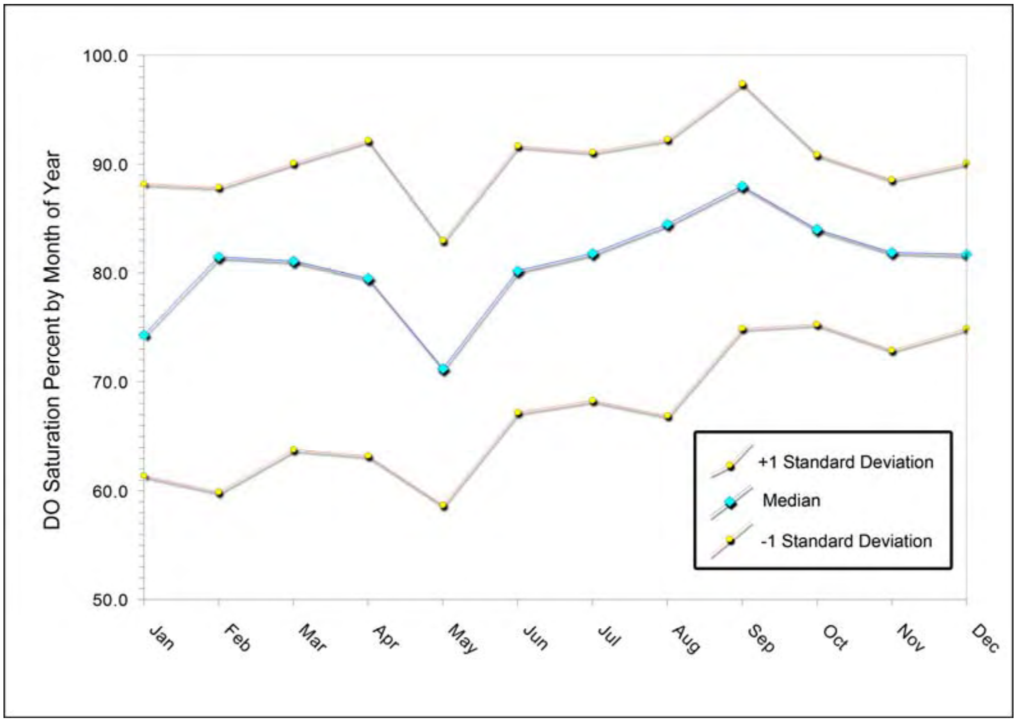

FIGURE ES-3.—Median monthly percent dissolved oxygen (DO) saturation (centerline) at the Tracy Fish Collection Facility with 84th percentile (upper line) and 16th percentile (lower line) plotted to approximate 68-percent confidence intervals (± 1 standard deviation).

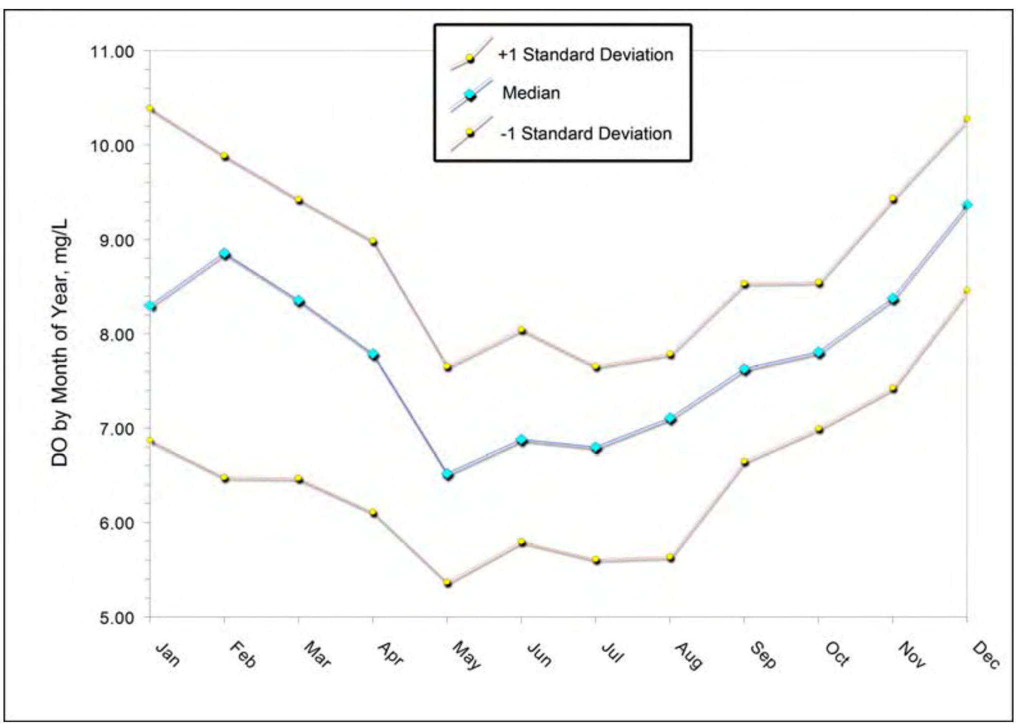

FIGURE ES-4.—Median monthly dissolved oxygen (DO) in mg/L (centerline) at the Tracy Fish Collection Facility with 84th percentile (upper line) and 16th percentile (lower line) plotted to approximate 68-percent confidence intervals (± 1 standard deviation).

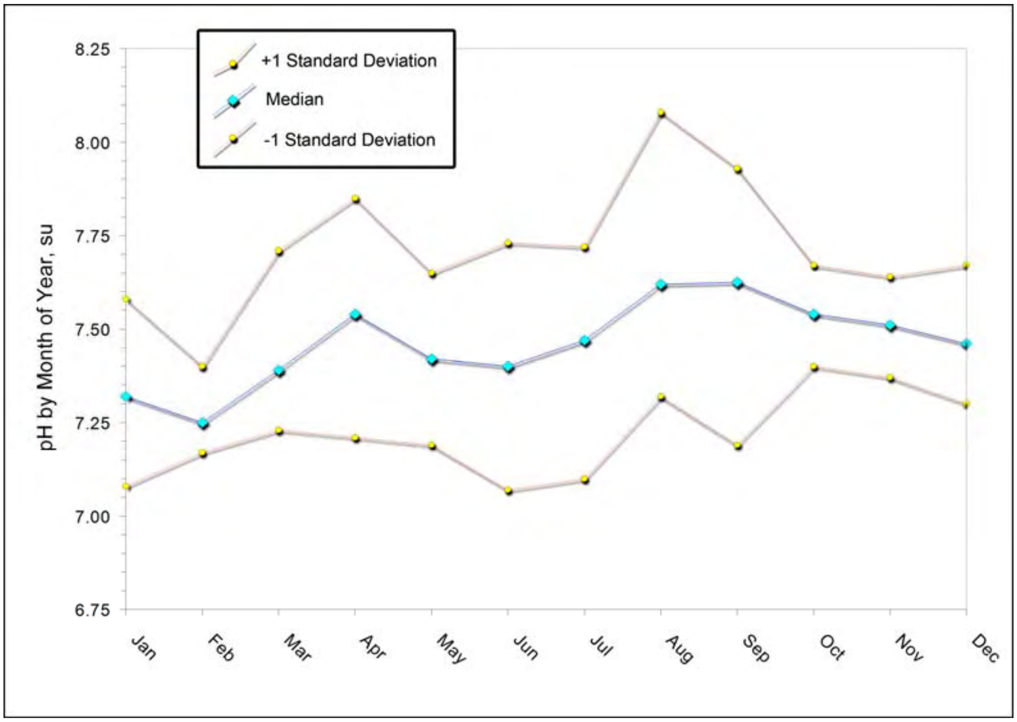

FIGURE ES-5.—Median monthly pH in standard units (su, centerline) at the Tracy Fish Collection Facility with 84th percentile (upper line) and 16th percentile (lower line) plotted to approximate 68-percent confidence intervals (± 1 standard deviation).

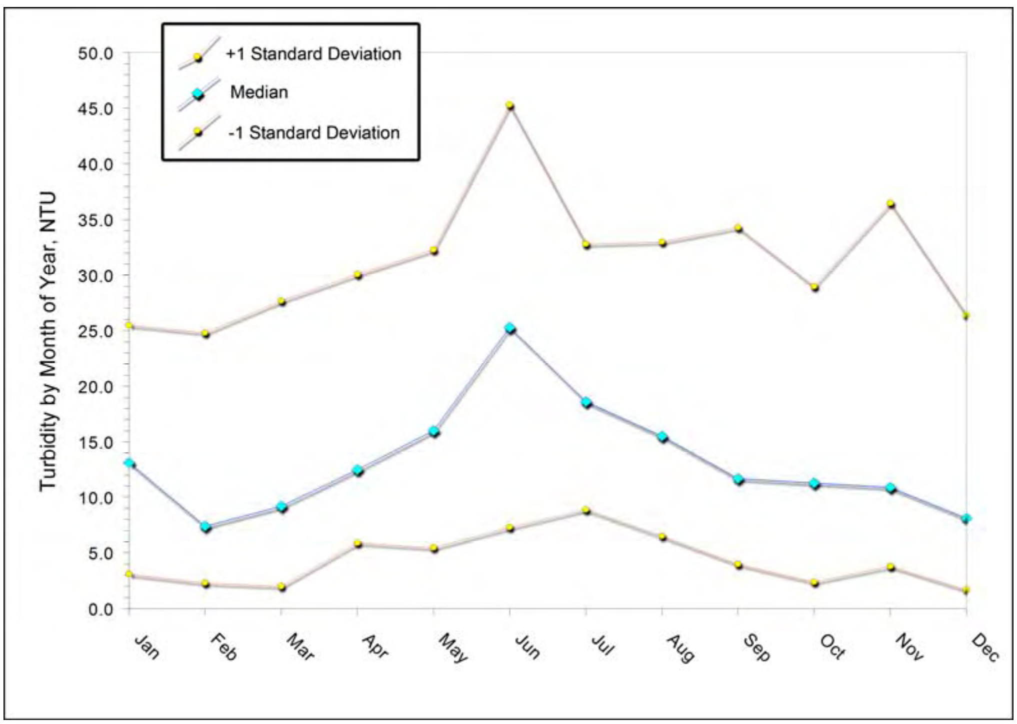

FIGURE ES-6.—Median monthly turbidity in nephlometric turbidity units (NTU, centerline) at the Tracy Fish Collection Facility with 84th percentile (upper line) and 16th percentile (lower line) plotted to approximate 68-percent confidence intervals (± 1 standard deviation).

The following are general summaries for each variable:

Temperature.—T data showed a complex seasonal distribution and ranged from 5.41 (during winter) to 29.0 °C (during summer), with a grand median of 17.4 °C. Median low T of 9.40 °C (Figure ES-1) occurred during January and median high of 24.6 °C in July. The T sensor was the most reliable probe and data were only lost during calibration and sonde inoperable periods.

Electrical Conductivity.—EC was normally distributed with some skewness and ranged from 199 to 1,220 µS/cm with a grand median of 366 µS/cm. EC is a proxy for salinity and is the water quality variable most affected by tides. Daily tidal variations of EC up to 300 µS/cm are not unusual at the TFCF. Median low EC was 246 µS/cm during July (Figure ES-2) and median high EC of 522 µS/cm in December. These results are thought to be caused by general runoff hydrology in the San Joaquin and Sacramento River watersheds with low EC water associated with spring snowmelt runoff. EC data is also affected by artificially altered flows in the south Delta. Temporary barriers, which retard the inflow of higher EC Old River water and opening of the Delta Cross Channel (DCC) gates that allows tidal transport of lower EC water south from the Sacramento River also influence EC at the TFCF.

Dissolved oxygen.—DO was normally distributed ranging from 0.1 (likely an anomalous value) to 12.5 mg/L with a grand median of 7.70 mg/L. Notably, DO was below 5.0 mg/L 5 percent of the POR (126 out of 2,512 days). Median low DO occurred in May (6.52 mg/L, Figure ES-4) and median high DO in December (9.37 mg/L). Lower DO is caused by higher temperatures and organic material concentrations in the water column common during the late spring and summer agricultural season. Nitrogen and phosphorus fertilizer runoff during the agricultural season also promotes algal productivity that can deplete DO.
Median percent DO saturation (Figure ES-3) was 81.1 percent and was observed below 50.0 percent (corresponding to DO = 4.6 mg/L) around 2.63 percent of the POR.

pH.—pH was normally distributed ranging from 6.28 to 8.65 with a grand median of 7.46. pH < 7.00 was observed only 3.0 percent of the POR and pH > 8.0 was observed 5.0 percent of the POR. Maximum median pH was seen in August (7.62, Figure ES-5) and minimum median pH in February (7.25). These results are suggestive of higher primary productivity and production of bicarbonate during the summer agricultural season.

Redox Potential.—Eh (not shown in this section, but included in the Appendix 3 summary table) ranged from 102 to 575 mV with a grand median value of 339 mV. However, there were significant operational and calibration problems with Eh probes that produced a large proportion of lost and censored data (29.3 percent). Additionally, Eh data measured with a platinum electrode are of limited interpretative value because of mixed potentials at the platinum-water interface, and DO is a better proxy for oxidation-reduction potential in flowing and well-mixed surface waters (Stumm and Morgan, 1994).

Turbidity.—Turbidity (Figure ES-6) was log-normally distributed and ranged from 0.1 NTU (not detected) to 200 NTU (a censoring value suggesting very short transient spikes above the probe calibration range) with a grand median of 13.2 NTU. The 5th to 95th percentiles ranged from 1.60 to 55.3 NTU. The transient high turbidity readings were observed only 1.0 percent of the POR, and not detected values only 0.10 percent of the POR.

Complexity and Assessment Issues

It is important to note that variability and hydraulic complexity in the south Delta makes assessment of any trend or summary generalizations about water quality processes at the TFCF difficult. While we have noted several general or qualitative trends and apparent causal relationships between variables, the basin scale influences of precipitation, runoff hydrology, and tides introduce significant year-to-year, seasonal, and daily variability that frustrates attempts to quantify these relationships.

Summaries of the entire POR by study month or study week may suggest a relationship between variables that is obscured when month of year or week of year is used as a summary grouping. This can occur because more extreme readings during some years may bias the estimates of central tendency and obscure seasonal trends. Figure ES-6 turbidity data suggest a maxima during June, but a closer examination of summaries by study day and study week reveal a trend of generally greater turbidity during winter.

Year to year variability and nonlinear or threshold response processes may also complicate interpretations of data trends or causal relationships. What might appear to be a causal relationship during one period may be less clear in subsequent periods. During study year 2 (April 2001–March 2002), spikes in turbidity data appeared to coincide with *some winter* rain events, but not others (Craft *et al.*, 2003). Tidal effects may be magnified or suppressed depending on the operations of the DCC gates or the nearby intake gates at Clifton Court Forebay.

General Water Quality Trends

Despite the variability and hydraulic complexity in the south Delta, we think that water quality at the TFCF does show expected responses to seasonal effects, basin hydrology, local rainfall, and artificial hydraulic and agricultural influences. EC shows the expected Western U.S. snowmelt runoff pattern, and over the POR, median EC appears to be lower as recent Sierra Nevada snowpack and spring runoff streamflows have increased. DO and pH also show expected seasonality, with lower DO and higher pH observed during warmer months.

Temporary Barriers and Delta Cross Channel Gates

Other than basin-wide factors (runoff hydrology, tides, and climate), a dominant influence on water quality at the TFCF appears to be the installation and removal of temporary local channel barriers and operation of the DCC gates near Walnut Grove, California. These seasonal channel barriers and the DCC diversions are intended to decrease salinity and improve general water quality for fish populations and other beneficial uses in the south Delta by restricting the inflow of higher salinity water from the Old River and enhancing the southerly transport of lower salinity water from the Sacramento River basin. When barriers are installed and the DCC gates are open from April through October, daily tidal variation and maximum EC are *generally* lower than when higher EC water from the San Joaquin

River watershed flows relatively unimpeded to the TFCF. We note that temporary barrier and DCC gate schedules vary from year to year, and that some temporary barriers have been notched to promote fish movement over the past several years.

Low DO Periods

During the summer, DO does drop below 5 mg/L often enough to warrant concern by TFCF and other salvage facility operators. During periods of lower intake channel DO, we recommend that TFCF personnel more closely monitor DO sensors inside the facility, especially in fish holding and transport tanks, and ensure that internal sensors are maintained and calibrated.

Recommendations

Because independent annual data review, validation, and assessment of the TFCF sonde data is an important QA function, we recommend that these oversight, analysis, and information transfer aspects of the sonde program continue. We also recommend the following as ways that the current program may be improved:

Consistent Calibration and Maintenance Is Essential

Previous experience at the TFCF has demonstrated that calibration and maintenance of sondes, and priority assignment of responsible personnel is essential to produce accurate and usable water quality data. We recommend that sonde calibration and maintenance performed by experienced technicians from the Mid-Pacific Regional Office continue. Sonde maintenance and calibration could be performed by trained TFCF personnel; however, management would need to maintain priority for any such local personnel assignment, and the local program should be audited and assessed for data quality improvement and ongoing corrective actions at least annually.

Regular Equipment Replacement

A review of sonde performance strongly suggests that sondes perform reliably for 2 years before operational problems begin to cause increased data loss. Therefore, we recommend replacing sondes at the outset of every third year of data collection, factory reconditioning the older sonde to serve as a backup, and making provisions in the TFFIP budget to accommodate ongoing equipment replacement.

Remote Data Monitoring

The percentage of lost data associated with the channel water quality sonde could be reduced by remote monitoring of sonde data using a web-based system such as the YSI Econet service. This service can alert field crews with automated emails when data are logged beyond acceptable limits (see Appendix 1 SOP for our current warning and control limits). The field crew could then take corrective actions and restore proper sonde function before routine scheduled visits. This kind of web-based system would also enable access to real-time sonde data for TFCF biologists and operators, allowing implementation of “low DO” operating protocols to reduce salvage losses.

INTRODUCTION

The Tracy Fish Collection Facility

The Tracy Fish Collection Facility (TFCF) is the Bureau of Reclamation (Reclamation) fish salvage facility at the head of the intake canal for the C.W. "Bill" Jones Pumping Plant (BJPP – formerly Tracy Pumping Plant), that removes entrained fish from Old River water before it is pumped into the Delta Mendota Canal (DMC). Both the TFCF and the BJPP were built in the early 1950s as part of Reclamation's Central Valley Project (CVP), a large water diversion infrastructure project that enabled agricultural expansion throughout most of the Central Valley of California. These facilities are located approximately 8 kilometers (km –4 miles, mi) northwest of Tracy, California, in the southern riverine estuary region of the Sacramento-San Joaquin River Delta (south Delta) that flows into San Francisco Bay in northern California (see map in Figure 1).

The BJPP pumps water for irrigation, municipal, and industrial uses from the Old River, a distributary of the San Joaquin River (SJR) into the DMC, which then flows southeast along the Central Valley. California's Department of Water Resources (CDWR) and Department of Fish and Game (CDFG) operate a similar salvage, pumping, and water diversion system (the State Water Project – SWP) directly to the north of the TFCF at Clifton Court Forebay (CCF). The SWP includes the Harvey O. Banks Pumping Plant (BPP), the John E. Skinner Delta Fish Protective Facility (SDFPF), and the California Aqueduct. Before the CVP and SWP diversion systems were implemented, SJR water flowed north unimpeded into San Francisco Bay. Much of the SJR is now recycled by being diverted south in the DMC and other State and Federal canals. Water pumped from the Old River at the TFCF is conveyed by a series of pumping stations on the DMC to the Mendota Pool to replace water diverted to the Friant-Kern Canal. DMC water then flows by gravity southward down the San Joaquin Valley in a network of canals where it is re-used before returning by way of the SJR (Liston *et al.*, 1993).

Project Background

This report is the fifth in a series from the research project, *Chemical Monitoring and Assessment at the Tracy Fish Facility*, funded as part of the Tracy Fish Facility Improvement Program (TFFIP). Started in 1989, the TFFIP was later mandated and funded by the Central Valley Project Improvement Act of 1992 (CVPIA) to investigate design and operational improvements for the Tracy Fish Collection Facility (TFCF). The purpose of this TFFIP research project is to develop a reliable reference or "baseline" water quality data set that combines historical water chemistry data, agricultural chemical application data, semi-continuous measurement of general water quality variables, and chemical analysis data from discrete and composite water samples collected at the TFCF. A baseline water quality data set is important to the TFFIP because water quality is a primary influence on the health of local fish populations.

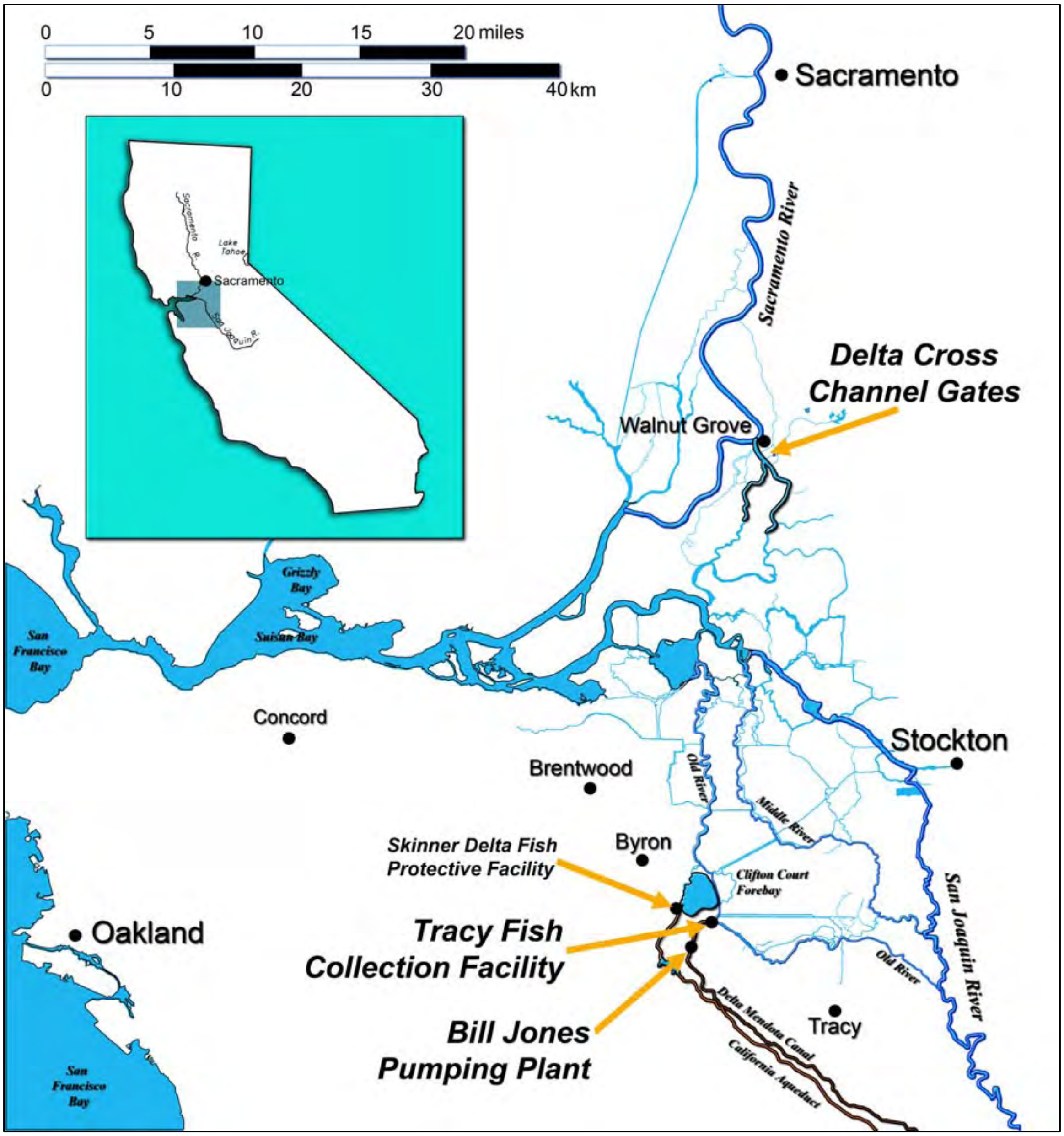

FIGURE 1.—Map showing the location of the Tracy Fish Collection Facility.

During 2000, personnel from the Reclamation Mid-Pacific (MP) Regional Office, Sacramento, California, began a calibration and maintenance program for a recording multiprobe (sonde) installed in the intake channel of the TFCF behind the trash rack (Figure 2). The variables measured by the sonde included water temperature (T, measured in degrees Celsius, °C), pH (a measure of acidity or hydrogen ion activity, measured in standard units, su), dissolved oxygen (DO, measured in milligrams per liter, mg/L), electrical conductivity (EC, a measure of salinity or total dissolved ions, measured in microSiemens per centimeter, µS/cm), oxidation-reduction (or redox) potential (Eh, measured in millivolts, mV), and turbidity (a measure of suspended particles, measured in nephelometric turbidity units, NTU).

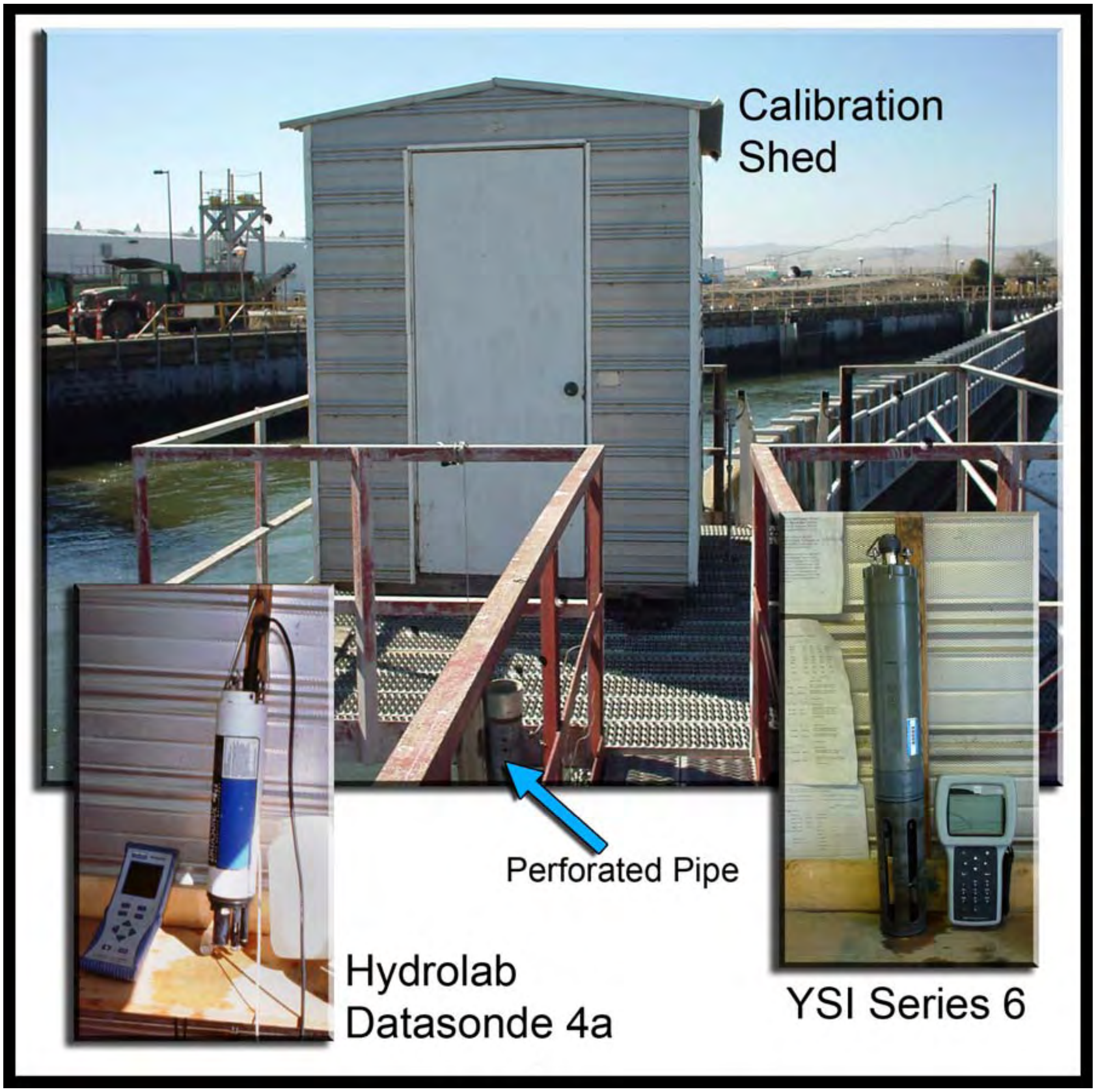

FIGURE 2.—Photo of the calibration shed and the sondes used at the Tracy Fish Collection Facility.

This report summarizes the almost 7-year period of record (POR) from April 1, 2000 though February 15, 2007 for validated sonde water quality measurements at the TFCF, and is a follow-up to previous Tracy Series reports on water quality published by Craft, *et al.* (2000, 2001, 2002, 2003).

General Factors Affecting Water Quality at the TFCF

The chemistry of TFCF intake water from the Old River is influenced by complex interactions of many regional and local variables. Regional influences include basin-wide snowmelt runoff and interactions between agricultural land use runoff within the marine sedimentary geology of the Central Valley of California. Water quality at the TFCF is affected by runoff from the drier southern extent of the Central Valley, drained by the

San Joaquin River (SJR), as well as the wetter northern basin drained by the Sacramento River. The regional influences can change year to year because of hydrologic cycle variability, snow pack in the different regions of the Sierra Nevada, and other trends such as increasing urban populations and land use changes (San Francisco Estuary Institute, 1997). Daily tidal fluctuations are a major influence on the water quality at the TFCF, and can produce large and rapid changes in EC within hours at the TFCF. Other influences include large-scale south Delta mixing of SJR and Sacramento River freshwater sources converging on San Francisco Bay, pumping from the BJPP, entrainment of high tides and pumping at the State facility at CCF, local irrigation return flows, local winter rainfall, chemical applications on crops, and intermittent channel dredging (State of California, 1999).

Temporary Barriers and Delta Cross Channel Gates

A major influence on TFCF water quality is the seasonal installation (usually in April and May) and removal (usually in September through November) of temporary channel barriers in the south Delta flow channels. The temporary barriers are embankments of piled rocks across the Old River, Middle River, and Grant Line Canal that retard inflows and mixing from the upstream SJR during high tides. The purpose of the temporary barriers is to improve water quality in the south Delta for fish and other beneficial water uses during the agricultural irrigation season. The Old River is the primary source water for the TFCF; however, operation of the Delta Cross Channel (DCC) gates (Figure 1) near Walnut Grove, California, allows for significant southerly transport and mixing of lower concentration Sacramento River water (median electrical conductivity, EC = 150 µS/cm) into the south Delta (State of California, 1999; Craft *et al.*, 2000).

Old River water at the TFCF intake contains total dissolved solids (TDS) ranging from 300 to 1,100 mg/L, with median EC of 479 µS/cm (Craft *et al.*, 2000), and contains sodium (Na^+) and chloride (Cl^-) as the principal inorganic constituents. Daily tidal EC fluctuations of 100 to 300 µS/cm are commonly observed at the TFCF. The fluctuations are thought to be caused by up-gradient transport and mixing of lower concentration waters from the Sacramento River by the rising tidal salt wedge (State of California, 1999). When local inflows from the SJR are further impeded by temporary channel barriers and the opening of the DCC gates, increased influence from lower concentration water from the northern Central Valley watersheds produces better water quality (lower maximum EC) and lower daily variation in EC at the TFCF.

Agricultural Influences

Another major influence on the water quality at the TFCF are local and basin-wide agricultural activities (Craft *et al.*, 2000) that mostly occur from April through October. Irrigation return flows may contain nitrogen and phosphorus from fertilizer applications and dissolved and suspended organic carbon from vegetation decay that directly affect algal productivity, pH, and DO at the TFCF. Agricultural applications of herbicides, pesticides, and fungicides and their formulation additives (usually organic surfactants, adjuvants, and sticking agents) also affect water quality. Localized storm runoff, usually during the winter rainy season, may mobilize suspended matter that increases turbidity, vegetative debris, and organic carbon in local waters. These varying and unpredictable chemical inputs enter the

Grant Line, Fabian, Bell, Victoria, and North Canals, Tom Paine Slough, Paradise Cut, and the Old and Middle Rivers.

The complex interactions that produce the water quality observed at the TFCF underscore the need for accurate measurements that are spatially and temporally representative.

METHODOLOGY

Water Quality Sondes and Calibration

The water quality variables T, pH, EC, DO, Eh, and turbidity were measured at 30-minute intervals using a sonde installed in a perforated pipe located behind the trash rack and intake structures of the TFCF (Figure 2; Craft *et al.*, 2002). The original sonde was the Hydrolab (now Hach® Environmental) DataSonde 4a that used the Surveyor 4a data logger. In 2005, the Hydrolab sonde was replaced with a Yellow Springs Instruments, Inc. (YSI) model QS 600 sonde and the model 650 Multiparameter Display System. Both sondes were deployed in the channel and operated with an on-board stirrer that was activated during programmed probe measurements.

Personnel from the Reclamation MP Region performed the routine calibration and maintenance procedures of the sonde on a biweekly schedule. During each biweekly event, the probe assembly was cleaned, EC was calibrated using a 1,000 µS/cm certified standard reference solution, pH using a two- or three-buffer calibration (pH = 4, 7, and 10), and Eh using Zobell's solution. DO was calibrated using air saturated with water at a measured barometric pressure, and turbidity was calibrated using two YSI standards: a certified 0-NTU and 123-NTU standard solutions. Calibration for the sonde probes were verified before reinstallation in the perforated pipe, and calibration checks and notes were recorded on field sheets and in the field logbook. Turbidity measurements were also verified independently using a separate calibrated turbidity meter. The standard operating procedure (SOP) followed for operation, calibration, and maintenance for the Hydrolab sonde may be found in Craft *et al.*, (2002). After replacement of the Hydrolab sonde, an annotated draft SOP and the manufacturer's manual were followed until the SOP for the YSI sonde (Appendix 1) was formalized and approved.

Computer and Database Methods

All data processing and analyses were performed using Microsoft® Windows (versions 98 through XP Professional) personal computers with spreadsheet, database, and statistical analysis software. Sonde readings were stored on internal probe memory and downloaded after calibration to a laptop using the data loggers. These data were then transmitted by the field crew as ASCII text e-mail attachments that were imported into Microsoft® Excel (versions 1997 to 2004) spreadsheets, or later directly as Excel files. Data were then reviewed, plotted, and shared with the field crew for feedback and any required corrective actions.

Biweekly sonde data files were combined in Excel to create a full-year file that was imported into Microsoft® Access (versions 1997 through 2004) as a 17,520-record table (17,568 during 2005). Statistical analyses were performed using SPSS® (Statistical Package for the Social Sciences, versions 8.0 through 12.0). Tables and queries exported from Access as Excel files were then converted to SPSS® file format using DBMSCopy (versions 6.06, SPSS, Inc.), or imported directly in later versions of SPSS® as Excel files. Some larger file transfers and conversions required use of comma-delimited ASCII text files.

Summary data tables were created using SPSS® analysis output summaries and Access queries. Processed and altered SPSS® files were also returned to Access as new tables, imported via conversion to an Excel spreadsheet or appended using cut and paste or paste-append operations. A summary of the Access database structure, table contents, and field names may be found in Appendix 2. The complete database as an Access or a comma-delimited ASCII text file are provided in the Appendix 5 CD-ROM and may also be downloaded from the Tracy Research Web site at: http://www.usbr.gov/pmts/tech_services/tracy_research/data/Multiprobe.html.

Missing Values and Data Censoring

As typical of any long-term monitoring program, there were malfunctions of the sondes and individual probes that caused data gaps and anomalous readings. Internal battery failures, sonde system crashes, electrical malfunctions, or sonde installation above low tide channel depth produced complete data losses (called sonde inoperable losses) of 11.9 percent of the POR. An additional 3.23 percent of biased, inaccurate, and anomalous data values from individual probes were also censored during the data review process. When all probe data were removed or censored, missing data observations with only date and time variables were inserted into the record.

Given the high hourly, daily, and seasonal variability and non-normal distributions observed for several water quality variables (Appendix 3), simple statistical methods for rejecting outliers were not useful. The following guidelines were followed for censoring individual probe data:

General Censoring Criteria.—Raw data sets were initially evaluated without censoring. Data recorded when the probes were not under water or during calibration periods were initially discarded. Negative numbers and values completely in error (pH>14, EC>2000) were then removed and frequencies for each variable recalculated. Variable values > 99th and < 1st percentiles were examined in the data table and censored if judged to be probe errors. If unusual readings were preceded by systematically trending data suggestive of probe fouling, calibration drift, or malfunction, data were censored back to the beginning of the biased trend. Unusual readings were also censored if they were not corroborated by conterminous data from other nearby state or federal water quality sampling stations (if available).

Temperature Data.—T data were only censored during calibration and maintenance or unsubmerged sonde periods.

Electrical Conductivity Data.—EC data were censored for values < 50 µS/cm or > 1,200 µS/cm.

Dissolved Oxygen Data.—Low DO values during cooler months (when more DO would be expected from inherent gas in water solubility) and high DO during warmer months were specifically scrutinized. Readings < 4.0 mg/L or percent DO saturation < 50 percent were removed if not corroborated by lower trending Eh values, other available station conterminous data, or observation of significant channel debris loads, stagnant flow, or excessive fish mortality at the TFCF. We deleted DO > 12.3 mg/L or > 120 percent DO saturation as suspected calibration drift.

pH Data.—Values < 6.75 were censored if nearby station conterminous data suggested pH > 7.00 and values > 8.25 were censored unless corroborated by nearby station conterminous data. Data were also censored if excessive variability in pH > ±0.5 su was observed over several hours that were not associated with a change in water quality from tidal inflows.

Redox Potential Data.—Eh < 100 mV or > 575 mV were censored.

Turbidity.—Values > 200 NTU were re-coded as 199.95 to indicate "above calibration range," and values < 0.5 NTU were re-coded as 0.1 NTU to indicate "not detected."

Graphing Data.—The initially censored full-year tables of 30-min interval data were then exported to Excel and plotted to identify any additional missed anomalous values. Extreme short-duration data spikes that were clearly anomalous were then censored.

Data Summaries and Statistics

Because of the non-normality and recoding of data for several variables (see Appendix 3 histograms for each variable), we used rank-based, non-parametric statistics to summarize data. Rank-based summaries include the median, the preferred estimate of central tendency, and percentile data frequencies. If data are normally distributed (as seen for full POR pH and DO data, Appendix 3, Figure A3-1), then the median equals the arithmetic average, and the 16th to 84th percentile range approximates the 68-percent confidence interval (CI) associated with ± 1 standard deviation. The 95-percent CI (± 1.96 standard deviations for n > 30) is approximated by the 2.5th to 97.5th percentile range. The advantage of percentiles is that these summary data do not require the assumption of normality, and may be used to estimate the percent of the POR a given variable was above or below a given critical value. For example, if the 5th percentile for DO is 4.99 mg/L, then we can infer that DO was below this value 5 percent of the POR, or 125.6 out of 2,511 d.

Note that the data summaries presented here are based on missing data from the last 6 weeks of the study year 7, from February 15 through the end of March 2007. These missing values will introduce minor biases to study year 7 summaries, and to summaries by month of year for February and March. Similarly, all censored and probe inoperable missing values may also introduce minor biases. However, we do not think these biases affect or alter any of the conclusions or recommendations we present.

Supplemental Data Sources

Supplemental data for streamflow discharge, BJPP pumping, weather, tides, photoperiod, and TFCF fish salvage totals were included in the sonde data Access database as daily values for comparison with water quality sonde data. Refer to Appendix 2 for table descriptions and field names for the water quality sonde database, which is included on the Appendix 5 CD-ROM as Access file, *Multiprobe.mdb*. Most supplemental data were downloaded from FTP (file transfer protocol) Internet sites or from federal and state agency data download websites.

Precipitation (measured in inches, in), and air temperature data (in degrees Fahrenheit, °F) for weather station 049001 – Tracy Pumping Plant, were obtained from the National Oceanic and Atmospheric Administration's National Climate Data Center (NCDC, 2007). Average daily flow discharge in cubic feet per second (cfs, ft^3/s) for gage station 11303500 – San Joaquin River Near Vernalis, California, and station 11447650 –Sacramento River at Freeport, California, were obtained from the USGS (USGS, 2007). Average daily pumping at the BJPP (measured in acre-feet per day, acre-ft/d) and DCC gate status data were obtained from the Reclamation Central Valley Operations Office (CVO), Sacramento, California (CVO, 2007). All pumping and flow data were converted to acre-ft/d or year (acre-ft/yr) for comparison. Operational schedules for the south Delta temporary barriers were obtained from the California Department of Water Resources, Office of State Water Project Planning (CDWR, 2007a). Fish salvage data for each species removed at the TFCF were obtained from the California Department of Fish and Game (CDFG) salvage FTP site (CDFG,2007), and processed for compatibility with sonde data using crosstab queries in Access. Daily salvage data were calculated based on 10-min counts performed four times daily at the TFCF.

Tide level (measured in centimeters relative to mean sea level, cm MSL), sunrise, sunset, and moon phase data were generated using harmonic constants in *Tides and Currents for Windows*, version 3.0, (Nobeltec Nautical Software, Beaverton, Oregon). Tidal data were calculated for the tide gage station located at the Grant Line Canal Bridge, approximately 11 km (6.9 mi) from the TFCF. These data provide a reference set to compare with Datasonde probe depth or CDWR river stage data (CDWR, 2007b) for the Old River at Byron, station ORB. Note that the actual tide stage at the Grant Line canal is significantly affected by local runoff and water management operations, but calculated values do not include these influences. Temporary barrier (TB) and DCC gate status data were coded as seen in Table 1.

TABLE 1.—Coding used to describe operations of temporary barriers (TB) and other events affecting the chemistry at the Tracy Fish Collection Facility

Temporary barrier/event	Installation	Installed	Removal	Notched or partial breaching	Not installed
Old River at TFCF	5	1	5	2.5	0
Grant Line Canal	6	2	6	3	0
Head of Old River TB	7	3	7	3.5	0
Middle River TB	8	4	8	4.5	0
Delta Cross Channel	NA	1.5 (open)	NA	NA	0 (closed)

All downloaded data files were processed to harmonize date and time formats, and to insert dates or times for missing records before combining with TFCF water quality sonde data.

RESULTS AND DISCUSSION

Data Quality Issues

The POR data file included a total of 723,312 possible data points (120,552 observations, 6 variables each). During data validation, 83,598 data points (13,933 observations) were lost due to sonde inoperability (11.6 percent of the POR). An additional 23,337 data points (3.23 percent of the POR) were censored. Overall, 85.1 percent of the 6.9-yr POR were accepted as validated quality measurements (616,377 data points). Table 2a summarizes the sonde inoperable and censored missing values by study year (a similar missing data summary for the entire POR organized by water quality variable was shown in Table ES-1 in the Executive Summary). Table 2b provides a summary of missing data by month of year for the entire POR.

Table 2a data strongly suggest that probe and sonde malfunctions and data problems increase in frequency after 2 years of field deployment – even with routine replacement of malfunctioning sensors and probes. The YSI sonde was deployed during study year 5 (April 2004–March 2005) and study years 6 and 7 show clear reductions in lost data with the replacement sonde. These increasing sonde failures are likely caused by corrosion of contacts, circuit failure, and water infiltration over time. The data strongly suggest that problems increase with deployment time and become serious after 3 years, so sondes should be replaced by a new instrument at the end of the second year in service. After factory reconditioning, the removed sonde can continue to provide useful service in shorter deployments as a backup or confirmation instrument.

Table 2b data show that probe malfunctions occur more frequently during the summer months when higher temperatures, organic carbon concentrations, suspended materials, and algal productivity lead to greater probe fouling. These data suggest that calibration and maintenance activities are especially important during the months of June through October. The summer months are also the most important to the TFCF when water quality issues such as lower DO and higher temperatures are more likely to have a deleterious effect on fish and salvage operations. Remote monitoring of sonde data is an option that would reduce lost data during the summer months by more quickly detecting probe malfunctions and calibration drift. Web based remote monitoring of sonde performance such as the YSI Econet service should be considered by TFFIP management as a way to reduce lost data, as well as to quickly alert TFCF operators when channel DO is low and facility DO sensors should be closely monitored.

Table 2a.—Valid, sonde inoperable, and censored data summarized by study year.

Study Year	1	2	3	4	5	6	7
Start Date	**1-Apr-00**	**1-Apr-01**	**1-Apr-02**	**1-Apr-03**	**1-Apr-04**	**1-Apr-05**	**1-Apr-06**
End Date	**31-Mar-01**	**31-Mar-02**	**31-Mar-03**	**31-Mar-04**	**31-Mar-05**	**31-Mar-06**	**15-Feb-07**
Total Possible Data Points	105,120	105,120	105,120	105,120	105,408	105,120	92,304
Sonde Inoperable Data Points Lost	6,462	5,862	8,112	20,832	29,190	8,100	5,040
Censored Data Points	2,452	6,348	6,302	4,361	2,559	6	1,968
Total Data Points Lost	8,914	12,210	14,414	25,193	31,749	8,106	7,008
Percent Probe Inoperable	6.15	5.58	7.72	19.8	27.7	7.71	5.45
Percent Censored	2.33	6.04	6	4.15	2.43	0.01	2.13
Percent Data Lost	8.48	11.62	13.71	23.97	30.12	7.71	7.58
Percent data validated	91.5	88.4	86.3	76	69.9	92.3	92.4

TABLE 2b.— Valid and missing data summarized by month of year for the entire period of record (POR).

Month	Statistics	Totals	Month	Statistics	Totals
January	Possible n	62,496	July	Possible n	62,496
	Valid n	55,325		Valid n	47,922
	Missing n	7,171		Missing n	14,574
	Percent Valid	**88.53**		**Percent Valid**	**76.68**
February	Possible n	52,992	August	Possible n	62,496
	Valid n	46,523		Valid n	51,173
	Missing n	6,325		Missing n	11,323
	Percent Valid	**87.79**		**Percent Valid**	**81.88**
March	Possible n	53,568	September	Possible n	60,480
	Valid n	47,261		Valid n	44,660
	Missing n	6,307		Missing n	15,820
	Percent Valid	**88.23**		**Percent Valid**	**73.84**
April	Possible n	60,480	October	Possible n	62,496
	Valid n	55,784		Valid n	50,283
	Missing n	4,696		Missing n	12,213
	Percent Valid	**92.24**		**Percent Valid**	**80.46**
May	Possible n	62,496	November	Possible n	60,480
	Valid n	56,979		Valid n	55,286
	Missing n	5,517		Missing n	5,194
	Percent Valid	**91.17**		**Percent Valid**	**91.41**
June	Possible n	60,480	December	Possible n	62,496
	Valid n	50,679		Valid n	54,502
	Missing n	9,801		Missing n	7,994
	Percent Valid	**83.79**		**Percent Valid**	**87.21**

Temperature Data Quality

The T sensor probe, a simple thermistor not subject to bias from biofouling in service, was the most reliable probe on the sondes. Only 0.28 percent of T data were censored for extreme or unusual readings, most likely observed during calibration and maintenance or sonde not submerged periods. The T sensor probe performance sets the baseline data loss for all probes from sonde failure at 13,993 out of 120,552 possible observations.

Electrical Conductivity Data Quality

The EC probe was fairly reliable when the sondes were operating properly; however, the conductivity cell can be affected by biofouling during the summer. Biofouling and other calibration drift issues caused an additional data censoring loss of 1.14 percent of the POR, and total missing EC of 12.7 percent.

Dissolved Oxygen Data Quality

The DO probe, which used a permeable membrane stretched over a polarographic sensing cell, was subject to problems from biofouling and calibration drift producing a censoring data loss of 0.615 percent of the POR and total missing DO of 12.2 percent. The generally robust flows, tidal fluctuations, and mixing in local surface waters suggest that DO should range from 7–10 mg/L (from 70- to 95-percent DO saturation) except under extraordinary conditions of summer heat, high algal productivity, and stagnant flow.

pH Data Quality

The pH probe was more subject to biofouling, calibration drift, and signal instability problems from disrupted internal electrolyte flow across the electrode sensing junction. These problems caused the censoring of 4.62 percent of pH data, and total missing pH data of 16.2 percent. Most of the calibration drift and electrode problems occurred during the warmer months of June through September.

Redox Potential Data Quality

The Eh platinum electrode installed on the Hydrolab sonde proved most problematic, likely from sensing-surface biofouling. After the Hydrolab sonde was replaced in 2005, Eh readings were measured using the pH electrode on the YSI sonde. Both probes suffered from biofouling problems. Anomalous readings caused censoring of 12.1 percent of Eh data – the largest percentage of all probes – for a total missing Eh data of 23.6 percent. While Eh measured in anaerobic waters is a fairly good indicator of redox conditions, the mixed potentials that occur in oxygenated waters at the platinum-water and pH sensing interface make Eh only a general redox indicator at the TFCF, and DO is a much better indicator of the true redox in natural oxygenated surface waters (Lindsay, 1979; Stumm and Morgan, 1996). Because of probe reliability and these theoretical considerations, the Eh data are of limited interpretative value and are only presented with significant qualifications.

Turbidity Data Quality

The turbidity probe was reliable with only 0.64 percent of data censored for a total missing data loss of 12.2 percent. The interpretative problem with turbidity is the frequent presence of short term spikes of high turbidity that help produce the log-normal data distributions seen in the Appendix 3 histograms. The re-coding of these high NTU values obscures any evaluation of the true turbidity range at the TFCF and will also introduce a bias towards lower estimates of the mean. Another issue to consider is that suspended materials will often form discrete plumes that are not uniform across the flow channel. This heterogeneity is problematic when using turbidity data in this report (measured at the edge of the channel) as an indicator of average channel turbidity or for suspended materials loading estimates. As such, these data must be interpreted with caution.

Hydrology and Local Precipitation

Despite the influence of tides, temporary channel restrictions, significant diversion and mixing of different regional water sources, and artificial pumping, the dominant variables affecting the water quality at the TFCF can be summarized by streamflow discharge in the San Joaquin and Sacramento Rivers. Discharge data for these 2 rivers and pumping at the BJPP are summarized by study year in Table 3. Note that these data are for study year periods (April 1 to March 31), not the typically used hydrologic years of October 1 to September 30, and that the hydrology data summaries for study year 7 are based on the same POR as the sonde data for year 7: from April 1, 2006 to February 15, 2007.

During the POR, discharge measured at the USGS gage station on the SJR at Vernalis, California averaged 7,759 acre-ft/d. This discharge is dominated by snowmelt from the southern ranges of the Sierra Nevada mountains, complicated with agricultural, municipal, industrial, water re-use, and artificial pumping. The SJR median EC is675 µS/cm (range 80 to 1,500 µS/cm) (Craft *et al.*, 2000). During this study, lowest discharge from the SJR was seen in study year 3 (April 2003–March 2003) at 1.31 million acre-ft/yr, and highest discharge was during the study year 7 POR at 6.62 million acre-ft (this despite excluding data from February 15 to March 31, 2007).

The SJR basin is much drier compared to the northern Central Valley drained by the Sacramento River, where discharge at the USGS gage station on the Sacramento River at Freemont, California averaged 45,463 acre-ft/d for the POR. This discharge, which also includes runoff from the American River, is almost 6 times that of the SJR at Vernalis, and median EC in the Sacramento river is 150 µS/cm (range 43 to 270 µS/cm) (Craft *et al.*, 2000). Because of the southward diversion of Sacramento River water by way of the DCC gates, water at the TFCF is strongly influenced by the lower-EC northern Central Valley water. The lowest discharge from the Sacramento River was seen in study year 2 (April 2001–March 2002) at 12.1 million acre-ft/yr, and highest discharge was during study year 6 (April 2005–March 2006) at 23.6 million acre-ft/yr.

TABLE 3.—Summary of Bill Jones Pumping Plant (BJPP) pumping and streamflow discharge affecting the water quality at the Tracy Fish Collection Facility (TFCF) by study year. Study years range from April 1 to March 31 and are provided to compare with water quality data summaries. Note that these discharge summaries are not for hydrologic year (from October 1 to September 30).

Study Year	Annual Rainfall, in	Pumping at BJPP		San Joaquin River at Vernalis Discharge		Sacramento River at Freemont Discharge	
		Average, acre-ft/d	Sum, acre-ft/yr	Average, acre-ft/d	Sum, acre-ft/yr	Average, acre-ft/d	Sum, acre-ft/yr
1	11.10	6,571	2,398,501	5,869	2,142,217	35,881	13,096,456
2	11.75	6,833	2,494,065	4,143	1,512,366	33,141	12,096,608
3	12.96	4,108	1,499,335	3,578	1,306,036	41,661	15,206,253
4	12.85	7,557	2,765,870	3,925	1,436,655	53,041	19,412,915
5	15.77	7,531	2,748,901	5,510	2,011,179	38,985	14,229,414
6	12.95	7,406	2,703,291	13,140	4,796,278	64,667	23,603,491
7	11.24	7,105	2,593,248	18,145	6,622,846	50,863	18,564,863

Discharge in the two basins varies by study year, both with respect to total discharge and relative discharge between the northern and southern basins. The Sacramento River discharge can be as low as 2.8 times the SJR (during study year 7, April 1, 2006–February 15, 2007) or it can be as high as 13.5 times the SJR (study year 4, April 2003–March 2004). Combined discharge was lowest during study year 2 (April 2001–March 2003) at 13.6 million acre-ft/yr and greatest during study year 6 (April 2005–March 2006) at 28.4 million acre-ft/yr. Combined discharge from both basins averaged 19.4 million acre-ft/yr for the POR.

The absolute and relative runoff discharges in the northern and southern basins are inherently complex, and this complexity is compounded by variable schedules for temporary barrier installation and removal and operation of the DCC gates. Annual runoff by study year is plotted with annual median EC in Figure 3, which shows that runoff hydrology and median EC appear to be correlated.

Export pumping at the BJPP varies from 1.50 million acre-ft/yr (study year 3, April 2002 – March 2003) up to 2.77 million acre-ft/yr (study year 4, April 2003 –March 2004) with an average pumping rate of 2.46 million acre-ft/yr for the POR (an average of 2.62 million acre-ft/yr with the low year 3 data excluded). Except for year 3, pumping data show much less annual variability compared to runoff discharges.

Water quality at the TFCF is also influenced in a complex way from local winter rain averaging 12.66-in/yr for the POR. Rain during the summer is rare. Generally, the winter rains can have a localized dilution effect on TFCF water, producing lower EC and pH depending on the length and severity of rainstorms. Winter rainfall varied from 11.10 in during study year 1, up to 15.77 in during study year 5 (April 2004–March 2005).

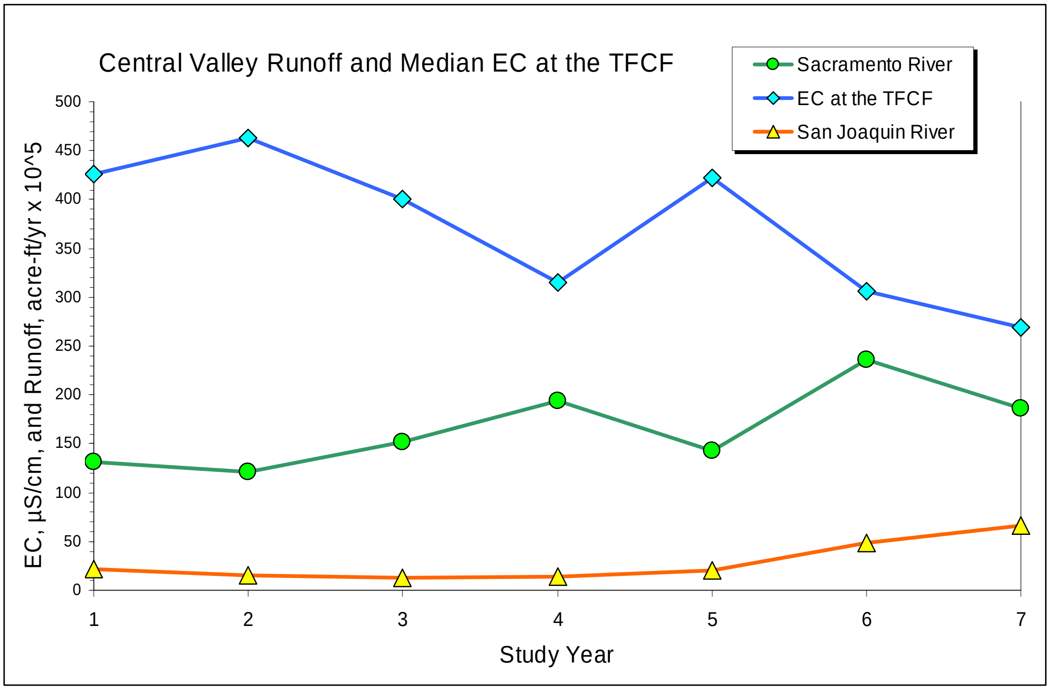

FIGURE 3.—Graph of scaled total annual stream flow discharge with median electrical conductivity (EC) at the Tracy Fish Collection Facility (TFCF) by study year. Annual discharge for Sacramento (green line, x 105 acre-ft) and San Joaquin Rivers (orange line, x 105 acre-ft) are plotted with median EC in µS/cm.

Water Quality Variable Summaries

Data are summarized for the water quality variables in appendices 3 and 4. Appendix 3 provides full POR summaries for each variable (no Eh summary) in Table A3-1, with full POR histograms for all measured variables in Figure A3-1. Figures A3-2 through A3-6 show histograms for each variable (except Eh) by month of year. Appendix 4, Table A4-1 provides a more detailed statistical and percentile summary of the water quality variables (no Eh) by month of year.

Histograms for the full POR suggest that pH and DO distributions are normal, while EC (skewness = 0.97) is slightly log-normal, and turbidity (skewness = 4.3) is highly log-normal. Seasonally variable T shows a complex distribution with winter, spring + fall, and summer peaks. The monthly histograms show that turbidity is consistently log-normal, and EC is mostly skewed from normal. Several variables show multi-mode monthly histograms (for example EC during September, Figure A3-3, and DO during February, Figure A3-4). The variety and complexity of these data distributions supports our preference for rank-based data summaries.

Temperature Summary

Water T is an important master variable that directly affects the rates of chemical and biological processes, DO and pH at the TFCF. Higher temperatures during summer reduce the solubility of oxygen and increase the rate of aquatic biological (algal and bacterial) activity and DO depletion. The rate of response in fish to low DO, toxins, and other stressors also increase with temperature (Portz *et al.*, 2005). Conversely, lower T during winter allows higher concentration of DO in water and inhibits biological processes.

Data summaries for water T are found in Appendix 3 (POR histogram in Figure A3-1 and histograms by month of year in Figure A3-2) and Appendix 4 (Table A4-1 detailed percentile summary by month of year). Figure 4 shows graphs of summaries of T by day of year (upper) and median T by study day (lower). The upper T graph shows the median and percentiles approximating the 68-percent CI (the 16th – 84th percentiles, in green) and the 95-percent CI (the 2.5th – 97.5th percentiles, in yellow).

Full POR water T ranged from 5.41 (during winter) to 29.0 °C (during summer), with a grand median of 17.4 °C. Median low T of 9.40 °C occurred during January and median high of 24.6 °C in July. Daily variation in T appears to be lower during the late summer and fall months and greater during spring.

Electrical Conductivity Summary

Dissolved ions in water will conduct electrical current and EC is a proxy measurement for salinity or total dissolved solids (TDS) in water, with higher ionic concentrations producing higher conductivity measurements. As such, it measures gross changes in dissolved concentrations in water and provides information regarding daily tidal fluctuations and the seasonal changes in TFCF source water quality from the annual snowmelt runoff cycle and artificial pumping, and re-use and recycling of south Delta water. EC varies over the year in both median value and extreme values and shows the most complex behavior among the water quality variables at the TFCF.

Data summaries for EC are found in Appendix 3 (POR histogram in Figure A3-1 and histograms by month of year in Figure A3-3) and Appendix 4 (Table A4-1 detailed percentile summary by month of year). EC for the full POR was normally distributed (Figure A3-1) and ranged from 199 to 1,220 µS/cm with a grand median of 366 µS/cm.

Median low EC = 246 µS/cm was observed during July and median high EC = 522 µS/cm during December. Figure 5a shows graphs of summaries by day of year (upper plot) and median EC by study day (lower plot). The upper EC graph shows the median and percentiles approximating the 68-percent CI (in green) and the 95-percent CI in yellow.

Annual and seasonal trends in EC are greatly affected by local runoff and export hydrology, specifically surface flows in the SJR and Sacramento River, local winter rainfall, and pumping by the BJPP. Figure 3 shows that annual median EC generally follows the overall level of runoff in the Central Valley – i.e. whether it is a generally wet or dry year for the Central Valley – and the lowest median EC values are seen during the last 2 study years. The primary hydrologic factor cycle affecting median EC is the Sierra Nevada snowmelt runoff with lower EC in the spring and early summer. This overall pattern can be seen in Figure 5a upper graph of EC by day of year, where the median traces out a broad concave curve over the year.

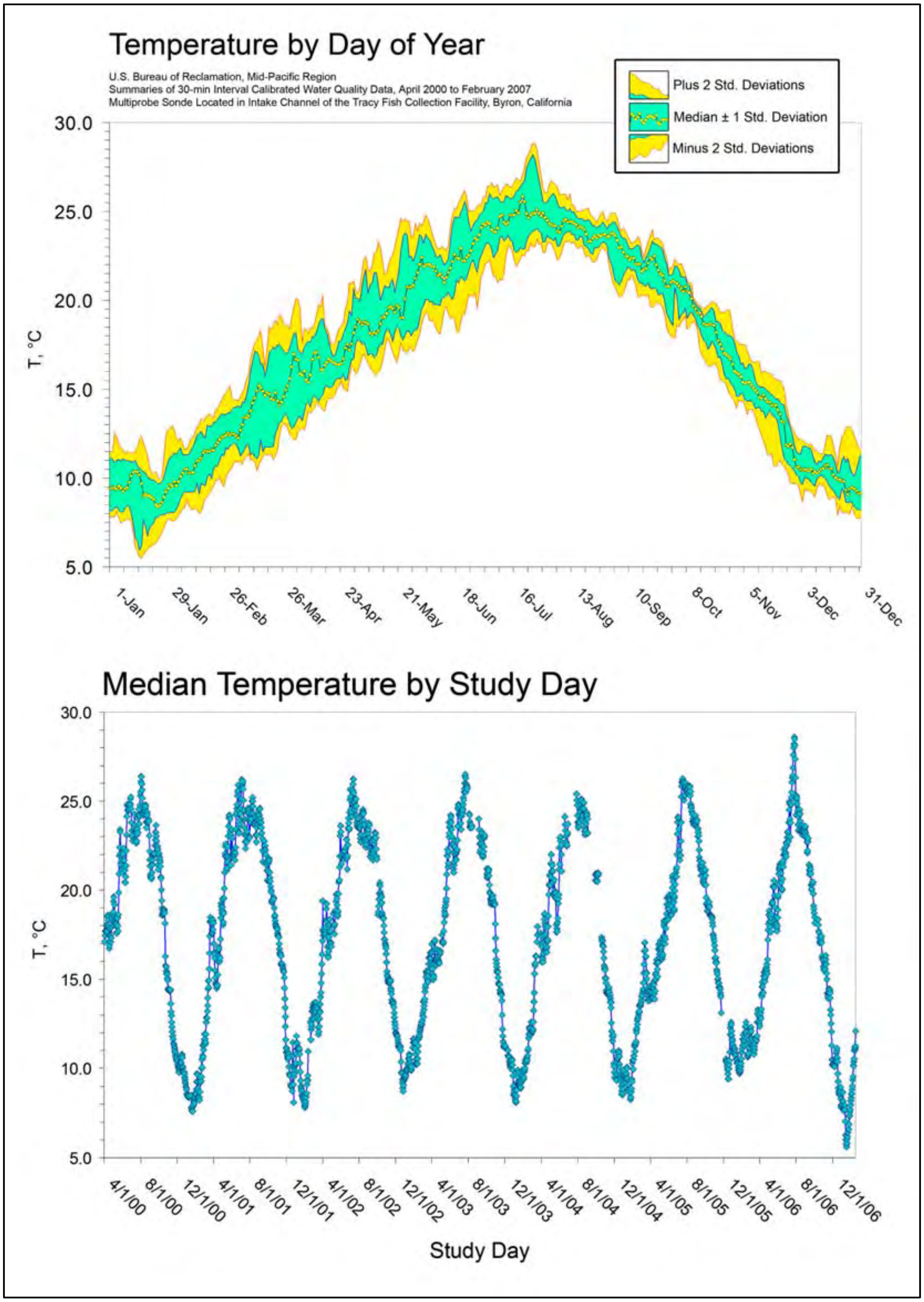

FIGURE 4.—Water temperature (T) in °C at the Tracy Fish Collection Facility. The top graph provides a summary of T by day of year with median and the percentile equivalents of the 68-percent (± 1 standard deviation, in green) and 95-percent (± 2 standard deviations, in yellow) confidence intervals. The bottom graph summarizes median daily T by study day for the period of record.

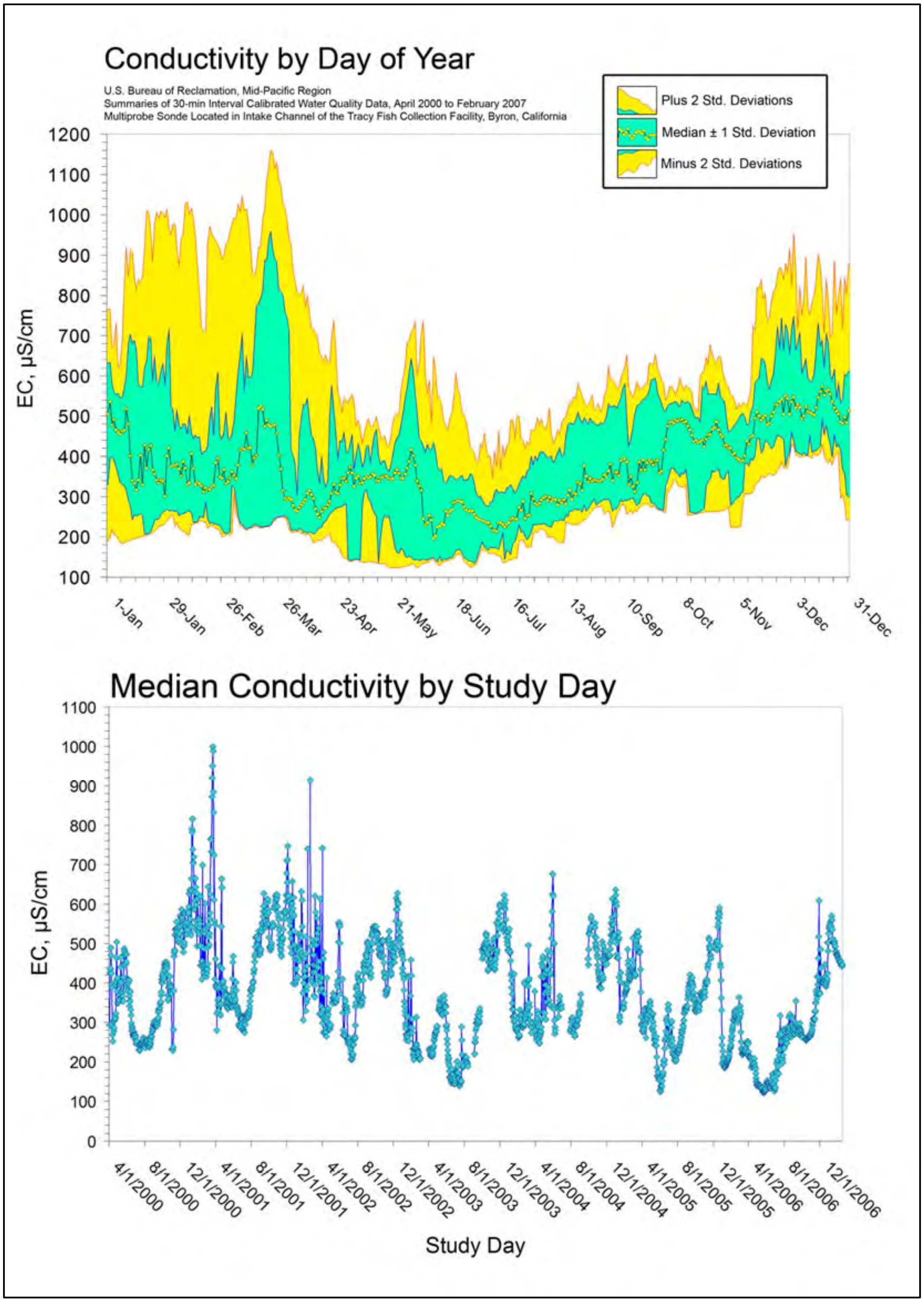

FIGURE 5a.—Electrical conductivity (EC) in µS/cm at the Tracy Fish Collection Facility. The top graph provides a summary of EC by day of year with median and the percentile equivalents of the 68-percent (± 1 standard deviation, in green) and 95-percent (± 2 standard deviations, in yellow) confidence intervals. The bottom graph summarizes median daily EC by study day for the period of record.

Seasonal trends for EC are more complex and less obvious, but are also strongly affected by local hydrology. Figure 5b compares daily median EC with streamflow runoff, winter rainfall events, and BJPP pumping. A close examination of Figure 5b shows that EC responds, at different times and to varying degrees, to all local hydrologic influences.

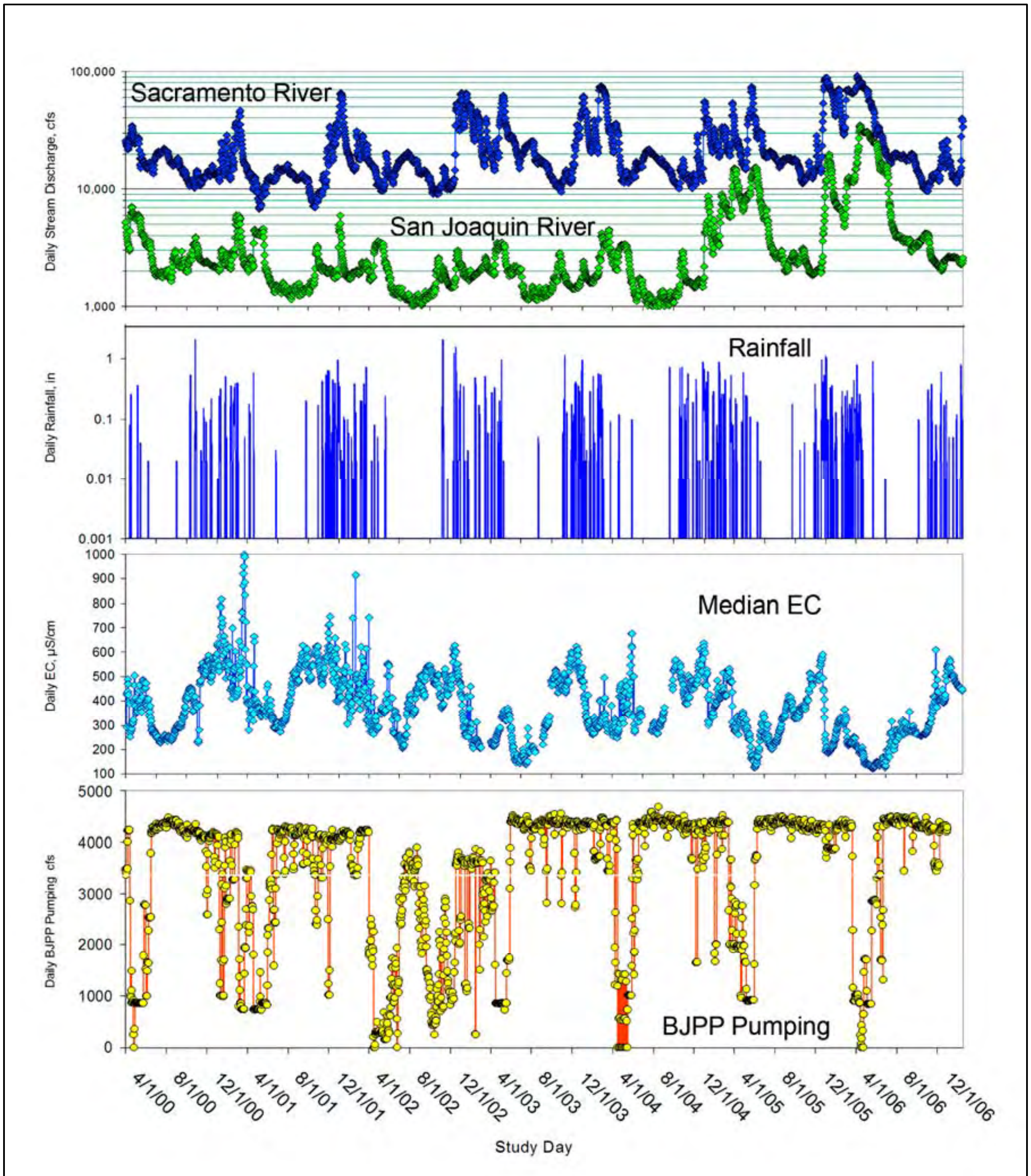

FIGURE 5b.—Hydrology and effects on electrical conductivity (EC) summarized by study day. This graph combines plots of daily streamflow discharge (upper plot) for the Sacramento and San Joaquin Rivers, rainfall at the Bill Jones Pumping Plant (BJPP) weather station (next lower plot), median daily EC (next lower plot, in blue), and BJPP pumping (lower plot).

EC is the water quality variable most affected by tides. Daily variations of 300 µS/cm are not unusual and can range from around 100 µS/cm up to 500 µS/cm. The daily EC fluctuation from tides, however, is greatly influenced by installation of temporary channel barriers near the TFCF, and simultaneous southward diversion of low-EC Sacramento River water by opening of the DCC gates (Figure 1). Temporary channel barriers, generally installed from May through November, can reduce the daily EC range and lower the median EC by inhibiting in-flow of higher-EC SJR water (Craft *et al.*, 2002, 2003, 2004). When these barriers are removed during December through April, much greater daily EC range and a higher median EC are observed. The upper Figure 5a graph of EC by day of year shows regions on the left and right with much greater variation in EC that correspond to the November through March period.

Dissolved Oxygen Summary

DO is probably the most important water quality variable at the TFCF, because fish survival depends on having adequate DO. While some fish like the adult splittail (*Pogonicthys macrolepidotus*) can tolerate DO as low as 0.6 mg/L, trout and salmon like the Chinook salmon (*Oncorhynchus tshawytscha*) may show adverse effects below DO = 5 mg/L (Portz *et al.*, 2005). If DO is below 5 mg/L, or percent DO saturation below 50 percent, fish experience significant stress from lack of oxygen, and earlier lifestage fish are more vulnerable to depressed DO. DO saturation below 30 percent (DO = 2–3 mg/L) is considered hypoxic and can cause fish kills in sensitive species. The U.S. Environmental Protection Agency (EPA) recommends DO criteria for different lifestages of fish and temperatures of waters that vary based on timed averages as well as minimum values (EPA, 1986). The EPA warm water 1-d minimum DO criterion for early lifestages (i.e., egg, larvae, smolt) is 5.0 mg/L, while other life stages have a 3.0 mg/L 1-d minimum criterion. A 7-d mean below 6.0 mg/L suggests impairment for early life stages, and a 30-day mean below 5.5 mg/L is considered deleterious for other life stages of fish.

Because gas solubility in water decreases with higher temperatures, less oxygen can dissolve in water during the warmer summer months. Unfortunately, microscopic phytoplankton (i.e., algae), zooplankton, and bacteria also use DO during these lower-DO summer months, and agricultural runoff of nitrogen and phosphorus encourages algal productivity in TFCF waters. When phytoplankton die at night, the organic carbon in their cells stimulates bacterial activity that depletes additional DO.

Data summaries for DO and percent DO saturation are found in Appendix 3 (Table A3-1, POR histogram for DO in Figure A3-1, and histogram for DO by month of year in Figure A3-4) and Appendix 4 (Table A4-1 detailed statistical summary by month of year). Figure 6a (percent DO saturation) and Figure 6b (DO in mg/L) show graphs of summaries by day of year (upper) and median value by study day (lower). The upper graphs by day of year show the median and percentiles approximating the 68-percent CI (in green) and the 95-percent CI (in yellow).

Full POR DO was normally distributed ranging from 0.1 to 12.5 mg/L with a grand median of 7.70 mg/L. Notably, DO was below 5.0 mg/L only 5 percent of the POR (126 out of 2,512 d). Median low DO occurred in May (6.52 mg/L) and median high DO in December

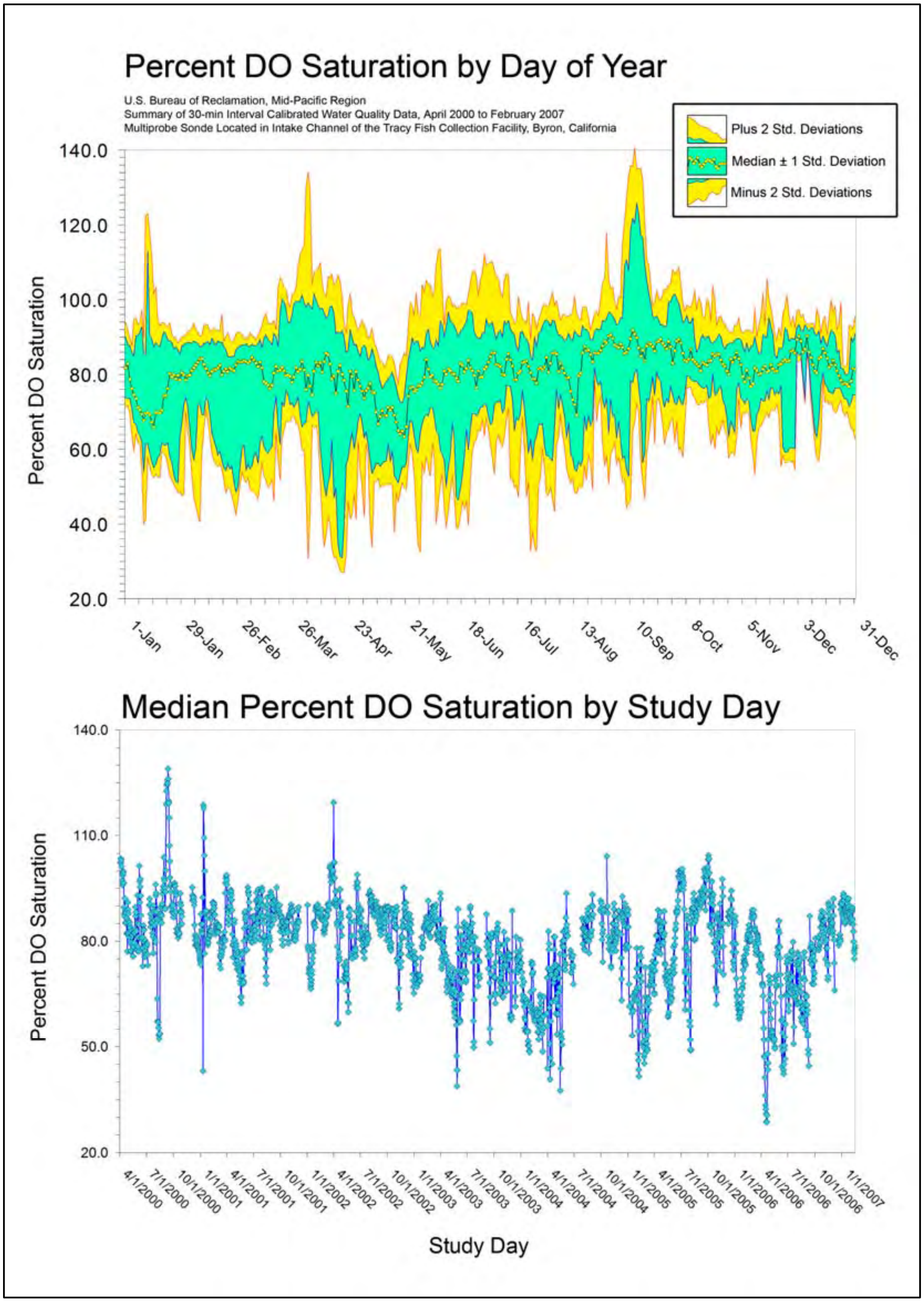

FIGURE 6a.—Percent dissolved oxygen (DO) saturation at the Tracy Fish Collection Facility. The top graph provides a summary of percent DO saturation by day of year with median and the percentile equivalents of the 68-percent (± 1 standard deviation, in green) and 95-percent (± 2 standard deviations, in yellow) confidence intervals. The bottom graph summarizes median daily percent DO saturation by study day for the period of record.

(9.37 mg/L). Median percent DO saturation (not shown but included in the raw data) was 81.1 percent and was observed below 50.0 percent 2.63 percent of the POR (66 out of 2,511 d).

The median DO data in the upper graph in Figure 6b shows a seasonal trend of lower DO during warmer months. These data are likely a direct result of the lower solubility of oxygen in warmer water. Note that there is no similar pattern in Figure 6a plot of median percent DO saturation by day of year. This is because percent DO saturation is calculated (internally by the sonde) and adjusts saturation for water temperature. Almost all DO saturation < 50 percent periods were during April through September (2,529 readings) with only 110 low DO readings from October through March. These data suggest that the warmer months when DO is normally depressed may increase the likelihood of hypoxia and fish kills during salvage and holding operations when waters with high biological productivity inside the TFCF become stagnant.

Because of this adjustment in percent DO saturation; we suggest that operators at the TFCF use 5 mg/L as the DO concentration of concern. The data suggest that DO in the channel is near or below this critical value around 5 percent of the time (3,010 out of 60,280 hrs).

pH Summary

pH is an important water quality variable that describes the acid-base equilibrium in natural waters. It influences the solubility of trace metals and affects the breakdown and complexation of organic materials. Enhanced biological activity will produce bicarbonate and raise the pH, and localized significant rainwater inflows (essentially distilled water with a pH around 5.75) and lower biological activity in winter will tend to lower the pH. The EPA aquatic life water quality criterion for pH is 6.5–9.0 (EPA, 1976).

Data summaries for pH are found in Appendix 3 (Table A3-1, POR histogram in Figure A3-1, and histograms by month of year in Figure A3-5) and Appendix 4 (Table A4-1 statistical summary by month of year). Figure 7 shows graphs of summaries by day of year (upper) and median pH by study day (lower). The upper pH graph shows the median and percentiles approximating the 68-percent CI (in green) and the 95-percent CI (in yellow).

pH was normally distributed ranging from 6.28 to 8.65 with a grand median of 7.46. pH < 7.00 was observed only 3.0 percent of the POR and pH > 8.0 was observed 5.0 percent of the POR. Maximum median pH was seen in August (7.62) and minimum median pH in February (7.25). There is a late summer peaking of median pH seen in the upper Figure 4e graph that is suggestive of higher primary productivity and production of bicarbonate during the summer agricultural season. In addition, the variability in pH appears to increase during the spring through fall months when temporary barriers are installed and the DCC gates are mostly open. This change in variability is likely the result of enhanced influence and mixing of Sacramento River water at high tides at the TFCF.

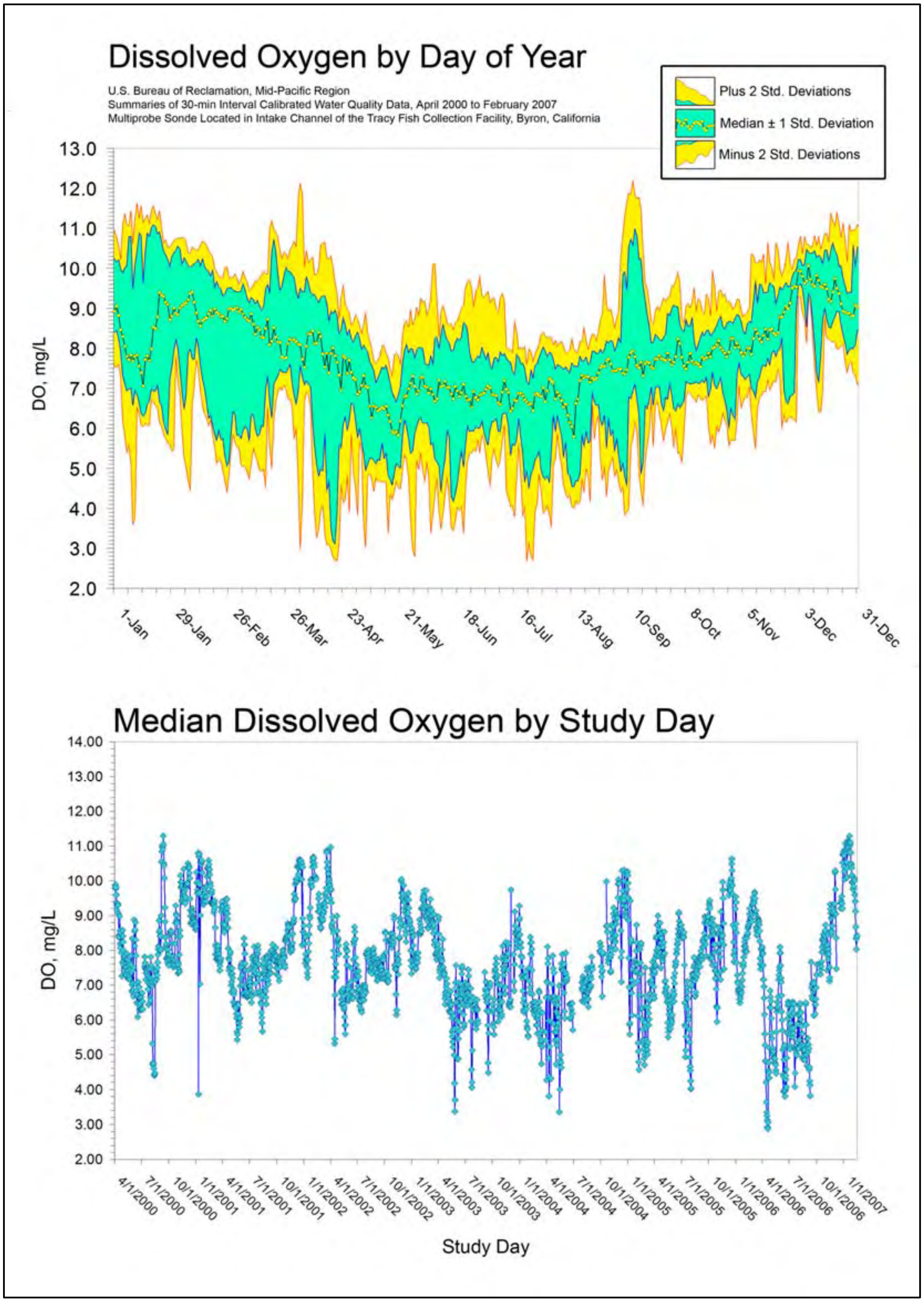

FIGURE 6b.—Dissolved oxygen (DO) in mg/L at the Tracy Fish Collection Facility. The top graph provides a summary of DO by day of year with median and the percentile equivalents of the 68-percent (± 1 standard deviation, in green) and 95-percent (± 2 standard deviations, in yellow) confidence intervals. The bottom graph summarizes median daily DO by study day for the period of record.

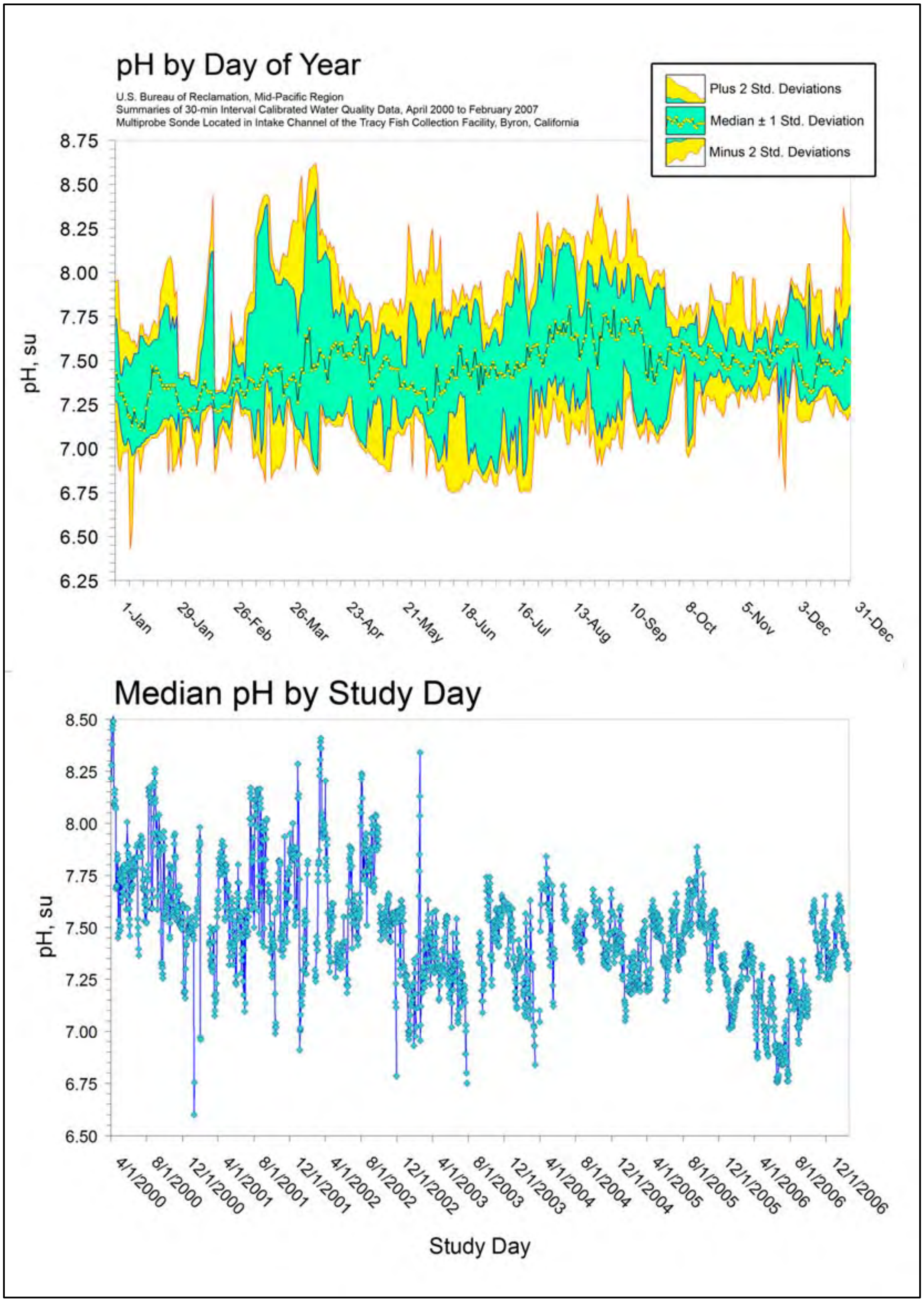

FIGURE 7.—pH in su at the Tracy Fish Collection Facility. The top graph provides a summary of pH by day of year with median and the percentile equivalents of the 68-percent (± 1 standard deviation, in green) and 95-percent (± 2 standard deviations, in yellow) confidence intervals. The bottom graph summarizes median daily pH by study day for the period of record.

Redox Potential Summary

Eh is an important water quality variable, but because of the problems with the Eh probes and the lack of observed anoxic conditions in the channel, DO is a much better indicator of redox conditions at the TFCF (Stumm and Morgan, 1994). Eh data are only summarized in Appendix 3, Figure A3-1 full-POR histogram, which shows the truncation of anomalous higher censored Eh values. Eh ranged from 102 to 575 mV with a grand median value of 339 mV. No correlations with other water quality variables (notably, DO) were observed, and no seasonal pattern in Eh was observed.

Turbidity Summary

Data summaries for turbidity are found in Appendix 3 (POR histogram in Figure A3-1 and histograms by month of year in Figure A3-6) and Appendix 4 (Table A4-1 detailed statistical summary by month of year). Figure 8 shows graphs of summaries by day of year (upper) and median turbidity by study day (lower). The upper turbidity graph shows the median and percentiles approximating the 68-percent CI (in green) and the 95-percent CI (in yellow).

Turbidity was log-normally distributed for both the full POR and by month (Figure A3-5) and ranged from 0.1 NTU (not detected) to > 200 NTU (a censoring value suggesting very short transient spikes above the probe calibration range) with a grand median of 13.2 NTU. The 5th to 95th percentiles ranged from 1.60 to 55.3 NTU. The transient high turbidity readings were observed only 1.0 percent of the POR (603 out of 60,300 hrs), and not detected values only 0.10 percent of the POR.

The winter months appear to show greater median turbidity and more transient high values, suggesting that erosion and runoff from winter rains may influence channel turbidity at the TFCF. While some turbidity spikes have been associated with larger rain events, turbidity does not respond to every rain event in the precipitation record. As mentioned in the Data Quality Section, turbidity measured in one location in the TFCF channel may not be representative of full channel average or median turbidity.

Daily Variations from Tides

The last behavior important to explain the gross water quality at the TFCF is the typical variability seen during day-to-day tidal changes. Figure 9 compares the behavior of EC, DO, and pH with tidal cycling over typical (but randomly selected) 4-d periods during summer (when temporary barriers are installed and DCC gates are open), and winter (when local channels flow freely and DCC gates are usually closed).

Ebb tide periods are shown on all Figure 9 graphs in vertical light blue bars. The important conclusion from Figure 9 is that there is some kind of response in most variables to both ebb (declining) and flood (rising) tidal flows.

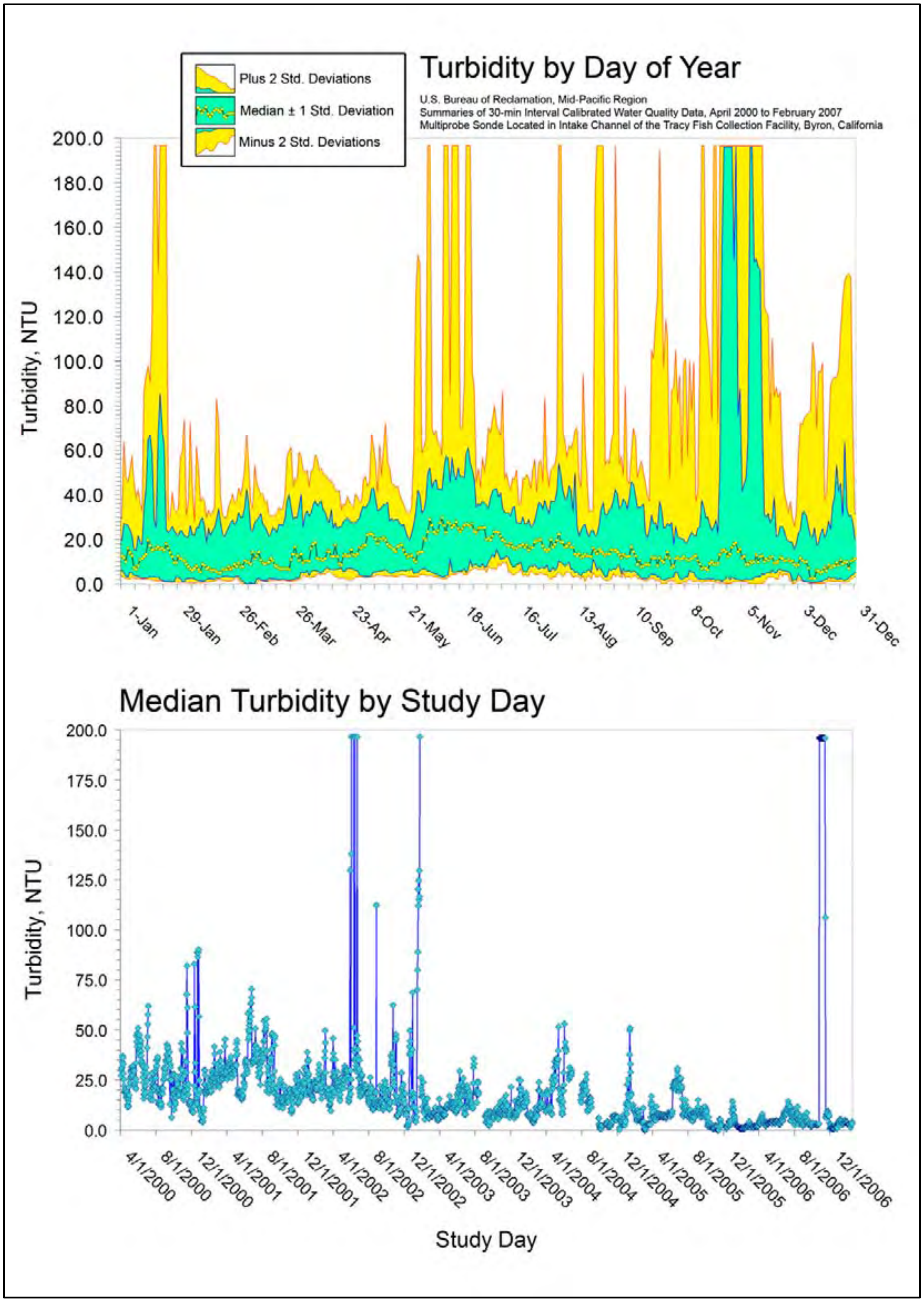

FIGURE 8.—Turbidity in nephlometric turbidity units (NTU) at the Tracy Fish Collection Facility. The top graph provides a summary of turbidity by day of year with median and the percentile equivalents of the 68-percent (± 1 standard deviation, in green) and 95-percent (± 2 standard deviation, in yellow) confidence intervals. The bottom graph summarizes median daily turbidity by study day for the period of record.

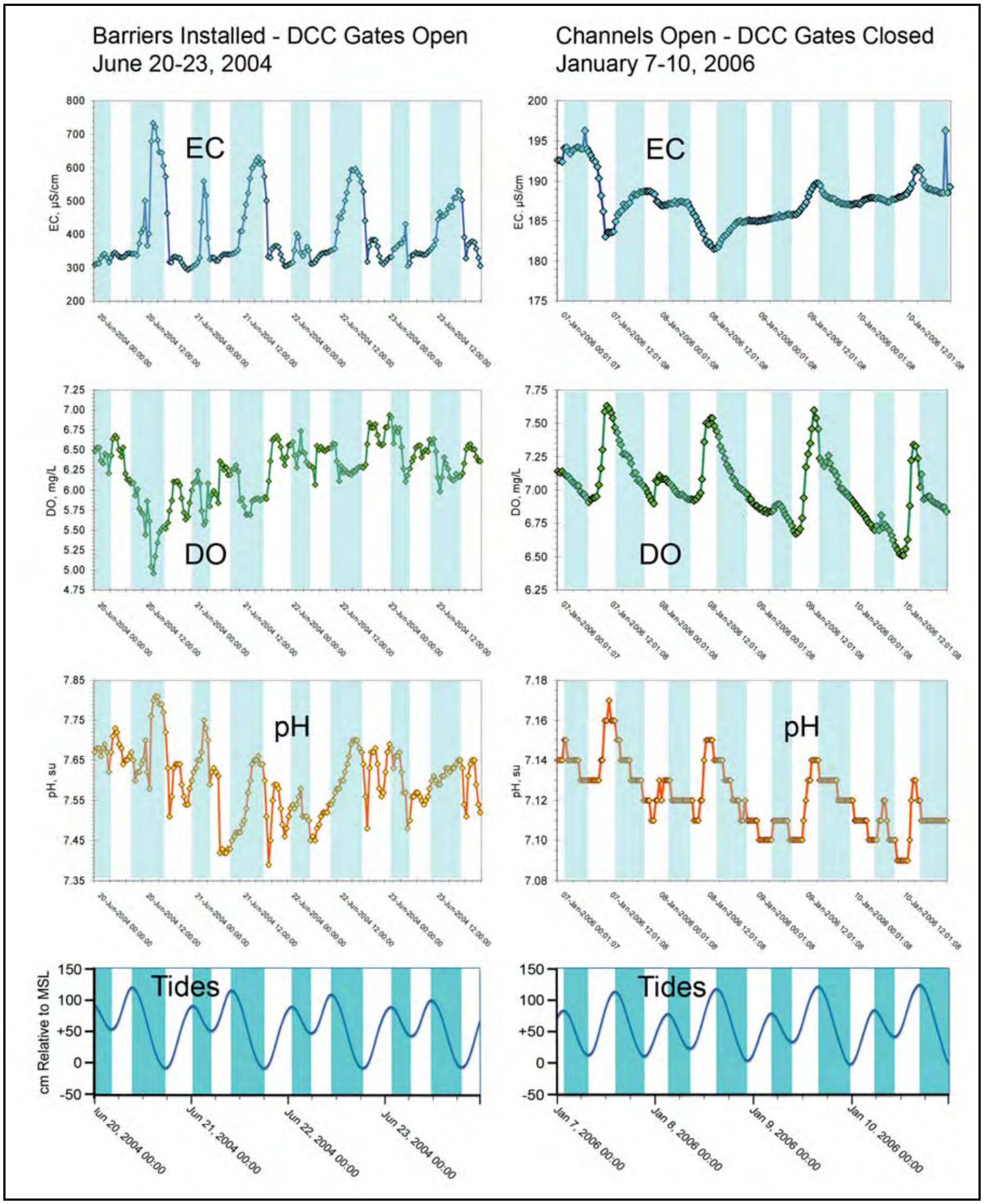

FIGURE 9.—Graphs showing 4 days of 30-min interval data during June 2004 when temporary barriers were installed and Delta Cross Channel (DCC) gates were open (left plots) and during January 2006 when local channels were open and Cross Channel gates were closed (right plots). Variables top to bottom are electrical conductivity (EC), dissolved oxygen (DO), pH, and calculated tide stage. Light blue bars represent ebb tide flows.

CONCLUSIONS AND RECOMMENDATIONS

Complexity and Assessment Issues

It is important to note that the issue of variability and hydraulic complexity in the south Delta makes assessment of any trend or summary generalizations about water quality processes at the TFCF difficult. While we have noted several general or qualitative trends and apparent causal relationships between variables, the basin scale influences of precipitation, runoff hydrology, and tides introduce significant year-to-year, seasonal, and daily variability that frustrates attempts to quantify these relationships.

Summaries of the entire POR by study month or study week may suggest relationships between variables that can be obscured when month of year or week of year is used as a summary grouping. This can occur because more extreme readings during some years may bias the estimates of central tendency and obscure seasonal trends. Figure ES-6 turbidity data suggest a maxima during June, but a closer examination of summaries by study day and study week reveal a trend of *generally* greater turbidity during *winter*.

Year to year variability and nonlinear or threshold response processes may also complicate interpretations of data trends or causal relationships. What might appear to be a causal relationship during one period may be less clear in subsequent periods. During study year 2 (April 2001–March 2002), spikes in turbidity data appeared to coincide with *some winter* rain events, but not others (Craft *et al.*, 2003). Tidal effects may be magnified or suppressed depending on the operations of the DCC gates or the nearby intake gates at Clifton Court Forebay.

Water Quality Issues

General Water Quality Patterns

Despite the variability and hydraulic complexity in south Delta, we think that water quality at the TFCF does show expected responses to seasonal effects, basin hydrology, local rainfall, artificial hydraulic, and agricultural influences. EC responds to the expected western U.S. seasonal snowmelt runoff cycle, and over the POR, there appears to be lower EC in TFCF waters, perhaps from enhanced recent Sierra Nevada snowpack and spring runoff streamflows. DO and pH also show expected seasonality, with lower DO and higher pH observed during warmer months.

Temporary Barriers and DCC Gates

Other than basin-wide factors (runoff hydrology, tides, and climate), the major influence on water quality at the TFCF appears to be the installation and removal of temporary local channel barriers and operation of the Delta Cross Channel (DCC) gates near Walnut Grove, California. When barriers are installed and the DCC gates are open from April through

October, daily tidal variation and maximum EC are *generally* lower than when higher EC water from the San Joaquin River watershed flows relatively unimpeded to the TFCF. We note that temporary barrier and DCC gate schedules vary from year to year, and that some temporary barriers have been notched to promote fish movement over the past several years.

Low DO Periods

During the summer, DO does drop below 5 mg/L often enough to warrant concern by TFCF and other salvage facility operators. During periods of lower intake channel DO, we recommend that TFCF personnel more closely monitor DO sensors inside the facility and ensure that internal sensors are maintained and calibrated. Facility DO sensors and salvage operations should be closely monitored to minimize fish salvage losses when channel DO is low.

Recommendations

Because independent annual data review, validation, and assessment of the TFCF sonde data is an important QA function, we recommend that these oversight, analysis, and information transfer aspects of the sonde program continue.

Consistent Calibration and Maintenance Is Essential

Previous experience at the TFCF has demonstrated that calibration and maintenance of sondes, and priority assignment of responsible personnel is essential to produce accurate and usable water quality data. We recommend that sonde calibration and maintenance performed by experienced technicians from the Mid-Pacific Regional Office continue. Sonde maintenance and calibration could be performed by trained TFCF personnel; however, management would need to maintain priority for any such local personnel assignment, and the local program should be audited and assessed for data quality improvement and ongoing corrective actions at least annually.

Regular Equipment Replacement

A review of sonde performance strongly suggests that sondes perform reliably for 2 years before operational problems begin to significantly impair data quality. Therefore, we recommend replacing sondes at the outset of every third year of data collection, and making provisions in the TFFIP budget to accommodate equipment replacement and/or regular factory refurbishing of sondes.

Remote Data Monitoring

The percentage of missing data associated with the channel water quality sonde could be reduced by remote monitoring of sonde data using a web-based system such as the YSI Econet service. This service can alert field crews with automated emails when data are logged beyond acceptable limits (see Appendix 1 SOP for our current warning and control limits). The field crew could then take corrective actions and restore proper sonde function before routine scheduled visits. This kind of web-based system would also enable access to real-time sonde data for TFCF biologists and operators, allowing implementation of "low DO" operating protocols to reduce salvage losses.

ACKNOWLEDGMENTS

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APPENDICES

Appendix 1 – Standard Operating Procedure for Maintenance, Calibration, and Operation of the YSI Model 6920 V2 Water Quality Sonde

Appendix 2 – Documentation for Access Database Tables

Appendix 3 – Histograms and Basic Statistical Summary for Water Quality Variables

Appendix 4 – Statistical Summaries of Water Quality Data

Appendix 5 – Guide to Files on Attached Volume 37 CD-ROM

Standard Operating Procedure for Automated Measuring of Water Quality Parameters at the Tracy Fish Collection Facility

Environmental Monitoring Branch
MP-157
Bureau of Reclamation
Mid-Pacific Region
Sacramento, California

Reviewed and Approved by D. Craft, Principal Investigator (PI)

June 12, 2001

Revised by M. Del Hoyo and Approved by D. Craft, PI,

December 2007

1. INTRODUCTION

This procedure is an amendment to the Environmental Monitoring Branch Standard 0perating Procedures (SOP) for Field Monitoring. This SOP describes calibration, record keeping, and measurement of water quality variables at the Tracy Fish Collection Facility (TFCF) in the Old River Channel using a YSI model 6920 V2 multiparameter sonde and a model 650 Multiparameter Display System (MDS) data logger.

2. BACKGROUND

This program was implemented to measure temperature (T, in °C), pH (in standard units [su]), dissolved oxygen (DO, in mg/L), conductivity (EC, in µS/cm), redox potential (Eh, in mV), and turbidity (in NTU) on a 30-min interval semi-continuous schedule at Reclamation's TFCF. The purpose for these measurements is to provide baseline water quality data to fishery researchers performing studies for improving fish salvage operations and designs for the Tracy Fish Facility Improvement Program, and as reference data for the Interagency Ecological Program water quality monitoring studies. The validated data are available for environmental impact assessment for any planned construction at or near the TFCF or by the general public. The TFCF is located on the Old River at the intake channel for the C.W. "Bill" Jones Pumping Plant (formerly Tracy Pumping Plant). The YSI sonde is installed in a perforated pipe behind the trash rack on the north side of the intake channel at the TFCF.

3. OPERATION, UPLOADING AND CALIBRATION OF YSI 6920 V2 SONDE WITH MODEL 650 MULTIPARAMETER DISPLAY SYSTEM

The complete operating procedures of the YSI QS 6-Series and 650 MDS are provided in the operating manuals. An abbreviated procedure is given below.

3.1 Equipment Set-up

Once the initial set-up procedure is performed, it is not necessary to repeat these procedures for routine calibration and maintenance unless internal batteries are replaced.

(1) Before deployment or when changing internal sonde batteries, install new batteries into sonde. Make sure the connector cap (top of sonde) is wiped dry.

(2) To install batteries, unscrew the connector cap first. Then unscrew the top portion of the YSI. Insert eight (AA) batteries, observing proper polarity. Screw top portion back on after applying a small amount of silicone grease to the O-ring.

(3) To install batteries for the 650 MDS, unbolt screws on the back of instrument. Insert four "C" batteries, observing proper polarity. Bolt screws back in.

(4) After installing batteries, connect **650 MDS** and **sonde** with the cable. Press the **Power** (green) button on the 650 MDS to turn it on. Change power settings and Check battery voltage for both the 650 MDS and YSI sonde.

(5) After the batteries are installed, you will need to change the power settings on the **650 MDS** so that the sonde is being powered from the internal batteries and **not** from the 650 MDS. From **650 Main Menu**, select **System setup** and press **Enter** (⟵**).** Select **Power sonde** and press **Enter** (⟵) to uncheck box. Hit **(Esc)** to get back to **650 Main Menu**.

(6) *To check battery voltage for 650 MDS*, after power on, from **650 Sonde Menu**, check bottom right corner of screen for "**± power bar"** or select **Sonde run** and press **Enter** (⟵**).** Voltage is displayed next to "**Volt**". Replace the MDS batteries if the voltage is < 9.0 V .

(7) *To check battery voltage for sonde*, from **650 Main Menu**, select **Sonde menu** and press **Enter** (⟵)**).** Select **Run,** then **Discreet sample,** and then **start sampling**. After 4 second stabilization, check value next to **Volt**. Replace the sonde batteries if the voltage is < 9.0 V. Hit **(Esc)** button to get back to **650 Main Menu**.

3.2 Routine Pre-Calibration Cleaning and Maintenance

(1) Remove the submerged sonde from the square steel pipe. The other round steel pipe can be used as a back-up. Note any excessive debris loads, visible turbidity, stagnant flow, or other unusual conditions in the channel on the log sheet.

(2) After removing the sonde from the pipe, rinse the outside with deionized (DI) water to remove any dirt or debris. Wipe dry with chem-wipes. Note any excessive accumulation of algae or scum on the sonde on the log sheet.

(3) Unscrew and remove the shield guard from the sonde. Half-fill the calibration cup with DI water, attach the cup, and shake the sonde to rinse off all probes to remove any dirt and debris. Discard DI water. Repeat the step two more times with fresh DI water.

(4) Keep calibration cup on, filled approximately ⅛ with DI water. Make sure the outside of connector cap is dry. Remove connector cap and connect the 650 MDS and the YSI sonde with the cable connection.

3.3 Uploading Data from YSI Sonde to 650 MDS

***Note**:* Upload the already stored sonde data prior to calibration. Before uploading the data, stop the sonde from logging so that these data are not included in the data file.

Stop Logging Data

(1) From 650 **Main Menu**, select **Sonde** menu and press **Enter** (←)

(2) Select **Run** and press **Enter** (←).

(3) Select **Unattended Sample** and press **Enter** (←).

(4) Scroll to the very bottom of the screen, select **Stop Logging**, and press **Enter** (←).

(5) Select Stop Logging and press Enter (←).

(6) A screen pops up asking "Are you sure you want to stop logging?" select **Yes** and press **Enter** (←). Press Escape **(Esc)** button to get Main screen.

You are now ready to upload the data from the YSI to the 650 MDS

(1) From the **Main** screen, select **File** and press **Enter** (←**).**

(2) Select **Upload** and press **Enter** (←**).** This will take you to all the files stored in the YSI.

(3) Highlight the ***file*** you want to upload and press **Enter** (←**).**

(4) Select **Proceed** and press **Enter** (←).

(5) Select **PC6000** for the file type and press **Enter** (←). (*This file type is compatible with the Ecowatch software).* Downloading will begin. "**Finished**" message appears when the download is complete. *The file has now been uploaded to the 650.*

(6) To view files stored in the YSI, Select **View file** and press **Enter** (←).

(7) Select the desired file and press **Enter** (←).

(8) Select **Proceed** and press **Enter** (←).

(9) Press the **(Esc)** button to get to **Main** menu.

3.4 Buffers and Standards

The YSI is calibrated for the following parameters: pH using pH = 7.00 and pH = 10.00 buffer solutions, EC using 1000 µS/cm standard, DO using air saturated with water vapor and the current barometric pressure, turbidity using a 0 and 11.2 NTU standard, Eh using a +229 mV standard and depth. Refer to Table A1-1 for calibration solutions and sources.

TABLE A1-1.—Calibration solutions and sources for the YSI sonde.

Standard	Stock Number	Contact Information	Address
pH = 7.00	1500-20L	Zak – Rep (512) 846-2893	Hydrotech ZS Consulting 324 Axis Deer Trail Hutto TX, 98634
pH = 10.00	1525-20L		
EC = 1,000 µS/cm	6950-20L		
ORP = +229 mV	7800-20L		
Turbidity = 0.0	6080	David Lee – Rep (916) 421-5199	YSI Inc. Repair Center 1725 Brannum Lane Yellow Springs OH 45387 (937) 767-7241 Fax (937) 767-9353 support@ysi.com
Turbidity 11.2	6073G		

3.5 Calibration and Maintenance for Individual Probes

Calibration sheets are kept in a three-ring binder stored in the shack at Tracy. Once the binder is full, it is stored back at the Regional office in Sacramento, CA and a new empty binder is created. A calibration sheet is to be completed every time the YSI sonde probes are calibrated.

Perform the following procedures for all sonde probe calibrations:

(1) Select **Sonde menu** and press **Enter** (←). Select **Calibration** and press Enter (←). Select the parameter you want to calibrate and then pres **Enter** (←).

(2) Calibrate the YSI in the same order as listed on the **Calibration Sheet**.

(3) Rinse the probes three times with DI water between each calibration.

(4) Rinse the probes with the calibration standard three times.

(5) Fill the cup up with the standard making sure all the probes are submerged.

(6) **Warning:** Do not use a probe that has given any “Calibration Error” or “Out if Range” warning messages.

3.5.1 Temperature

Temperature is generally the most reliable probe and no routine calibration is necessary. However, the operator should be vigilant for odd and unexpected readings. These would include higher than expected temperatures in winter, lower than expected temperatures in summer, negative or extreme readings, or readings clearly inconsistent with previous trends. Refer to the section **Monitoring Probe Performance and Corrective Actions** below for a guide to expected values in the channel.

Important – Use back-up unit 6920 V2 to compare to for odd and unexpected readings. Refer to the section **Monitoring Probe Performance and Corrective Actions** when such matters occur.

3.5.2 Conductivity

(1) Calibrate conductivity first; avoid any contamination of the standard.

(2) Never calibrate with conductivity standards that are less than 1.0 mS/cm. You are setting the slope on a linear device so a good strong conductivity signal will give you the best performance. Use 1.0 mS/cm for fresh water, 10 mS/cm for brackish to estuarine, and 50 mS/cm for salt water.

(3) Pre-rinse the cal cup and sensors with a small amount of the calibration standard and discard.

(4) Insure that the conductivity probe is completely submerged in standard. The hole in the side of the probe must be under the surface of the solution and not have any trapped bubbles in the side opening.

(5) If the sonde should report **"Out Of Range"**, investigate the cause. Never override a calibration error message without fully understanding the cause. Typical causes for error messages are incorrect entries. For example, entering 1000 microSiemens instead of 1.0 milliSiemens (**Note:** the sonde requires the input in milliSiemens). Low fluid level and/or air bubbles in the probe cell can also cause error messages to appear.

(6) When the calibration has been accepted, check the conductivity cell constant which can be found in the sonde's **Advanced Menu** under **Cal Constants**. Record the value on the calibration sheet.

Important – Use back-up unit 6920 V2 to compare to for odd and unexpected readings. Refer to the section **Monitoring Probe Performance and Corrective Actions** when such matters occur.

3.5.3 pH

(1) Go to the sondes "**Report Menu**" and turn on the pH mV output. This will allow the sonde to display the millivolts or the probes raw output, as well as, the pH units during the calibration process.

(2) Recondition the probe if a slow response in the field has been reported. The procedure to do this can be found in your manual under the "**Sonde Care and Maintenance Section**".

(3) In most cases, a two point calibration is all that is required. Bracket the expected in-situ pH values; use the three point calibration only if the in-situ pH value is unknown. **Start all calibrations in Buffer 7!**

(4) Calibrate the pH. Insure that the temperature probe is in solution with the standard, record the pH millivolts (mV) at each calibration point. The mV output is the unprocessed pH output, and the acceptable range for each buffer is shown below.

Buffer 4	=	+180	± 50 mV
Buffer 7	=	0	± 50 mV
Buffer 10	=	-180	± 50 mV

(5) After recording the pH mV for the calibration points, you must determine the slope of the sensors. This is done by determining the difference between the two calibration points that were used. For example, if we recorded a +3 mV for buffer 7 and a -177 for the buffer 10 then the slope would be 180. The acceptable range for the slope is 165 to 180. Once the slope drops below 160, the sensor should be taken out of service**.**

Warning: Do not use a probe that has given any "Calibration Error" or "Out if Range" warning messages.

Important – Use back-up unit 6920 V2 to compare to for odd and unexpected readings. Refer to the section **Monitoring Probe Performance and Corrective Actions** when such matters occur.

3.5.4 Dissolved Oxygen – Unattended / Sampling DO Sensor Preparation

Note: Perform steps 1-5 only when necessary. They are not to be performed every time the sonde is calibrated.

(1) Inspect the DO probe anodes; recondition using the 6035 reconditioning kit if they are not bright and shiny.

(2) Install a new membrane, making sure that it is tightly stretched and wrinkle free. **WARNING:** Replace the probe o-ring if it is loose or stretched out. If you remove the DO probe from the sonde, be sure to inspect the probe port and connector for moisture. Remove any moisture droplets from the connector and thread areas. Verify that the probe is clean and dry then apply a small amount of silicone grease to the o-ring before it is reassembled. **Note:** DO membranes will be slightly unstable during the first 3 to 6 hours after they are installed; it is

strongly recommended that the final calibration of a DO sensor being used in Unattended studies take place after this period.

(3) Go to the sondes **Report** menu and enable the **DO Charge**. Now go to the **Run** menu and start the sonde in the **Discrete Run** mode at a 4 second rate, allow the sonde to run (burn-in) for 10 minutes. Record the DO Charge after about 5 minutes. The number should read between 25 and 75.

(4) After the burn-in is complete, go to the sonde's **Advanced Menu** and confirm that the RS-232 auto sleep function is enabled. If the sonde is to be connected to an SDI-12 data logger then the SDI-12 auto sleep must be enabled as well. Wait 60 seconds before proceeding to Step 5.

(5) Start the probe in the **Discrete Run** mode at a 4 second rate and record the first 10 DO% numbers on paper, the numbers must start at a high number and drop with each four second sample, example: 110, 105, 102, 101.5, 101.1, 101.0, 100.8, 100.4, 100.3, 100.1. **It does not matter if the numbers do not reach 100%, it is only important that they have the same high to low trend.** If you have a probe that starts at a low number and steadily climbs upward then the sensor has a problem and it must not be used. **Note**: Initial power up can make the first two DO% samples read low, the first two samples can be disregarded.

(6) The probe is now ready to be calibrated. Set the Auto Sleep RS-232 for the intended application. **ON** for **UNATTENDED STUDIES** and **OFF** for **SAMPLING MEASUREMENTS.** Set the sonde into the calibration cup with approximately 1/8 inch of water. Do not engage the threads, and do not allow water to contact the membrane, you may also use the wet towel method. The sonde must now sit in this saturated environment for at least 10 minutes before the DO calibration can begin.

(7) **Warning: t**he sonde must be idle and not in the "RUN" mode for 5 minutes prior to starting the DO calibration. Calibrate the sonde in DO% be sure to enter your local barometric pressure in mm/hg. In Unattended mode (RS-232 Auto-Sleep ON) the DO probe will be calibrated automatically once the barometric pressure is entered and the warm-up time counter counts down to zero. For **Discrete** or **Sampling** the user will press the Enter Key when the DO readings are stable. Wait at least three minutes after you enter the barometric pressure before you press the enter key again to calibrate for Discrete/Sampling DO measurements.

(8) When the calibration is complete go to the sonde's **Advanced Menu** and then to the **Cal Constants** and record the **DO Gain**. The gain should be 1.0 with a Range of -0.7 to +1.4. The probe should be successfully calibrated and ready to prepare for the study. Like with the other parameters, any warning messages displayed by the sonde during the calibration are a cause for concern and must be investigated before collecting field data with the sonde.

Warning: Avoid having the DO probe membranes contact the calibration cup or sensor guard during transfers. Keep the DO probe in sight when removing or installing the sensor guard and cal cup.

Note: **Use** the Winkler Titration (see SOP for operation) to perform confirmation tests for out of range readings (see corrective action summary below).

3.5.5 Turbidity – Model 6136 Probe

Note: The calibration of all YSI turbidity sensors must be done with either YSI distributed standards, Hach StablCal, or Diluted Hach 4000 NTU formazin or standards that have been prepared according to instructions in Standard Methods (Section 2130B). Standards from other vendors are NOT approved, and their use will likely result in a bad calibration and incorrect field readings. Please refer to the turbidity calibration section of your manual for more information.

(1) The first step is to confirm that the turbidity probe is functioning properly. Confirm that the wiper is parking correctly. It should be positioned at approximately 180 degrees opposite of the optics. The wiper should reverse direction during the wipe cycle. In addition, the output of the probe should increase when you place your finger in front of the optics. If the wiper does not park correctly or reverse direction then make sure that the underside of the wiper is clean and free of mud, sediment, or other fouling, replace the wiper or pad with a spare if needed. If the probe does not show an increase in output or the wiper does not park correctly, then you must stop the calibration and determine the cause of the problem.

(2) Calibrating turbidity is best done in a lab environment; calibrations in the field can result in errors. It is better to post-calibrate a sonde back in the lab than to attempt a calibration of an optical probe in the field, especially if you are working out of a small boat or in less than clean conditions.

(3) Never use plastic beakers or containers for turbidity calibrations standards. Clear plastics will reflect the infrared light beam and cause errors. Use of the supplied calibration/storage cup with its black end cap is highly recommended. Note: the black PVC end cap does not reflect the IR light source. Glassware can also be used, but due to the possibility of light source reflection, the sensor guard must be installed on the sonde. Do not use small containers like 35 mm film storage containers. For your calibration, a minimum distance of 3.0 inches is required from the probe face to bottom of the calibration chamber.

(4) Always insure that the all submerged parts of the sonde and wipers are clean before beginning any turbidity calibration. Remove the EDS wiper and replace it with a clean standard (no brush) wiper (black colored). Sediment or other contaminants can contaminate the standard if not cleaned. Make especially sure the optics are clean, no finger prints!

(5) Always start with the zero (0) NTU standard first. Pour the 0 NTU cal standard solution into the calibration cup – pour down the side so you do not aerate the sample. Set your sonde on top of the calibration cup (do not engage the threads). Verify that there are no air bubbles on the probe face, run the wiper at least once before accepting the first point.

(6) **Note**: The Standard YSI calibration cup is slightly shorter than the sondes sensor guard. The shorter cup minimizes the use of standards when calibrating the sensors. In deployments where very low turbidity readings are expected, the sonde should be spaced off the calibration cup two inches. The sonde may report a slightly negative reading (typically less than -1.0 NTU) when calibrating with the sonde resting on the calibrating cup. A new longer cup is available (p/n 116275) which eliminates the need for the two inch spacing.

(7) Calibrate the second point with the value that correlates to the turbidity sensor that is installed on the sonde. Again wipe the probe at least once before pressing the enter button. Note: Never override a calibration error message without fully understanding the cause of the problem. Calibration errors messages usually indicate that problems exist that will result in incorrect field readings.

Note: For YSI prepared AMCO-AEPA standards, the value entered by the user during the calibration protocol is DIFFERENT depending on which YSI turbidity sensor (6026 or 6136) is being calibrated. The part numbers for the YSI standards and their calibration values are listed by probe below.

* Currently, the model 6136 turbidity probe is installed on both (original and back-up) 6920 V2 sondes. Use the standard 11.2 NTU for your second point.

YSI Part Number	6026 Value	6136 Value*
608000	0 NTU	0.0 NTU
607200	10.0 NTU	11.2 NTU
607300	100.0 NTU	23.0 NTU
607400	800.0 NTU	1,000.0 NTU

Important – Use back-up unit 6920 V2 or Hach 2100P Turbidity meter to compare to for odd and unexpected readings. Refer to the section **Monitoring Probe Performance and Corrective Actions** when such matters occur.

3.5.6 Depth

(1) Make certain that the depth sensor module is in air and not immersed in any solution. Also, check to see if the sensor channel is free of dirt. If channel needs to be rinsed, fill the syringe with water, making certain the other side of the

channel is not blocked, releasing the water so it will flushed thru emptying on the other side of the sonde.

(2) From the Calibration menu, select Pressure-Abs or Pressure-Gage (depending if you have a vented level sensor).

(3) Input 0.00 or some known offset in feet. Press Enter and monitor the stabilization of the depth readings with time.

(4) When no significant change occurs for approximately 30 seconds, press Enter to confirm calibration. This zeros the sensor with regard to current barometric pressure. Then press Enter again to return to the Calibration menu.

(5) Got to Advance Menu and then to Cal constants and record the Pressure offset on the calibration sheet.

3.5.7 Eh/ORP/Redox

(1) The ORP and pH sensors are combined on all current YSI sondes. You must calibrate the pH sensors first and insure that it is working properly before calibrating the ORP. If the pH probe will not calibrate for any reason then the ORP has been disabled and can not be used as well.

(2) Refer to the sonde manual for reconditioning tips and cleaning instructions.

Eh CALIBRATION CHART

Temperature °C	Zobell Solution Value, mV
-5	270.0
0	263.5
5	257.0
10	250.5
15	244.0
20	237.5
25	231.0
30	224.5
35	218.0
40	211.5
45	205.0
50	198.5

Important – Use back-up unit 6920 V2 to compare to for odd and unexpected readings. Refer to the section **Monitoring Probe Performance and Corrective Actions** when such matters occur.

3.6 Confirming Proper Sonde Measurements in Channel

After completing maintenance and calibration for the individual sonde probes, remove the calibration cup, re-attach the probe guard and lower the sonde into the square pipe to the correct depth in the channel. Set the MDS to read data directly and allow the sonde to equilibrate for 5 min in the channel water and then observe all water quality variables being measured. Check for the following:

(1) Check each variable for acceptable values. Refer to the section **Monitoring Probe Performance and Corrective Actions** below for a guide to expected values for each of the water quality variables measured in the channel. If observed values are beyond the upper and lower control limits (UCL-LCL), pull the sonde and take appropriate corrective actions.

(2) Check each probe for reading stability. This means that readings do not bounce or drift erratically. If any probes show this behavior, and the sonde is submerged properly, there is likely a serious problem. Remove the sonde and perform corrective actions covered in **Monitoring Probe Performance and Corrective Actions.**

(3) Use common sense when confirming proper sonde performance. Any negative value suggests the sonde is not submerged or serious trouble with a probe. If the channel is full of debris and suspended material, and turbidity is very low, something is wrong. If the water is unusually clear and turbidity is high, something is wrong. If it is winter, and summer temperature readings (in the 20's °C) are seen, something is wrong. If the channel is flowing normally, and DO is low, something is wrong.

(4) If you suspect that the erratic or unusual readings might be caused by a clogged or fouled pipe, pull the sonde and take measurement in the open channel. "Normal" readings in the channel mean the pipe needs clearing and cleaning.

Note: If all probes are operating properly and measuring as expected, confirm that the sonde is correctly installed at the proper depth to remain immersed during low tide.

3.7 Monitoring Probe Performance and Corrective Actions

3.7.1 General Corrective Action Procedure

When any unusual readings are suspected during sonde confirmation measurements in the channel, follow this general corrective action procedure:

(1) Re-confirm proper sonde electronic operation and battery voltage.

(a) Battery voltage OK? If YES – go to step 2). If NO – change batteries if needed, and re-calibrate the probes. Re-install sonde in pipe and observe readings.

(b) Readings still odd? If YES – go to step 2).

(c) All OK? If YES – go to next **section** to set the sonde for unattended measurements.

(d) Problems? YES – go to step 2).

(2) Repeat the cleaning and calibration procedures for the individual probe showing an unusual reading.

(a) Re-install sonde in channel and observe readings. All OK? If YES – go to next **section** to set the sonde for unattended measurements.

(b) Reading still odd or out of range? If YES – go to step 3).

(3) Remove the sonde from the pipe, rinse probes with DI water, then submerge in the open channel outside the pipe and allow to equilibrate for 5 minutes.

(a) Readings in pipe confirmed by open channel measurements and probes all stable? If YES – go to step 4).

(4) Confirm the odd channel reading using an independent instrument (a separate and calibrated pH, EC, or turbidity meter, or a calibrated backup sonde) or alternate technique (using a Winkler Titration).

(a) Calibration of sonde probe OK and odd channel reading confirmed? If YES – note on log sheet and advise program manager or principal investigator (PI) of unusual data. Be vigilant over the next several calibration visits for the suspect probe readings and watch for probe drift or unusual systematic trend in data that might suggest a problem with the probe.

Note: Make sure independent instrument or sonde is operating correctly and calibrated.

(b) All OK? If YES – go to next step 5). If NO – **replace sonde with backup unit**, perform all system checks and probe calibrations and channel confirmation. Add additional log sheet for backup sonde calibration records and checks. Note sonde replacement on both log sheets and advise supervisor and PI of problem.

(c) Re-install re-checked or replacement backup sonde in pipe and observe readings. All OK?

(d) If YES – go to next **section** to set the sonde for unattended measurements.

(e) Original sonde replaced by backup? If YES – initiate probe replacement or sonde repair. Advise supervisor and PI, schedule repairs, and start procurement actions to initiate process as soon as possible.

(5) Re-install sonde in pipe and confirm installation depth in pipe.

3.7.2 Guidelines for Probe Measurements

Use the guidelines below (based on 7-year's data at the TFCF) for taking defined corrective actions when readings are unusual. The upper and lower control limits (UCL and LCL) are based respectively on the 97.5th percentile (UCL) and the 2.5th percentile (LCL). These percentiles correspond to the 95-percent confidence intervals associated with limits based on ± 2 standard deviations.

For several variables (EC, DO, and T), there are significant seasonal differences for the control limits, and these are explained in separate sections below. For pH, Eh, percent DO saturation, and turbidity, uniform control limits may be used year-round.

Use Table A1-2 information to perform the appropriate corrective actions when sonde probe readings are beyond the control limits after calibration. The general corrective action procedure in section 3.7.1 applies to all probes and measurements. Table A1-3 provides the year-round limits for pH, Eh, percent DO saturation, and turbidity.

3.7.3 Limits for Conductivity

Conductivity varies over the year both in median value and extreme values and shows some of the most complex behavior among the water quality variables at the TFCF. Every day, there are large changes in EC from tidal inflows. The daily tidal fluctuation in EC can range from around 100 µS/cm up to 500 µS/cm. Seasonal trends in median EC are caused by the overall annual hydrologic cycle of snowmelt producing a spring minima and winter maxima that affects all source waters at the TFCF. This overall pattern can be seen in Figure A1-1 graph of EC at the TFCF summarized by day of year, where the median traces out a broad blue "smile" over the year.

TABLE A1-2.—Summary of corrective actions (refer to **section 3.7.1** for details) when probe readings are exceed upper and lower control limits.

Probe Reading	Corrective Actions
Above UCL	(1) Check internal battery, Check internal sonde diagnostic, Re-clean, Re-recalibrate, Re-check reading. (2) Still high? Check against independent calibrated instrument or nearby station. (3) High value confirmed? Note on log sheet. Check future probe data and advise PI. (4) High value not confirmed? Replace-Service and advise your supervisor and PI.
Between UCL-LCL	**No Corrective Action – Near limits? Confirm reading.**
Below LCL	(1) Check internal battery, Check internal sonde diagnostic, Re-clean, Re-recalibrate, Re-check reading. (2) Still low? Check against independent calibrated instrument or nearby station. (3) Low value confirmed? Note on log sheet. Check future probe data and advise PI. (4) Low value not confirmed? Replace-Service and advise your supervisor and PI.

Upper Control Limit – UCL
Lower Control Limit – LCL
PI – Principal Investigator or client project manager

TABLE A1-3.—Year-round control limits for percent dissolved oxygen (DO) saturation, pH, redox potential (Eh), and turbidity.

Limits	Percent DO Sat	pH, su	Eh, mV	Turbidity, NTU
UCL	101	8.13	473	97.3
Median	**81.2**	**7.46**	**339**	**13.2**
LWL	49.6	6.93	255	1.0

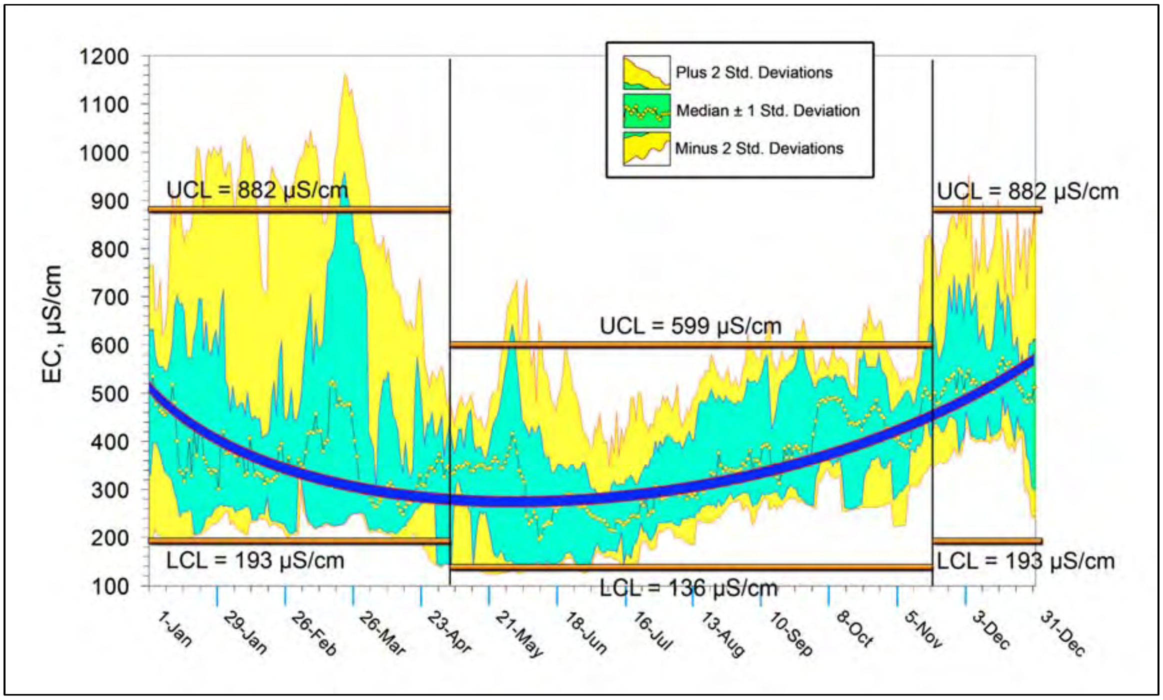

FIGURE A1-1.—Graph of electrical conductivity (EC) by day of year showing much higher variability during cooler months December through April. Lower EC variability, from May through November, when temporary channel barriers are installed. Note the different upper (UCL) and lower (LCL) control limits for these two periods.

Because of complex situation with daily tides and temporary barrier operations, the operator should use two sets of warning and control limits, found in Table A1-4, for taking corrective action during the two periods of the year.

TABLE A1-4.—Table of control limits for electrical conductivity (EC) during two different times of year.

Percentile	Limit	December through April	May through November
97.5th	UCL, µS/cm	882	599
50th	Median, µS/cm	414	344
2.5th	LCL, µS/cm	193	136

3.7.4 Dissolved Oxygen

DO also shows a seasonal trend with lower values observed during warmer months. This is caused mostly by the seasonal temperature cycle, less gas will dissolve in water at higher temperature. The presence of nutrients and organic carbon in the water from spring and summer agricultural activity also tends to deplete available DO. Table A1-5 provides a guide for upper and lower control values during the two periods in the year. Note these periods, based on the 7-year data record at the TFCF, are slightly different from the periods for EC.

TABLE A1-5.—Table of control limits for dissolved oxygen (DO) during two different times of year.

Percentile	Limit	November through March	April through October
97.5th	UCL, mg/L	10.9	9.46
50th	Median, mg/L	8.72	7.23
2.5th	LCL, mg/L	5.53	4.24

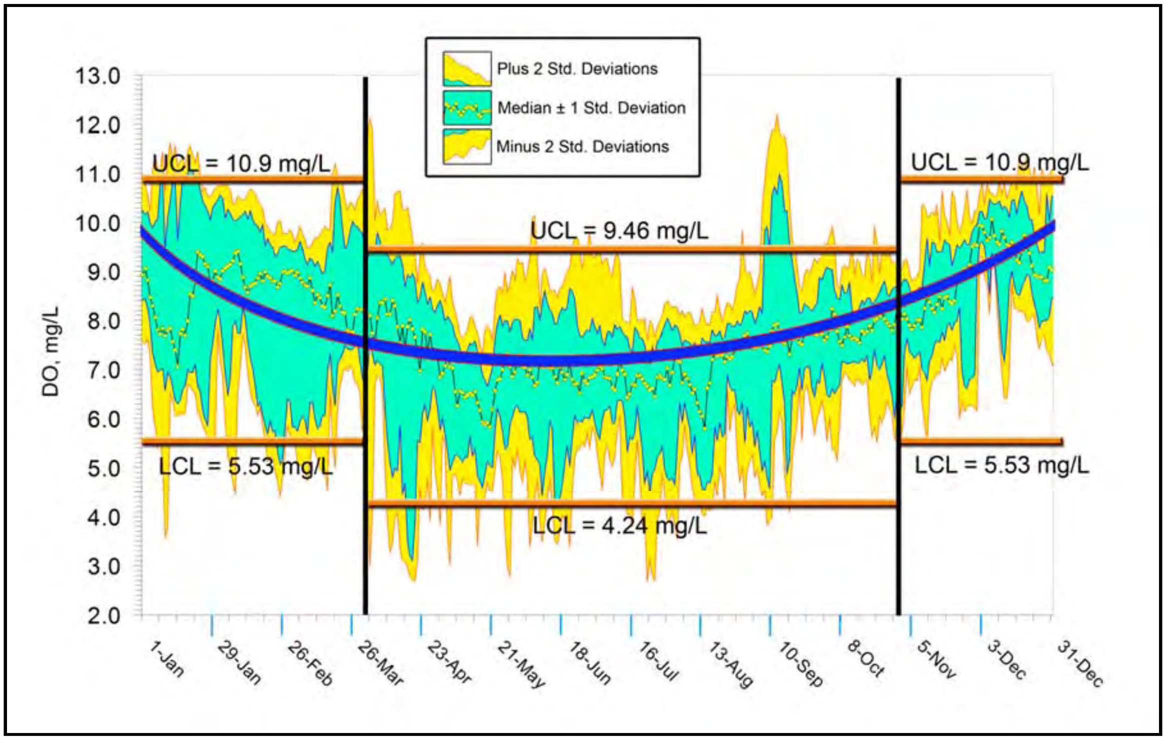

FIGURE A1-2.—Graph of dissolved oxygen (DO) by day of year showing much higher values for DO during the cooler months November through March. Note the different upper and lower control limits for these two periods.

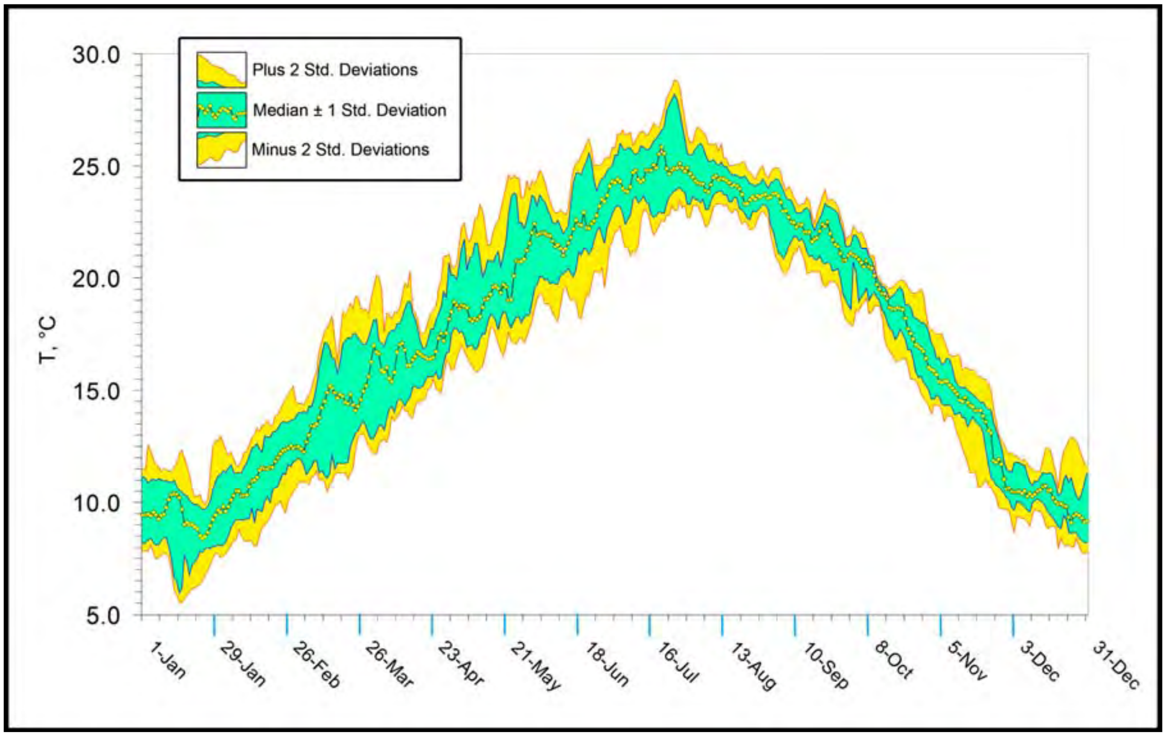

FIGURE A1-3.—Graph of temperature (T) by day of year showing seasonal variation. Use common sense to judge if T values are anomalous.

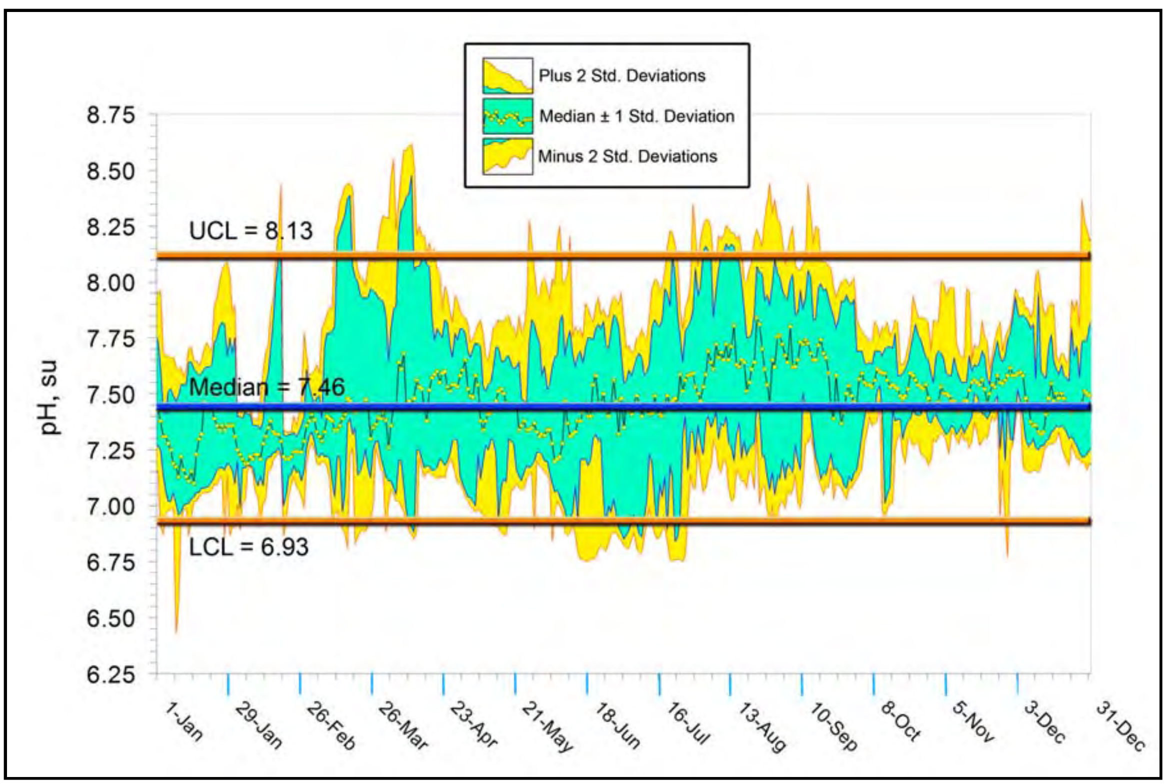

FIGURE A1-4.—Graph of pH by day of year showing median and upper and lower control limits.

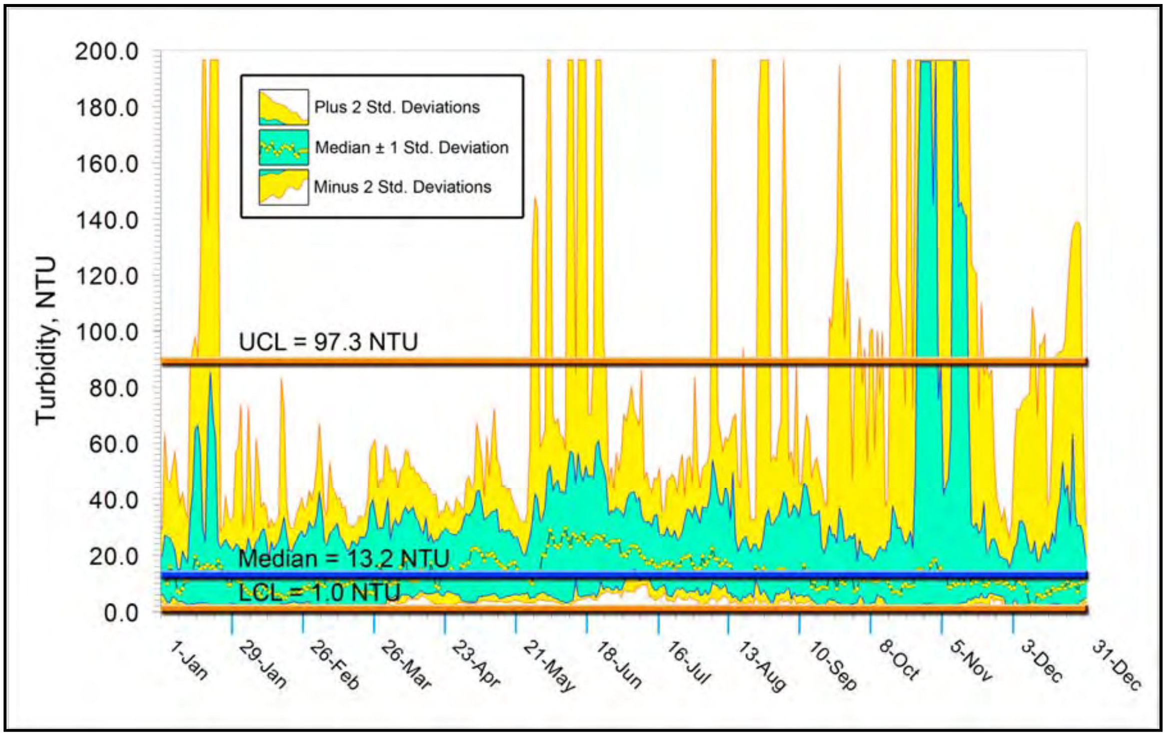

FIGURE A1-5.—Graph of percent DO saturation by day of year showing median and upper and lower control limits.

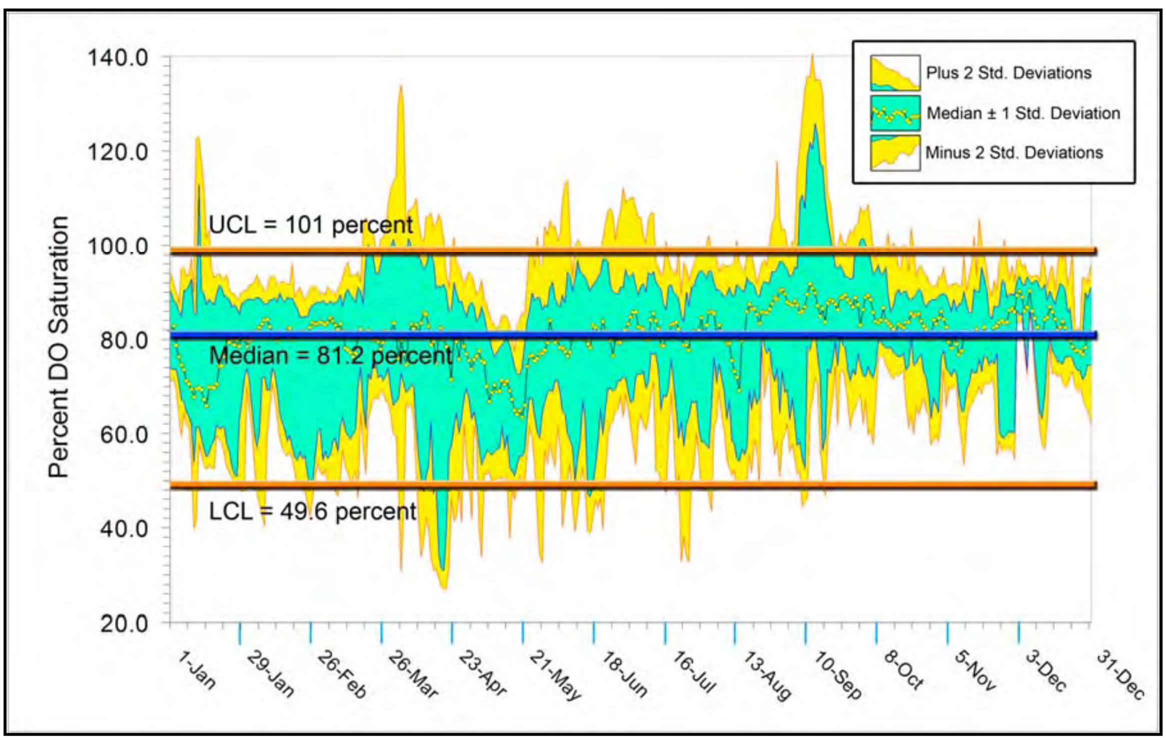

FIGURE A1-6.—Graph of turbidity by day of year showing median and upper and lower control limits.

3.8 Setting Up a File to Log Data For Unattended Sampling

After calibrating the individual probes, confirming proper sonde operation and channel readings, and confirming correct sonde depth in the pipe, set the sonde to measure and log data unattended:

(1) To set up file to log data select Sonde menu from 650 Main Menu and press Enter (←).

(2) Select Run from Main screen and press Enter (←).

(3) Select Unattended sample and press Enter (←).

(4) Enter the Interval for 00:30:00. Enter start date as MM/DD/Year.

(5) Set duration days for 20 days to log data for this program (This can be set for any number of days but be aware of the battery life and free memory days).

(6) Enter the File name as the current date in MM-DD-YR. (Press the number pad several times to get the number desired).

(7) Enter the Site name as CANAL. (Press the letter pad several times to get the letter desired).

(8) Select Start logging and press Enter (←).

(9) In the next screen the question, "Are you sure?" appears. Select yes and press Enter (←). The top of the screen now reads, Logging.

(10) Press the (Esc) button twice to get to the Main screen.

(11) Select Status and press Enter (←). The Status screen displays logging information. Next to Logging should read "Active." Press the (Esc) button to get to the Main menu.

3.9 Uploading Files from 650 MDS to PC

(1) Install ***Ecowatch*** software version 3.18 to PC (check system requirements) before downloading data. After download, connect the 650 MDS to a serial port of the PC using the ***655174 PC interface cable***.

(2) Power on 650 MDS, and then open ***Ecowatch*** on PC. Click the **sonde icon** in the upper toolbar, and set the COM port number to match your interface.

(3) On the 650, select **File** and press **Enter** (←).

(4) Select **Upload to PC** and press **Enter** (←).

(5) Select the **file** you wish to transfer and press **Enter** (←). The 650 and PC displays will show the progress of the file transfer until completion.

(6) After transfer the file will be located in the **C:\ECOWWIN\DATA**.

Note: For files with a .glp extension, an additional screen will appear on activating the transfer that gives a choice of binary, CDF, or ASCII for moving the file to the computer. You currently must use either the CDF or ASCII format for transfer so that the .glp file can be viewed in Notepad or other word processing program.

3.10 Opening/Formatting Files

(1) Open *Ecowatch.* Click the open file icon and select the file you uploaded. The file opens the data in graph form

(2) To view the data in a table format, click the table icon.

(3) To add or remove parameters from the table, in the toolbar click Setup, select Parameters, then select Add/Remove.

(4) The following are the parameters to Remove: DO charge, pH mV.

(5) The following are the parameters to Add: Battery, DO %, Salinity.

(6) Change the units for EC and Depth to μS/cm and feet respectively by clicking on the unit button, then the gray arrow and selecting the appropriate unit.

(7) Save the file by clicking the disk icon in the toolbar. Name the file "default" and click the Save button. You have up to 9 data displays that be saved per data file in order to save your settings so that you can load it another time and have it look exactly the same as when you saved it.

(8) To export the file so that it can be read in *Microsoft Excel*, click File, Export, CDF/WMF (*make sure under the Export format that the Comma Delimited (CDF) is selected*). If you want to export the graph, select Window Metafile (WMF).

(9) Export the file in I: MP157\Environmental\Tracy\Tracy FCF\Tables\present year.

(10) Open the file in *Microsoft Excel*.

(11) Text Import Wizard pops up. Make sure Delimited is selected, click Next button. Check the Comma box, click the Next button. Click Finish button.

FIELD INSTRUMENT CALIBRATION SHEET

Project Name___________________________ **Date/Time** ___/___/______ ___:___

Instrument #____________ **YSI or Hydrolab** **Operator** ________________________

	Initial Value	Adjusted Value	Post Value Date/Time __/__/___ __:__	
EC (µS/cm)				
Low ______	____________	_____________	____________	
High______	____________	_____________	____________	
Conductivity cell	____________	**(Range 5.0 ± .45)**	__/__/___ __:__	**probe change**

==

pH (su)				
pH 7	____________	_____________	____________	
mV buffer 7	____________	**(Range 0 MV ± 50 mV)**	__/__/___ __:__	**probe change**
pH 4	____________	____________	____________	
mV buffer 4	____________	**(Range +180 ± 50 mV)**		
pH 10	____________	_____________	____________	
mV buffer 10	____________	**(Range -180 ± 50 mV)**		

NOTE: Span between pH 4 and 7, & pH 7 and 10 mV numbers should be ~ 165 to 180 mV.

==

Dissolved O_2 (mg/L) **100% saturation @ ______mm/Hg**

____________ ____________ _____________

DO charge ____________ **(Range 25 – 75)** __/__/___ __:__ **probe change**

DO gain ____________**(Range -0.7 – +1.4)** **100% saturation @ ______mm/Hg**

==

Turbidity (NTU) **Inst #**__________ **probe change** __/__/___ __:__

Low_______	____________	____________	____________
Med_______	____________	____________	____________
High_______	___________	_____________	____________

==

Depth (ft.) ____________ _____________ ____________

Pressure Offset____________ **(Range -14.7 ± 6)** __/__/___ __:__ **probe change**

==

ORP (mV Zobell Solution)

mV_____ ___________ ____________ ____________

temp^{0}C___ ____________**temp ^{0}C**

mV Offset ____________**(Range 0 ± 100)** __/__/___ __:__ **probe change**

REMARKS:____

ACCESS DATABASE TABLES

The water quality data from this report are in a Microsoft® Access database file included in the CD-ROM attachment to this report (see Appendix 5 for list and description of files included). The primary database is **Multiprobe.mdb**, which contains the full sonde water quality data record and supplemental data for creating custom queries. Data tables from this database file may also be viewed at the Tracy Research website: http://www.usbr.gov/pmts/tech_services/tracy_research/data/WaterQualityData.html.

In this database, descriptive names have been used for all columns in data tables (field or variable names) with units substituting underscores for characters not allowed in Oracle® and SQL® field names. *Date* and *Time* fields use the same names in all tables. Additional documentation may be found for field names in the *Design* view for each table (from the *View* menu, select *Design View*). Access queries may be used to generate data tables that combine water quality and supplemental data.

Multiprobe.mdb

This database contains the full POR water quality data set measured at 30-min intervals, and additional water quality data tables that provide summaries by day of year, week of year, month of year, study hour, study day, study week, and study month.

Multiprobe.mdb also contains supplemental data tables for hydrology, temporary barriers, weather, tides and photoperiod, and fish salvage that may be combined with the water quality data using Access queries to investigate interactions between variables.

Table: WQ DATA – ALL DATA APR 2000 – FEB 2007

This is the complete 30-min interval data set with 120,542 observations and 22 fields. This large table cannot be exported in full to Excel because of the 65,000 row limit, but can be combined with supplemental data using Access queries. This table is also available as a comma delimited ASCII file on the enclosed CD-ROM.

Columns (Field-Variable Names)

Name	Type	Size
ID	Long Integer	4
Date	Date/Time	8
Time	Date/Time	8
Datetime	Date/Time	8
Datetime_by_hr	Date/Time	8
Year	Long Integer	4

Name	Type	Size
Month	Long Integer	4
Week_of_yr	Long Integer	4
Day_of_Month	Long Integer	4
Day_of_Year	Long Integer	4
Hour_of_Day	Long Integer	4
Study_Year	Long Integer	4
Study_Month	Long Integer	4
Study_Week	Long Integer	4
Study_Day	Long Integer	4
T_degC	Double	8
EC_uS_cm	Double	8
DO_Percent_Saturation	Double	8
DO_mg_L	Double	8
pH_su	Double	8
Eh_mv	Double	8
Turbidity_NTU	Double	8

Table: WQ DATA – ALL DATA HOURLY APR 2000 – FEB 2007

This is a smaller 60,271-observation, 18-field table of hourly averaged data covering the full POR. It may be exported to Excel and can be combined with supplemental data using Access queries. This table is also available as a comma delimited ASCII file and Excel spreadsheet file on the enclosed CD-ROM.

Columns (Field-Variable Names)

Name	Type	Size
Datetime_by_hr	Date/Time	8
Year	Long Integer	4
Month	Integer	2
Week	Integer	2
Day_m	Integer	2
Day_yr	Long Integer	4
Hour_d	Long Integer	4
stud_yr	Integer	2
stud_mo	Long Integer	4
stud_wk	Long Integer	4
stud_d	Long Integer	4
T_degC	Double	8
EC_uS_cm	Double	8
DOpct	Double	8
DO_mg_L	Double	8
pH_su	Double	8
Eh_mV	Double	8
Turb_NTU	Double	8

Table: WQ DATA – Summary by Day of Year

This 365-observation, 39-field table summarizes the entire POR by day of year. Supplemental data may not be combined with these data without appropriate averaging.

Columns (Field-Variable Names)

Name	**Type**	**Size**
ID	Long Integer	4
Day of Year	Long Integer	4
DD-MMM	Text	8
Date	Date/Time	8
T_05th_dyr	Double	8
T_16th_dyr	Double	8
T_Median_dyr	Double	8
T_84th_dyr	Double	8
T_95th_dyr	Double	8
EC_05th_dyr	Double	8
EC_16th_dyr	Double	8
EC_Median_dyr	Double	8
EC_84th_dyr	Double	8
EC_95th_dyr	Double	8
DOpct_05th_dyr	Double	8
DOpct_16th_dyr	Double	8
DOpct_Median_dyr	Double	8
DOpct_84th_dyr	Double	8
DOpct_95th_dyr	Double	8
DO_05th_dyr	Double	8
DO_16th_dyr	Double	8
DO_Median_dyr	Double	8
DO_84th_dyr	Double	8
DO_95th_dyr	Double	8
pH_05th_dyr	Double	8
pH_16th_dyr	Double	8
pH_Median_dyr	Double	8
pH_84th_dyr	Double	8
pH_95th_dyr	Double	8
Eh_05th_dyr	Double	8
Eh_16th_dyr	Double	8
Eh_Median_dyr	Double	8
Eh_84th_dyr	Double	8
Eh_95th_dyr	Double	8
Turbidity_05th_dyr	Double	8
Turbidity_16th_dyr	Double	8
Turbidity_Median_dyr	Double	8
Turbidity_84th_dyr	Double	8
Turbidity_95th_dyr	Double	8

Table: WQ DATA – Summary by Month of Year

This table summarizes the entire POR by month of year: 12 observations, 52 fields. Supplemental data may not be combined with these data without appropriate averaging.

Columns (Field-Variable Names)

Name	Type	Size
ID	Long Integer	4
Month	Text	25
Month_Num	Long Integer	4
T_05th_mm	Double	8
T_16th_mm	Double	8
T_25th_mm	Double	8
T_Median_mm	Double	8
T_75th_mm	Double	8
T_84th_mm	Double	8
T_95th_mm	Double	8
EC_05th_mm	Double	8
EC_16th_mm	Double	8
EC_25th_mm	Double	8
EC_Median_mm	Double	8
EC_75th_mm	Double	8
EC_84th_mm	Double	8
EC_95th_mm	Double	8
DOpct_05th_mm	Double	8
DOpct_16th_mm	Double	8
DOpct_25th_mm	Double	8
DOpct_Median_mm	Double	8
DOpct_75th_mm	Double	8
DOpct_84th_mm	Double	8
DOpct_95th_mm	Double	8
DO_05th_mm	Double	8
DO_16th_mm	Double	8
DO_25th_mm	Double	8
DO_Median_mm	Double	8
DO_75th_mm	Double	8
DO_84th_mm	Double	8
DO_95th_mm	Double	8
pH_05th_mm	Double	8
pH_16th_mm	Double	8
pH_25th_mm	Double	8
pH_Median_mm	Double	8
pH_75th_mm	Double	8
pH_84th_mm	Double	8
pH_95th_mm	Double	8

Name	**Type**	**Size**
Eh_05th_mm	Double	8
Eh_16th_mm	Double	8
Eh_25th_mm	Double	8
Eh_Median_mm	Double	8
Eh_75th_mm	Double	8
Eh_84th_mm	Double	8
Eh_95th_mm	Double	8
Turbidity_05th_mm	Double	8
Turbidity_16th_mm	Double	8
Turbidity_25th_mm	Double	8
Turbidity_Median_mm	Double	8
Turbidity_75th_mm	Double	8
Turbidity_84th_mm	Double	8
Turbidity_95th_mm	Double	8

Table: WQ DATA – Summary by Week of Year

This table summarizes the entire POR by week of year: 52 observations, 38 fields. Supplemental data may not be combined with these data without appropriate averaging.

Columns (Field-Variable Names)

Name	**Type**	**Size**
ID	Long Integer	4
Week	Long Integer	4
Begin Date	Date/Time	8
T_05th_ww	Double	8
T_16th_ww	Double	8
T_Median_ww	Double	8
T_84th_ww	Double	8
T_95th_ww	Double	8
EC_05th_ww	Double	8
EC_16th_ww	Double	8
EC_Median_ww	Double	8
EC_84th_ww	Double	8
EC_95th_ww	Double	8
DOpct_05th_ww	Double	8
DOpct_16th_ww	Double	8
DOpct_Median_ww	Double	8
DOpct_84th_ww	Double	8
DOpct_95th_ww	Double	8
DO_05th_ww	Double	8
DO_16th_ww	Double	8
DO_Median_ww	Double	8

Name	Type	Size
DO_84th_ww	Double	8
DO_95th_ww	Double	8
pH_05th_ww	Double	8
pH_16th_ww	Double	8
pH_Median_ww	Double	8
pH_84th_ww	Double	8
pH_95th_ww	Double	8
Eh_05th_ww	Double	8
Eh_16th_ww	Double	8
Eh_Median_ww	Double	8
Eh_84th_ww	Double	8
Eh_95th_ww	Double	8
Turbidity_05th_ww	Double	8
Turbidity_16th_ww	Double	8
Turbidity_Median_ww	Double	8
Turbidity_84th_ww	Double	8
Turbidity_95th_ww	Double	8

Table: WQ DATA – Summary Study Day

This table summarizes the entire POR by study day (sd) starting April 1, 2000, 2,512 observations, 38 fields. Field names include water quality variable with percentile (5th percentile, _05th) and summary period (study day, _sd). Supplemental data may be combined with these data directly using Access queries.

Columns (Field-Variable Names)

Name	Type	Size
ID	Long Integer	4
Study day	Double	8
Date	Date/Time	8
T_05th_sd	Double	8
T_16th_sd	Double	8
T_Median_sd	Double	8
T_84th_sd	Double	8
T_95th_sd	Double	8
EC_05th_sd	Double	8
EC_16th_sd	Double	8
EC_Median_sd	Double	8
EC_84th_sd	Double	8
EC_95th_sd	Double	8
DOpct_05th_sd	Double	8
DOpct_16th_sd	Double	8
DOpct_Median_sd	Double	8

Name	Type	Size
DOpct_84th_sd	Double	8
DOpct_95th_sd	Double	8
DO_05th_sd	Double	8
DO_16th_sd	Double	8
DO_Median_sd	Double	8
DO_84th_sd	Double	8
DO_95th_sd	Double	8
pH_05th_sd	Double	8
pH_16th_sd	Double	8
pH_Median_sd	Double	8
pH_84th_sd	Double	8
pH_95th_sd	Double	8
Eh_05th_sd	Double	8
Eh_16th_sd	Double	8
Eh_Median_sd	Double	8
Eh_84th_sd	Double	8
Eh_95th_sd	Double	8
Turbidity_05th_sd	Double	8
Turbidity_16th_sd	Double	8
Turbidity_Median_sd	Double	8
Turbidity_84th_sd	Double	8
Turbidity_95th_sd	Double	8

Table: WQ DATA – Summary Study Month

This table summarizes the entire POR by study month (sm) starting April 1, 2000: 83 observations, 38 fields. Field names include water quality variable with percentile (5th percentile, _05th) and summary period (study month, _sm). Supplemental data may not be combined with these data without appropriate averaging.

Columns (Field-Variable Names)

Name	Type	Size
ID	Long Integer	4
Study_Month	Long Integer	4
Date	Date/Time	8
T_05th_sm	Double	8
T_16th_sm	Double	8
T_Median_sm	Double	8
T_84th_sm	Double	8
T_95th_sm	Double	8
EC_05th_sm	Double	8
EC_16th_sm	Double	8
EC_Median_sm	Double	8

Name	Type	Size
EC_84th_sm	Double	8
EC_95th_sm	Double	8
DOpct_05th_sm	Double	8
DOpct_16th_sm	Double	8
DOpct_Median_sm	Double	8
DOpct_84th_sm	Double	8
DOpct_95th_sm	Double	8
DO_05th_sm	Double	8
DO_16th_sm	Double	8
DO_Median_sm	Double	8
DO_84th_sm	Double	8
DO_95th_sm	Double	8
pH_05th_sm	Double	8
pH_16th_sm	Double	8
pH_Median_sm	Double	8
pH_84th_sm	Double	8
pH_95th_sm	Double	8
Eh_05th_sm	Double	8
Eh_16th_sm	Double	8
Eh_Median_sm	Double	8
Eh_84th_sm	Double	8
Eh_95th_sm	Double	8
Turbidity_05th_sm	Double	8
Turbidity_16th_sm	Double	8
Turbidity_Median_sm	Double	8
Turbidity_84th_sm	Double	8
Turbidity_95th_sm	Double	8

Table: WQ DATA – Summary Study Week

This table summarizes the entire POR by study week (sw) starting April 1, 2000: 363 observations, 38 fields. Field names include water quality variable with percentile (5th percentile, _05th) and summary period (study week, _sw). Supplemental data may not be combined with these data without appropriate averaging.

Columns (Field-Variable Names)

Name	Type	Size
ID	Long Integer	4
Study_Week	Long Integer	4
Date	Date/Time	8
T_05th_sw	Double	8
T_16th_sw	Double	8
T_Median_sw	Double	8

Name	Type	Size
T_84th_sw	Double	8
T_95th_sw	Double	8
EC_05th_sw	Double	8
EC_16th_sw	Double	8
EC_Median_sw	Double	8
EC_84th_sw	Double	8
EC_95th_sw	Double	8
DOpct_05th_sw	Double	8
DOpct_16th_sw	Double	8
DOpct_Median_sw	Double	8
DOpct_84th_sw	Double	8
DOpct_95th_sw	Double	8
DO_05th_sw	Double	8
DO_16th_sw	Double	8
DO_Median_sw	Double	8
DO_84th_sw	Double	8
DO_95th_sw	Double	8
pH_05th_sw	Double	8
pH_16th_sw	Double	8
pH_Median_sw	Double	8
pH_84th_sw	Double	8
pH_95th_sw	Double	8
Eh_05th_sw	Double	8
Eh_16th_sw	Double	8
Eh_Median_sw	Double	8
Eh_84th_sw	Double	8
Eh_95th_sw	Double	8
Turbidity_05th_sw	Double	8
Turbidity_16th_sw	Double	8
Turbidity_Median_sw	Double	8
Turbidity_84th_sw	Double	8
Turbidity_95th_sw	Double	8

Table: Daily Tides

This table provides multiple low and high daily tide information for the full POR: 2,512 observations, 14 fields.

Columns (Field-Variable Names)

Name	Type	Size
ID	Long Integer	4
Date	Date/Time	8
Tide1 Time of Day	Date/Time	8
Low Tide or High Tide1	Text	1

Name	Type	Size
Tide1 Level, cm relative to Mean Sea Level	Double	8
Tide 2 Time of Day	Date/Time	8
Low Tide or High Tide2	Text	1
Tide2 Level, cm relative to Mean Sea Level	Double	8
Tide3 Time of Day	Date/Time	8
Low Tide or High Tide3	Text	1
Tide3 Level, cm relative to Mean Sea Level	Double	8
Tide4 Time of Day	Date/Time	8
Low Tide or High Tide4	Text	1
Tide4 Level, cm relative to Mean Sea Level	Double	8

Table: Events Near the TFCF

This table provides information regarding local temporary channel barrier and the Delta Cross Channel gate status for the full POR: 2,512 observations, 5 fields.

Columns (Field-Variable Names)

Name	Type	Size
Date	Date/Time	8
OldRiverNearTFCFTemporaryBarrierStatusDaily	Double	8
GrantLineCanalTemporaryBarrierStatusDaily	Double	8
HeadOfOldRiverTemporaryBarrierStatusDaily	Double	8
MiddleRiverTemporaryBarrierStatusDaily	Double	8
DeltaCrossChannelGateStatusDaily	Double	8

Table: Fish Salvage at the TFCF

This table provides daily fish salvage data by species reported by the TFCF for the full POR: 2,512 observations, 59 fields.

Columns (Field-Variable Names)

Name	Type	Size
Date	Date/Time	8
TPPPumpingAcreft_d	Double	8
SumofallFishSalvaged_day	Double	8
AmericanShad	Double	8
BigscaleLogperch	Double	8
BlackBullhead	Double	8
BlackCrappie	Double	8
BlueCatfish	Double	8
Bluegill	Double	8

Name	Type	Size
BrownBullhead	Double	8
Carp	Double	8
ChameleonGoby	Double	8
ChannelCatfish	Double	8
ChinookSalmon	Double	8
DeltaSmelt	Double	8
FatheadMinnow	Double	8
FreshwaterEel	Double	8
GoldenShiner	Double	8
Goldfish	Double	8
GreenSturgeon	Double	8
GreenSunfish	Double	8
Hardhead	Double	8
Hitch	Double	8
InlandSilverside	Double	8
LampreysAllSpp	Double	8
LargemouthBass	Double	8
LongfinSmelt	Double	8
Miscellaneous	Double	8
Mosquitofish	Double	8
PacificBrookLamprey	Double	8
PricklySculpin	Double	8
RainwaterKillifish	Double	8
RedShiner	Double	8
RedearSunfish	Double	8
RiffleSculpin	Double	8
SacramentoBlackfish	Double	8
SacramentoPerch	Double	8
SacramentoPikeminnow	Double	8
SacramentoSucker	Double	8
ShimofuriGoby	Double	8
SmallmouthBass	Double	8
Splittail	Double	8
StaghornSculpin	Double	8
StarryFlounder	Double	8
SteelheadRainbowTrout	Double	8
StripedBass	Double	8
StripedMullet	Double	8
ThreadfinShad	Double	8
ThreespineStickleback	Double	8
TuiChub	Double	8
TulePerch	Double	8
Wakasagi	Double	8
Warmouth	Double	8
WhiteBass	Double	8

Name	Type	Size
WhiteCatfish	Double	8
WhiteCrappie	Double	8
WhiteSturgeon	Double	8
YellowPerch	Double	8
YellowfinGoby	Double	8

Table: Hydrology

This table provides daily average streamflow discharge at the USGS gage station on the San Joaquin River at Vernalis and daily average pumping at the BJPP for the full POR: 2,512 observations, 3 fields.

Columns (Field-Variable Names)

Name	Type	Size
Date	Date/Time	8
PumpingAtTheTPP_cfs	Long Integer	4
USGSGageAtVernalis_cfs	Long Integer	4

Table: Sun Moon

This table provides sunrise, sunset, photoperiod, and lunar information for the full POR: 2,512 observations, 8 fields.

Columns (Field-Variable Names)

Name	Type	Size
Date	Date/Time	8
SunriseHHmm	Date/Time	8
SunsetHHmm	Date/Time	8
LengthOfDaylightHHmm	Date/Time	8
MoonriseHHmm	Date/Time	8
MoonsetHHmm	Date/Time	8
MoonQuarter	Text	255
MoonPhaseDegrees	Double	8

Table: Weather at Tracy

This table provides daily air temperature in °F and precipitation in for the full POR: 2,512 observations, 10 fields.

Columns (Field-Variable Names)

Name	Type	Size
Date	Date/Time	8
StudyDay	Long Integer	4
Coopid	Long Integer	4
Year	Long Integer	4
Month	Integer	2
Day	Integer	2
MaximumAirTemperature_degF	Double	8
MinimumAirTemperature_degF	Double	8
AverageAirTemperature_degF	Double	8
Precipitation_inches	Double	8

TABLE A3-1.—Summary of all variables for period of record April 1, 2000 to February 15, 2007.

All Data	T, °C	EC, µS/cm	Percent DO Saturation	DO, mg/L	pH, su	Turbidity, NTU
Statistics						
Valid n	106,285	105,240	101,816	105,219	101,052	105,845
Missing n	14,267	15,312	18,736	15,333	19,500	14,707
Mean	**17.1**	**390**	**79.1**	**7.71**	**7.47**	**20.7**
s	5.44E+00	1.57E+02	1.33E+01	1.51E+00	2.87E-01	2.90E+01
S.E. of Mean	1.67E-02	4.83E-01	4.16E-02	4.67E-03	9.02E-04	8.92E-02
Mode	23.9	288	88.5	7.82	7.33	>200
Range	23.6	1100	120	10.2	2.37	>200
Minimum	5.41	119	22.6	2.28	6.28	<0.5
Maximum	29.0	1220	143	12.5	8.65	>200
Skewness	-6.82E-02	9.65E-01	-4.29E-01	-1.63E-01	4.23E-01	4.30E+00
S.E. of Skewness	7.51E-03	7.55E-03	7.68E-03	7.55E-03	7.71E-03	7.53E-03
Kurtosis	-1.26E+00	1.57E+00	1.15E+00	-3.23E-03	5.98E-01	2.21E+01
S.E. of Kurtosis	1.50E-02	1.51E-02	1.54E-02	1.51E-02	1.54E-02	1.51E-02
Percentiles						
0.01th	5.51	121	26.0	2.49	6.45	<0.5
0.05th	5.67	123	28.2	2.70	6.68	<0.5
0.1th	5.82	123	29.4	2.86	6.75	<0.5
0.5th	6.96	127	38.3	3.50	6.81	<0.5
1st	7.71	134	43.5	3.99	6.86	0.6
2.5th	8.26	143	49.6	4.58	6.93	1.0
5th	8.87	167	54.2	5.06	7.03	1.6
10th	9.79	212	60.6	5.79	7.13	2.6
16th	10.6	243	66.1	6.27	7.21	3.8
20th	11.1	261	68.9	6.50	7.24	4.7
25th	11.9	277	71.8	6.74	7.29	6.1
30th	13.3	293	74.2	6.97	7.33	7.2
40th	15.3	328	78.1	7.37	7.39	9.7
Median (50th)	**17.4**	**366**	**81.2**	**7.71**	**7.46**	**13.2**
60th	19.2	413	83.9	8.06	7.52	17.4
70th	21.3	463	86.5	8.50	7.59	22.0
75th	22.2	483	87.7	8.75	7.63	24.9
80th	23.0	506	89.1	9.00	7.68	28.3
84th	23.5	528	90.3	9.25	7.74	31.7
90th	24.2	575	93.0	9.68	7.84	39.4
95th	24.9	674	97.2	10.2	7.99	55.3
97.5th	25.6	777	101	10.6	8.13	97.3
99th	26.3	897	108	11.0	8.25	>200
99.5th	26.7	972	118	11.2	8.37	>200
99.9th	28.3	1060	133	11.7	8.52	>200
99.95th	28.6	1110	136	11.9	8.57	>200
99.99th	28.8	1170	139	12.2	8.63	>200

Figure A3-1.- Histograms for all water quality variables for period of record April 1, 2000 through February 15, 2007.

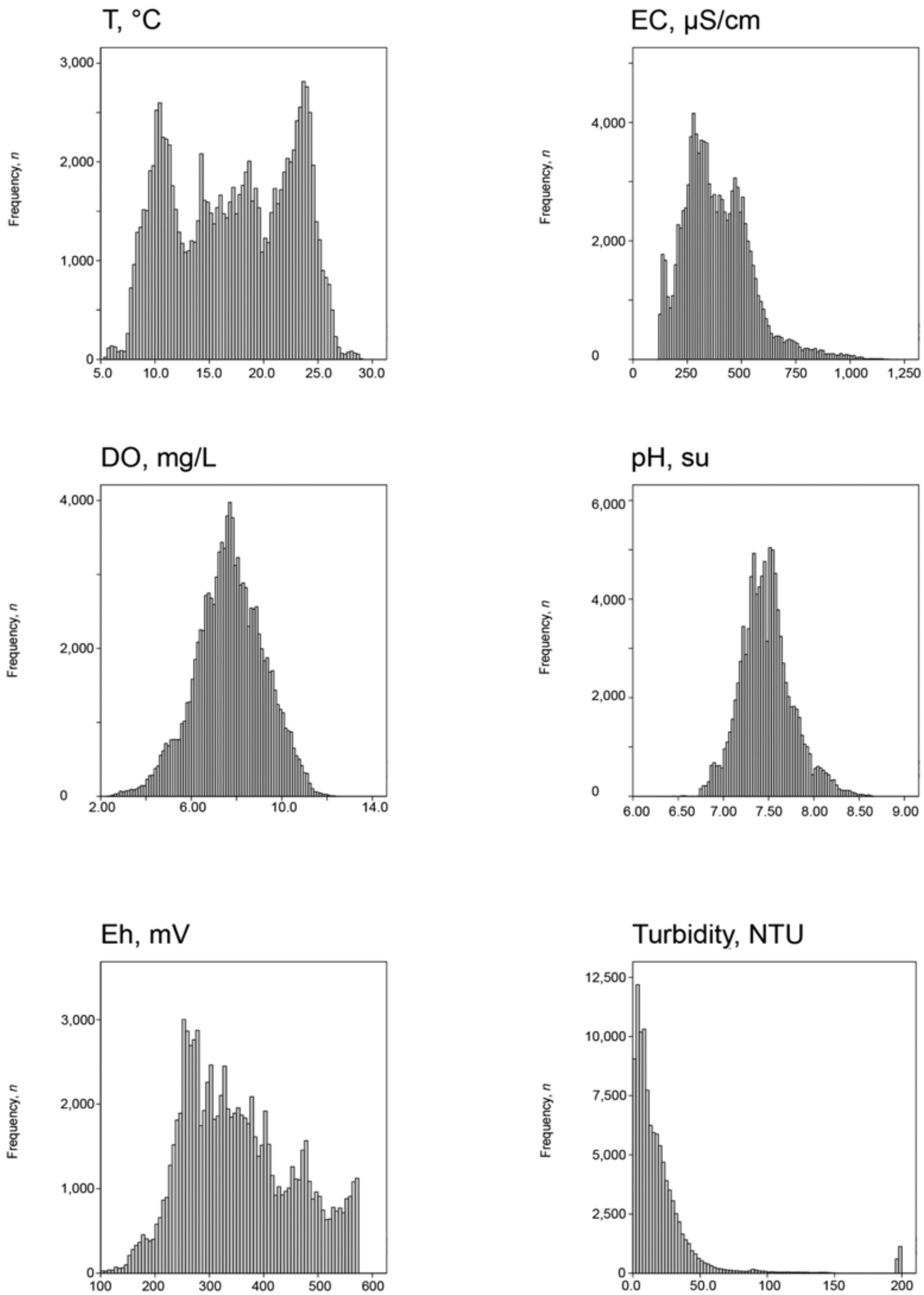

Figure A3-2.- Histograms for T in °C by month of year for period of record April 1, 2000 through February 15, 2007.

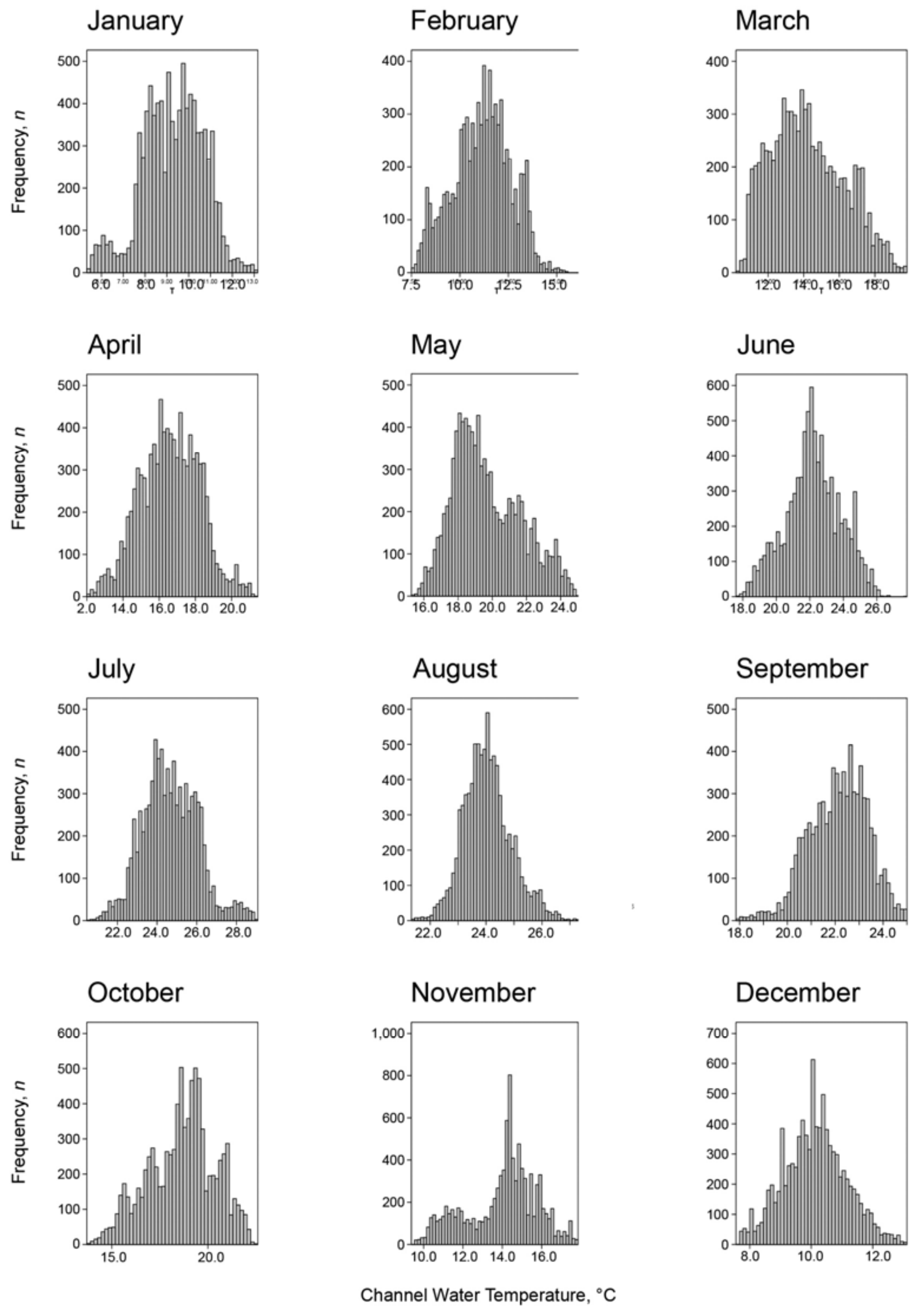

Figure A3-3.- Histograms for EC in µS/cm by month of year for period of record April 1, 2000 through February 15, 2007.

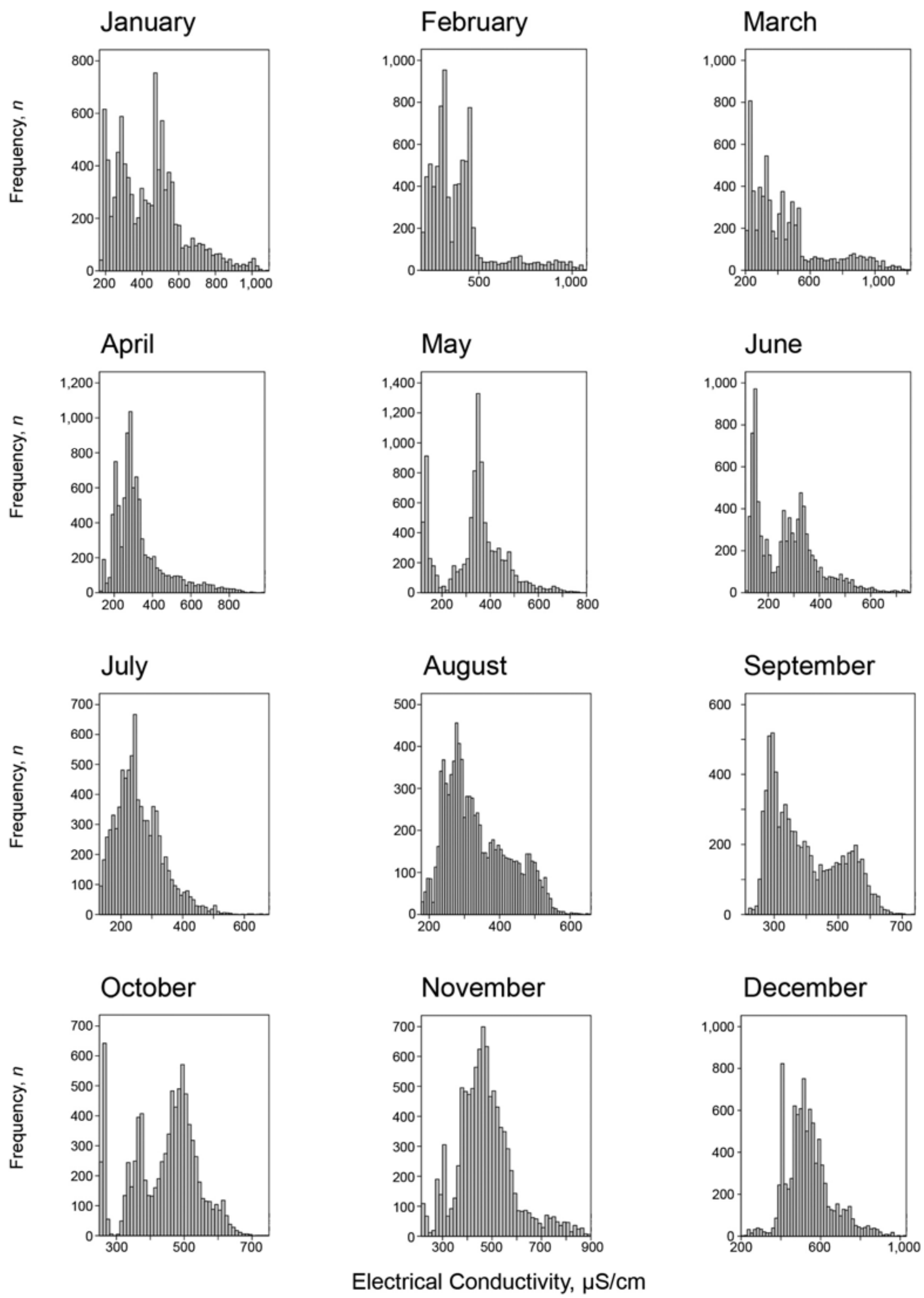

Figure A3-4.- Histograms for DO in mg/L by month of year for period of record April 1, 2000 through February 15, 2007.

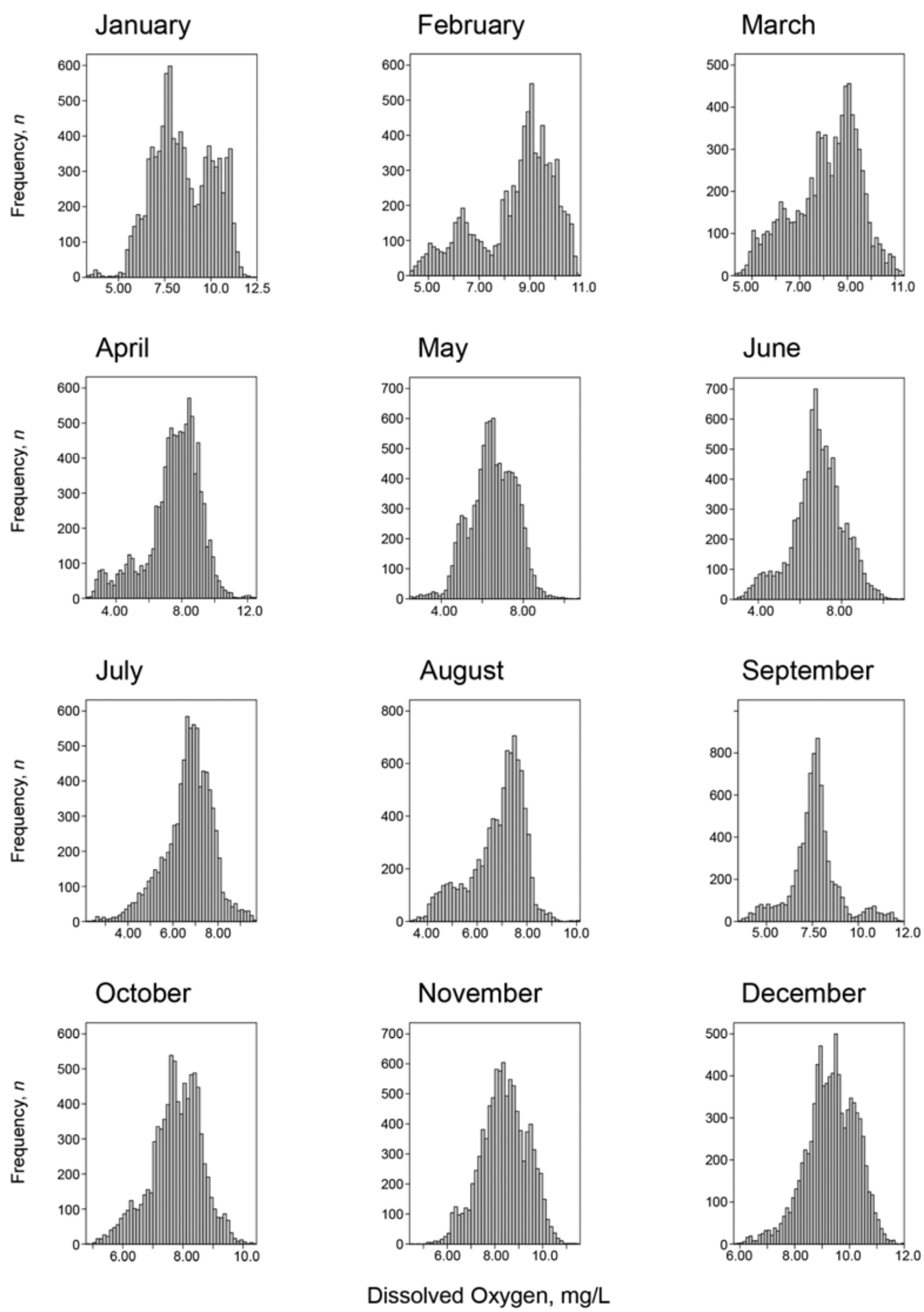

Figure A3-5.- Histograms for pH in su by month of year for period of record April 1, 2000 through February 15, 2007.

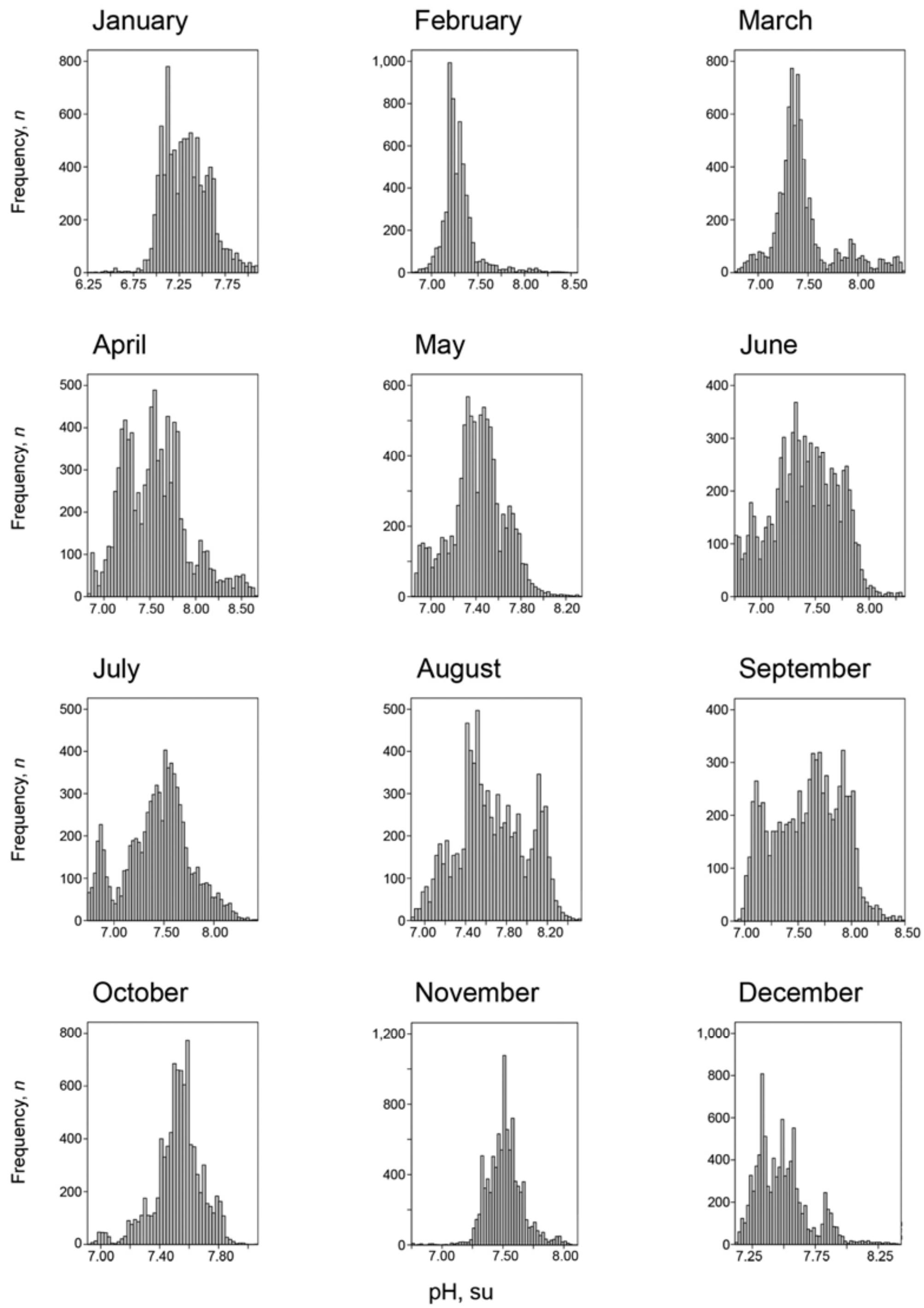

Figure A3-6.- Histograms for turbidity in NTU by month of year for period of record April 1, 2000 through February 15, 2007.

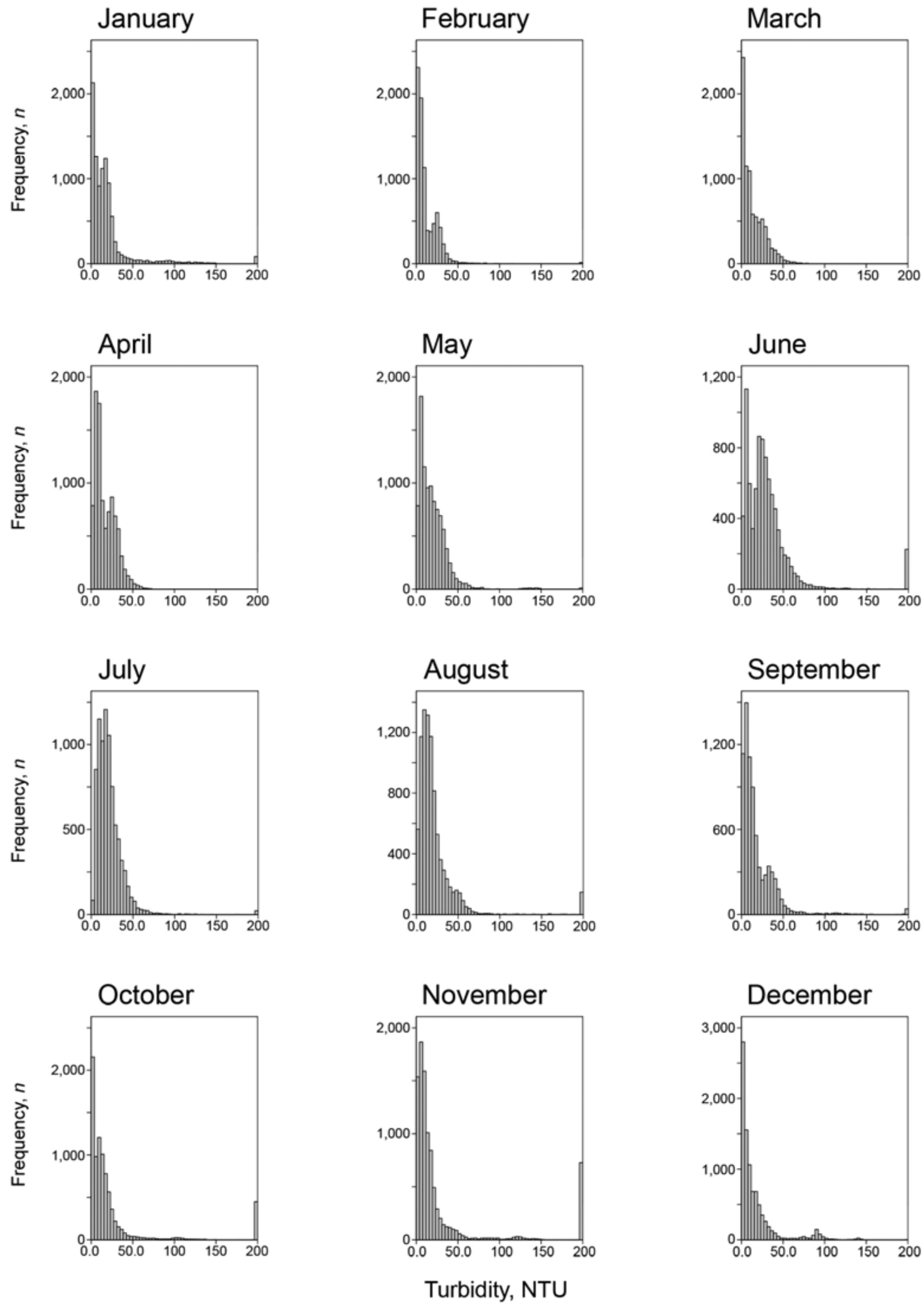

TABLE A4-1.— Summary statistics and percentiles for temperature (T), electrical conductivity (EC), percent dissolved oxygen (DO), ph, and turbidity by month of year.

January	T, °C	EC, µS/cm	Percent DO Saturation	DO, mg/L	pH, su	Turbidity, NTU
Statistics						
Valid n	9,278	9,605	9,168	9,592	9,296	9,529
Missing n	1,138	811	1,248	824	1,120	887
Mean	9.29	441	74.93	8.50	7.33	19.2
s	1.39E+00	1.82E+02	1.31E+01	1.59E+00	2.47E-01	2.71E+01
S.E. of Mean	1.44E-02	1.85E+00	1.36E-01	1.63E-02	2.56E-03	2.77E-01
Mode	9.10	464	85.3	7.70	7.13	0.9
Range	7.62	902	91.2	8.97	1.82	>200
Minimum	5.41	182	38.5	3.38	6.28	<0.5
Maximum	13.03	1080	130	12.4	8.10	>200
Skewness	-2.74E-01	7.66E-01	2.22E-01	-8.46E-05	3.17E-01	3.89E+00
S.E. of Skewness	2.54E-02	2.50E-02	2.56E-02	2.50E-02	2.54E-02	2.51E-02
Kurtosis	-1.03E-01	3.63E-01	3.60E-01	-7.47E-01	2.59E-01	1.85E+01
S.E. of Kurtosis	5.08E-02	5.00E-02	5.12E-02	5.00E-02	5.08E-02	5.02E-02
Percentiles						
0.01th	5.41	182	38.5	3.38	6.28	<0.5
0.1th	5.49	183	39.5	3.50	6.44	0.9
0.5th	5.65	186	44.2	4.04	6.65	0.9
2.5th	6.07	191	50.6	5.72	6.96	1.0
16th	7.97	257	61.4	6.87	7.08	3.1
25th	8.31	286	65.6	7.33	7.13	4.2
Median (50th)	9.37	437	74.3	8.30	7.32	13.1
75th	10.3	539	85.4	9.91	7.49	21.1
84th	10.7	596	88.2	10.4	7.58	25.5
97.5th	11.7	874	94.8	11.2	7.87	104.0
99.5th	12.6	1010	119	11.5	8.04	>200
99.9th	13.0	1030	125	11.8	8.09	>200
99.99th	13.0	1080	130	12.4	8.10	>200

TABLE A4-1.—Summary statistics and percentiles for temperature (T), electrical conductivity (EC), percent dissolved oxygen (DO), ph, and turbidity by month of year. Note that study year 7 included data only up to February 15, 2007 (continued).

February	T, °C	EC, µS/cm	Percent DO Saturation	DO, mg/L	pH, su	Turbidity, NTU
Statistics						
Valid n	8,243	8,241	8,243	8,243	5,774	8,224
Missing n	565	567	565	565	3,034	584
Mean	11.14	395	76.6	8.45	7.30	12.4
s	1.50E+00	1.68E+02	1.28E+01	1.53E+00	1.91E-01	1.46E+01
S.E. of Mean	1.65E-02	1.85E+00	1.41E-01	1.68E-02	2.52E-03	1.61E-01
Mode	10.0	298	84.4	9.01	7.21	0.9
Range	8.69	868	61.0	6.54	1.75	>200
Minimum	7.50	198	39.6	4.37	6.79	0.6
Maximum	16.2	1070	101	10.9	8.54	>200
Skewness	-1.15E-01	1.81E+00	-9.63E-01	-7.79E-01	2.23E+00	5.02E+00
S.E. of Skewness	2.70E-02	2.70E-02	2.70E-02	2.70E-02	3.22E-02	2.70E-02
Kurtosis	-4.88E-01	3.31E+00	-1.93E-01	-3.16E-01	7.97E+00	4.97E+01
S.E. of Kurtosis	5.39E-02	5.39E-02	5.39E-02	5.39E-02	6.44E-02	5.40E-02
Percentiles						
0.01th	7.50	198	39.6	4.37	6.79	0.6
0.1th	7.60	199	40.3	4.40	6.85	0.6
0.5th	7.82	204	42.2	4.57	6.91	0.7
2.5th	8.24	212	47.2	5.01	7.02	0.8
16th	9.53	263	59.9	6.48	7.17	2.3
25th	10.1	289	69.1	7.60	7.20	3.5
Median (50th)	11.2	348	81.5	8.86	7.25	7.4
75th	12.2	445	86.0	9.56	7.34	19.3
84th	12.7	463	87.9	9.89	7.40	24.8
97.5th	13.7	922	91.5	10.6	7.87	39.0
99.5th	14.7	1020	94.0	10.8	8.20	81.0
99.9th	15.2	1050	96.2	10.9	8.40	>200
99.99th	16.2	1070	101	10.9	8.54	>200

TABLE A4-1.—Summary statistics and percentiles for temperature (T), electrical conductivity (EC), percent dissolved oxygen (DO), ph, and turbidity by month of year. Note that these data are missing study year 7 values (continued).

March	*T, °C*	*EC, µS/cm*	*Percent DO Saturation*	*DO, mg/L*	*pH, su*	*Turbidity, NTU*
Statistics						
Valid n	8,211	6,901	8,195	8,195	8,118	8,205
Missing n	717	2,027	733	733	810	723
Mean	14.2	453	79.0	8.12	7.45	14.0
s	2.03E+00	2.26E+02	1.31E+01	1.39E+00	3.05E-01	1.35E+01
S.E. of Mean	2.24E-02	2.72E+00	1.45E-01	1.54E-02	3.39E-03	1.49E-01
Mode	13.4	420	83.3	8.91	7.35	<0.5
Range	9.37	1020	74.6	6.98	1.68	>200
Minimum	10.4	202	44.3	4.36	6.79	<0.5
Maximum	19.8	1220	119	11.3	8.47	>200
Skewness	3.32E-01	1.23E+00	-3.40E-01	-4.71E-01	1.26E+00	1.82E+00
S.E. of Skewness	2.70E-02	2.95E-02	2.71E-02	2.71E-02	2.72E-02	2.70E-02
Kurtosis	-7.06E-01	6.83E-01	-2.01E-01	-4.45E-01	1.74E+00	9.66E+00
S.E. of Kurtosis	5.40E-02	5.90E-02	5.41E-02	5.41E-02	5.44E-02	5.41E-02
Percentiles						
0.01th	10.4	202	44.3	4.36	6.79	<0.5
0.1th	10.4	204	46.1	4.50	6.80	<0.5
0.5th	10.8	208	47.9	4.82	6.86	<0.5
2.5th	11.0	219	50.9	5.13	6.95	<0.5
16th	12.1	248	63.8	6.47	7.23	2.0
25th	12.7	292	71.1	7.23	7.29	2.7
Median (50th)	14.0	390	81.1	8.36	7.39	9.2
75th	15.7	524	87.3	9.15	7.50	21.9
84th	16.6	692	90.1	9.43	7.71	27.7
97.5th	18.4	1020	102	10.4	8.32	46.8
99.5th	19.1	1140	109	11.0	8.42	62.5
99.9th	19.6	1170	117	11.2	8.44	76.8
99.99th	19.8	1220	119	11.3	8.47	>200

TABLE A4-1.—Summary statistics and percentiles for temperature (T), electrical conductivity (EC), percent dissolved oxygen (DO), ph, and turbidity by month of year (continued).

April	T, °C	EC, µS/cm	Percent DO Saturation	DO, mg/L	pH, su	Turbidity, NTU
Statistics						
Valid n	9,518	9,450	9,296	9,296	8,794	9,521
Missing n	562	630	784	784	1,286	559
Mean	16.6	331	77.3	7.52	7.56	17.2
s	1.65E+00	1.36E+02	1.73E+01	1.64E+00	3.52E-01	1.25E+01
S.E. of Mean	1.69E-02	1.40E+00	1.80E-01	1.70E-02	3.75E-03	1.28E-01
Mode	15.9	276	88.0	8.37	7.22	7.6
Range	9.27	832	116	10.22	1.80	194.9
Minimum	12.0	138	22.6	2.29	6.85	1.7
Maximum	21.3	970	139	12.5	8.65	>200
Skewness	7.18E-03	1.62E+00	-7.27E-01	-8.54E-01	5.96E-01	1.40E+00
S.E. of Skewness	2.51E-02	2.52E-02	2.54E-02	2.54E-02	2.61E-02	2.51E-02
Kurtosis	-2.59E-01	2.66E+00	7.67E-01	7.03E-01	2.25E-01	6.18E+00
S.E. of Kurtosis	5.02E-02	5.04E-02	5.08E-02	5.08E-02	5.22E-02	5.02E-02
Percentiles						
0.01th	12.0	138	22.6	2.29	6.85	1.7
0.1th	12.3	138	25.9	2.58	6.86	1.8
0.5th	12.7	142	28.0	2.81	6.87	1.9
2.5th	13.3	163	32.6	3.25	6.97	2.8
16th	14.9	215	63.3	6.11	7.21	5.9
25th	15.5	248	69.5	6.80	7.27	7.3
Median (50th)	16.6	291	79.5	7.79	7.54	12.5
75th	17.8	368	88.5	8.61	7.76	25.7
84th	18.3	442	92.2	8.99	7.85	30.1
97.5th	20.0	721	104	10.0	8.44	46.0
99.5th	20.9	839	115	10.9	8.58	58.5
99.9th	21.1	906	133	12.1	8.63	76.8
99.99th	21.3	970	139	12.5	8.65	>200

TABLE A4-1.—Summary statistics and percentiles for temperature (T), electrical conductivity (EC), percent dissolved oxygen (DO), ph, and turbidity by month of year (continued).

May	*T, °C*	*EC, µS/cm*	*Percent DO Saturation*	*DO, mg/L*	*pH, su*	*Turbidity, NTU*
Statistics						
Valid n	9,741	9,741	9,521	9,521	9,203	9,740
Missing n	675	675	895	895	1,213	676
Mean	19.7	336	71.1	6.51	7.41	19.5
s	1.99E+00	1.25E+02	1.20E+01	1.10E+00	2.39E-01	1.75E+01
S.E. of Mean	2.02E-02	1.27E+00	1.23E-01	1.12E-02	2.49E-03	1.78E-01
Mode	21.50	344	68.7	6.22	7.32	3.7
Range	9.98	674	89.8	8.24	1.48	>200
Minimum	15.3	119	28.5	2.47	6.84	2.1
Maximum	25.3	793	118	10.7	8.32	>200
Skewness	4.91E-01	7.27E-02	-9.93E-02	-2.29E-01	-4.48E-02	3.69E+00
S.E. of Skewness	2.48E-02	2.48E-02	2.51E-02	2.51E-02	2.55E-02	2.48E-02
Kurtosis	-5.12E-01	1.25E-01	1.18E-01	7.44E-02	6.33E-02	2.55E+01
S.E. of Kurtosis	4.96E-02	4.96E-02	5.02E-02	5.02E-02	5.11E-02	4.96E-02
Percentiles						
0.01th	15.3	119	28.5	2.47	6.84	2.1
0.1th	15.6	121	30.7	2.68	6.87	2.8
0.5th	16.0	123	37.1	3.28	6.88	2.9
2.5th	16.5	125	49.1	4.45	6.92	3.2
16th	17.8	152	58.7	5.37	7.19	5.5
25th	18.2	274	63.6	5.83	7.28	7.3
Median (50th)	19.3	348	71.2	6.52	7.42	16.0
75th	21.1	400	79.5	7.33	7.56	27.2
84th	21.9	445	83.0	7.66	7.65	32.3
97.5th	23.9	604	93.5	8.44	7.85	55.6
99.5th	24.5	692	104	9.13	8.05	136.0
99.9th	24.8	750	109	9.87	8.25	>200
99.99th	25.3	793	118	10.7	8.32	>200

TABLE A4-1.—Summary statistics and percentiles for temperature (T), electrical conductivity (EC), percent dissolved oxygen (DO), ph, and turbidity by month of year (continued).

June	T, °C	EC, µS/cm	Percent DO Saturation	DO, mg/L	pH, su	Turbidity, NTU
Statistics						
Valid n	8,810	8,805	8,790	8,790	8,311	8,800
Missing n	1,270	1,275	1,290	1,290	1,769	1,280
Mean	22.2	273	78.9	6.86	7.40	31.2
s	1.65E+00	1.20E+02	1.37E+01	1.22E+00	3.05E-01	3.26E+01
S.E. of Mean	1.76E-02	1.27E+00	1.46E-01	1.30E-02	3.35E-03	3.47E-01
Mode	22.2	145	79.5	6.70	7.33	>200
Range	10.1	627	88.4	7.97	1.57	>200
Minimum	17.7	119	34.6	2.95	6.75	<0.5
Maximum	27.8	746	123	10.9	8.32	>200
Skewness	-8.58E-02	8.60E-01	-5.46E-01	-3.30E-01	-1.03E-01	3.47E+00
S.E. of Skewness	2.61E-02	2.61E-02	2.61E-02	2.61E-02	2.69E-02	2.61E-02
Kurtosis	-3.35E-01	6.13E-01	5.69E-01	3.49E-01	-6.14E-01	1.47E+01
S.E. of Kurtosis	5.22E-02	5.22E-02	5.22E-02	5.22E-02	5.37E-02	5.22E-02
Percentiles						
0.01th	17.7	119	34.6	2.95	6.75	<0.5
0.1th	18.0	122	36.7	3.17	6.75	<0.5
0.5th	18.3	125	39.7	3.50	6.76	2.5
2.5th	18.9	131	45.5	4.04	6.80	3.2
16th	20.6	146	67.2	5.80	7.07	7.3
25th	21.2	158	72.2	6.23	7.19	12.1
Median (50th)	22.2	268	80.2	6.88	7.40	25.3
75th	23.3	340	87.5	7.62	7.63	38.0
84th	24.0	377	91.7	8.05	7.73	45.3
97.5th	25.3	555	103	9.12	7.91	>200
99.5th	25.9	690	111	9.80	8.10	>200
99.9th	26.2	736	117	10.3	8.29	>200
99.99th	27.8	746	123	10.9	8.32	>200

TABLE A4-1.—Summary statistics and percentiles for temperature (T), electrical conductivity (EC), percent dissolved oxygen (DO), ph, and turbidity by month of year (continued).

July	***T, °C***	***EC, µS/cm***	***Percent DO Saturation***	***DO, mg/L***	***pH, su***	***Turbidity, NTU***
Statistics						
Valid n	8,332	8,339	8,334	8,334	7,998	8,212
Missing n	2,084	2,077	2,082	2,082	2,418	2,204
Mean	24.7	260	80.2	6.68	7.44	21.5
s	1.40E+00	7.60E+01	1.22E+01	1.09E+00	3.26E-01	1.61E+01
S.E. of Mean	1.53E-02	8.33E-01	1.34E-01	1.19E-02	3.65E-03	1.78E-01
Mode	24.1	174	82.2	6.68	7.51	15.3
Range	8.38	540	87.3	7.40	1.69	>200
Minimum	20.6	130	27.6	2.28	6.75	<0.5
Maximum	29.0	671	115	9.68	8.44	>200
Skewness	2.67E-01	9.09E-01	-7.45E-01	-5.93E-01	-1.10E-01	4.52E+00
S.E. of Skewness	2.68E-02	2.68E-02	2.68E-02	2.68E-02	2.74E-02	2.70E-02
Kurtosis	1.04E-01	1.12E+00	1.05E+00	8.17E-01	-2.90E-01	4.04E+01
S.E. of Kurtosis	5.37E-02	5.36E-02	5.36E-02	5.36E-02	5.48E-02	5.40E-02
Percentiles						
0.01th	20.6	130	27.6	2.28	6.75	<0.5
0.1th	21.0	132	31.9	2.62	6.75	0.5
0.5th	21.3	137	38.4	3.09	6.76	3.4
2.5th	22.1	146	51.7	4.16	6.81	4.8
16th	23.3	186	68.3	5.61	7.10	8.9
25th	23.7	205	74.2	6.12	7.23	11.4
Median (50th)	24.6	246	81.8	6.80	7.47	18.6
75th	25.6	305	88.3	7.41	7.63	27.3
84th	26.1	330	91.1	7.66	7.72	32.8
97.5th	27.9	440	100	8.68	8.07	53.1
99.5th	28.6	509	108	9.35	8.22	93.0
99.9th	28.8	611	112	9.51	8.35	>200
99.99th	29.0	671	115	9.68	8.44	>200

TABLE A4-1.—Summary statistics and percentiles for temperature (T), electrical conductivity (EC), percent dissolved oxygen (DO), ph, and turbidity by month of year (continued).

August	***T, °C***	***EC, µS/cm***	***Percent DO Saturation***	***DO, mg/L***	***pH, su***	***Turbidity, NTU***
Statistics						
Valid n	8,951	8,952	8,953	8,953	8,519	8,862
Missing n	1,465	1,464	1,463	1,463	1,897	1,554
Mean	24.1	338	81.1	6.82	7.66	22.1
s	8.56E-01	9.08E+01	1.28E+01	1.09E+00	3.37E-01	2.76E+01
S.E. of Mean	9.05E-03	9.59E-01	1.35E-01	1.15E-02	3.65E-03	2.93E-01
Mode	23.6	277	87.8	7.15	7.50	>200
Range	5.95	479	80.3	6.79	1.66	>200
Minimum	21.4	179	40.2	3.29	6.87	<0.5
Maximum	27.4	658	121	10.1	8.53	>200
Skewness	3.81E-01	6.19E-01	-8.29E-01	-8.00E-01	6.01E-02	4.67E+00
S.E. of Skewness	2.59E-02	2.59E-02	2.59E-02	2.59E-02	2.65E-02	2.60E-02
Kurtosis	4.16E-01	-5.59E-01	7.30E-02	7.49E-02	-8.10E-01	2.59E+01
S.E. of Kurtosis	5.18E-02	5.18E-02	5.18E-02	5.18E-02	5.31E-02	5.20E-02
Percentiles						
0.01th	21.4	179	40.2	3.29	6.87	<0.5
0.1th	21.5	182	42.9	3.52	6.90	0.4
0.5th	21.9	187	47.1	3.89	6.95	1.7
2.5th	22.5	204	51.5	4.29	7.04	2.6
16th	23.2	248	66.9	5.64	7.32	6.5
25th	23.5	268	74.4	6.24	7.43	9.2
Median (50th)	24.0	315	84.5	7.11	7.62	15.5
75th	24.5	403	90.2	7.60	7.92	24.7
84th	24.9	447	92.3	7.79	8.08	33.0
97.5th	26.0	527	98.5	8.33	8.24	69.6
99.5th	26.6	560	105	8.96	8.35	>200
99.9th	27.1	619	116	9.75	8.44	>200
99.99th	27.4	658	121	10.1	8.53	>200

TABLE A4-1.—Summary statistics and percentiles for temperature (T), electrical conductivity (EC), percent dissolved oxygen (DO), ph, and turbidity by month of year (continued).

September	T, °C	EC, µS/cm	Percent DO Saturation	DO, mg/L	pH, su	Turbidity, NTU
Statistics						
Valid n	7,577	7,586	7,586	7,586	7,590	7,578
Missing n	2,503	2,494	2,494	2,494	2,490	2,502
Mean	22.1	397	87.4	7.63	7.59	18.7
s	1.21E+00	1.07E+02	1.54E+01	1.36E+00	3.15E-01	2.24E+01
S.E. of Mean	1.39E-02	1.23E+00	1.76E-01	1.56E-02	3.62E-03	2.57E-01
Mode	22.6	295	86.5	7.72	7.92	2.6
Range	7.05	512	101	8.76	1.55	>200
Minimum	18.0	219	42.2	3.61	6.93	<0.5
Maximum	25.0	731	143	12.4	8.48	>200
Skewness	-3.22E-01	5.36E-01	2.94E-01	3.45E-01	-6.96E-02	4.16E+00
S.E. of Skewness	2.81E-02	2.81E-02	2.81E-02	2.81E-02	2.81E-02	2.81E-02
Kurtosis	-7.16E-02	-9.59E-01	1.66E+00	1.71E+00	-9.16E-01	2.58E+01
S.E. of Kurtosis	5.63E-02	5.62E-02	5.62E-02	5.62E-02	5.62E-02	5.63E-02
Percentiles						
0.01th	18.0	219	42.2	3.61	6.93	<0.5
0.1th	18.1	222	43.5	3.73	6.97	<0.5
0.5th	18.5	241	46.5	4.05	7.00	<0.5
2.5th	19.6	261	53.4	4.63	7.06	1.8
16th	20.8	288	74.9	6.65	7.19	4.0
25th	21.3	301	80.6	7.04	7.33	5.9
Median (50th)	22.2	367	88.0	7.63	7.63	11.7
75th	23.0	490	93.5	8.11	7.85	25.2
84th	23.3	534	97.4	8.54	7.93	34.3
97.5th	24.3	607	126	11.1	8.12	65.6
99.5th	24.8	643	136	11.9	8.31	>200
99.9th	24.9	684	140	12.1	8.44	>200
99.99th	25.0	731	143	12.4	8.48	>200

TABLE A4-1.—Summary statistics and percentiles for temperature (T), electrical conductivity (EC), percent dissolved oxygen (DO), ph, and turbidity by month of year (continued).

October	T, °C	EC, µS/cm	Percent DO Saturation	DO, mg/L	pH, su	Turbidity, NTU
Statistics						
Valid n	8,760	8,763	8,483	8,547	8,763	8,555
Missing n	1,656	1,653	1,933	1,869	1,653	1,861
Mean	18.6	442	83.4	7.77	7.53	25.1
s	1.73E+00	9.60E+01	8.88E+00	8.50E-01	1.61E-01	4.52E+01
S.E. of Mean	1.84E-02	1.03E+00	9.64E-02	9.19E-03	1.72E-03	4.89E-01
Mode	19.3	495	85.5	7.66	7.53	>200
Range	8.78	490	60.5	5.47	1.13	>200
Minimum	13.8	251	49.8	4.87	6.93	<0.5
Maximum	22.6	741	110	10.3	8.06	>200
Skewness	-2.77E-01	-2.75E-01	-2.95E-01	-4.08E-01	-6.49E-01	3.15E+00
S.E. of Skewness	2.62E-02	2.62E-02	2.66E-02	2.65E-02	2.62E-02	2.65E-02
Kurtosis	-4.72E-01	-5.34E-01	5.47E-01	1.97E-01	1.18E+00	9.04E+00
S.E. of Kurtosis	5.23E-02	5.23E-02	5.32E-02	5.30E-02	5.23E-02	5.30E-02
Percentiles						
0.01th	13.8	251	49.8	4.87	6.93	<0.5
0.1th	14.0	254	56.7	5.14	6.96	<0.5
0.5th	14.4	255	58.5	5.37	6.99	<0.5
2.5th	15.2	259	63.0	5.86	7.15	0.7
16th	16.8	341	75.3	7.00	7.40	2.4
25th	17.4	370	78.7	7.28	7.45	3.8
Median (50th)	18.8	462	84.0	7.81	7.54	11.3
75th	19.8	507	88.5	8.37	7.62	20.9
84th	20.5	529	90.9	8.55	7.67	29.0
97.5th	21.7	615	101	9.36	7.82	>200
99.5th	22.1	651	107	9.71	7.87	>200
99.9th	22.2	687	109	10.1	7.95	>200
99.99th	22.6	741	110	10.3	8.06	>200

TABLE A4-1.—Summary statistics and percentiles for temperature (T), electrical conductivity (EC), percent dissolved oxygen (DO), ph, and turbidity by month of year (continued).

November	T, °C	EC, µS/cm	Percent DO Saturation	DO, mg/L	pH, su	Turbidity, NTU
Statistics						
Valid n	9,588	9,586	8,149	9,550	9,491	9,580
Missing n	492	494	1,931	530	589	500
Mean	14.0	473	80.7	8.39	7.51	30.3
s	1.77E+00	1.16E+02	8.65E+00	9.76E-01	1.49E-01	5.28E+01
S.E. of Mean	1.81E-02	1.18E+00	9.58E-02	9.99E-03	1.53E-03	5.39E-01
Mode	15.4	460	82.2	8.31	7.51	>200
Range	8.30	678	68.6	6.94	1.35	>200
Minimum	9.50	216	44.5	4.50	6.75	<0.5
Maximum	17.8	893	113	11.4	8.10	>200
Skewness	-4.55E-01	7.45E-01	-6.43E-01	-2.09E-01	1.86E-01	2.60E+00
S.E. of Skewness	2.50E-02	2.50E-02	2.71E-02	2.51E-02	2.51E-02	2.50E-02
Kurtosis	-4.31E-01	1.26E+00	7.67E-01	-1.76E-01	2.12E+00	5.37E+00
S.E. of Kurtosis	5.00E-02	5.00E-02	5.43E-02	5.01E-02	5.03E-02	5.00E-02
Percentiles						
0.01th	9.50	216	44.5	4.50	6.75	<0.5
0.1th	9.60	217	52.1	5.32	6.78	<0.5
0.5th	9.88	224	56.0	5.83	7.07	<0.5
2.5th	10.4	274	58.7	6.32	7.27	0.6
16th	11.8	376	72.9	7.43	7.37	3.8
25th	12.9	401	76.1	7.77	7.42	5.9
Median (50th)	14.3	463	81.9	8.38	7.51	10.9
75th	15.1	528	86.4	9.07	7.59	21.6
84th	15.7	564	88.6	9.44	7.64	36.5
97.5th	17.2	775	95.5	10.1	7.86	>200
99.5th	17.6	852	102	10.6	7.98	>200
99.9th	17.7	878	106	10.9	8.04	>200
99.99th	17.8	893	113	11.4	8.10	>200

TABLE A4-1.—Summary statistics and percentiles for temperature (T), electrical conductivity (EC), percent dissolved oxygen (DO), ph, and turbidity by month of year (continued).

December	T, °C	EC, µS/cm	Percent DO Saturation	DO, mg/L	pH, su	Turbidity, NTU
Statistics						
Valid n	9,276	9,271	7,098	8,612	9,195	9,039
Missing n	1,140	1,145	3,318	1,804	1,221	1,377
Mean	10.1	537	81.9	9.33	7.49	16.5
s	1.02E+00	1.16E+02	7.69E+00	9.15E-01	2.10E-01	2.34E+01
S.E. of Mean	1.05E-02	1.20E+00	9.13E-02	9.86E-03	2.19E-03	2.46E-01
Mode	10.4	537	78.6	9.54	7.35	1.0
Range	5.45	813	51.9	6.04	1.30	196.5
Minimum	7.66	207	52.3	5.86	7.12	<0.5
Maximum	13.1	1020	104	11.9	8.42	>200
Skewness	9.55E-02	7.57E-01	-4.35E-01	-4.31E-01	1.02E+00	2.77E+00
S.E. of Skewness	2.54E-02	2.54E-02	2.91E-02	2.64E-02	2.55E-02	2.58E-02
Kurtosis	-1.95E-01	1.13E+00	2.45E-01	2.89E-01	1.16E+00	8.45E+00
S.E. of Kurtosis	5.09E-02	5.09E-02	5.81E-02	5.28E-02	5.11E-02	5.15E-02
Percentiles						
0.01th	7.66	207	52.3	5.86	7.12	<0.5
0.1th	7.69	236	55.0	6.21	7.13	<0.5
0.5th	7.78	249	57.6	6.42	7.15	<0.5
2.5th	8.10	361	64.1	7.29	7.19	0.6
16th	9.07	422	74.9	8.46	7.30	1.7
25th	9.43	467	77.0	8.78	7.33	2.8
Median (50th)	10.1	522	81.7	9.37	7.46	8.1
75th	10.8	591	87.8	10.0	7.59	19.2
84th	11.2	633	90.1	10.3	7.67	26.4
97.5th	12.2	828	94.5	10.9	7.96	92.5
99.5th	12.8	912	97.9	11.3	8.26	134.3
99.9th	13.0	969	101	11.6	8.37	143.3
99.99th	13.1	1020	104	11.9	8.42	>200

GUIDE TO FILES

The enclosed CD-R disk contains the sonde water quality database and other supplemental data used in this report. Data tables from this database file may also be viewed or downloaded from the Tracy Research website:
http://www.usbr.gov/pmts/tech_services/tracy_research/data/WaterQualityData.html

Access 2002 Files (*.mdb)

Multiprobe.mdb

This is the master database file that contains all available sonde water quality data from the intake channel at the TFCF along with supplemental data such as tides, streamflow, weather, and temporary barrier schedules. A full description of the tables, their field names and properties are summarized in Appendix 2.

ASCII Comma Delimited Files (csv – comma separated variables)

These files are comma separated ASCII text files that include channel sonde water quality data only. This is a neutral format that should allow export of the TFCF data to statistics programs such as SAS and SPSS, or other database programs such as SQL and Oracle. Note that even though these files will open in Excel, they contain many more rows of data than the 65,000 maximum for Excel.

TracyMultiprobeWQData-ALLData30minApr2000-Feb2007.csv —
30-min interval data

TracyMultiprobeWQData-ALLDataHourlyApr2000-Feb2007.csv —
Hourly interval data

Excel 2002 Data File (*.xls)

The following files are in Excel 2002 workbook format containing spreadsheets that summarize the TFCF channel sonde water quality data and supplemental data.

TracyMultiprobeWQData-SummaryAllTables.xls — This file contains summaries of sonde water quality variables by day of year, week of year, month of year, and summary tables by study year, study month, study week, and study day.