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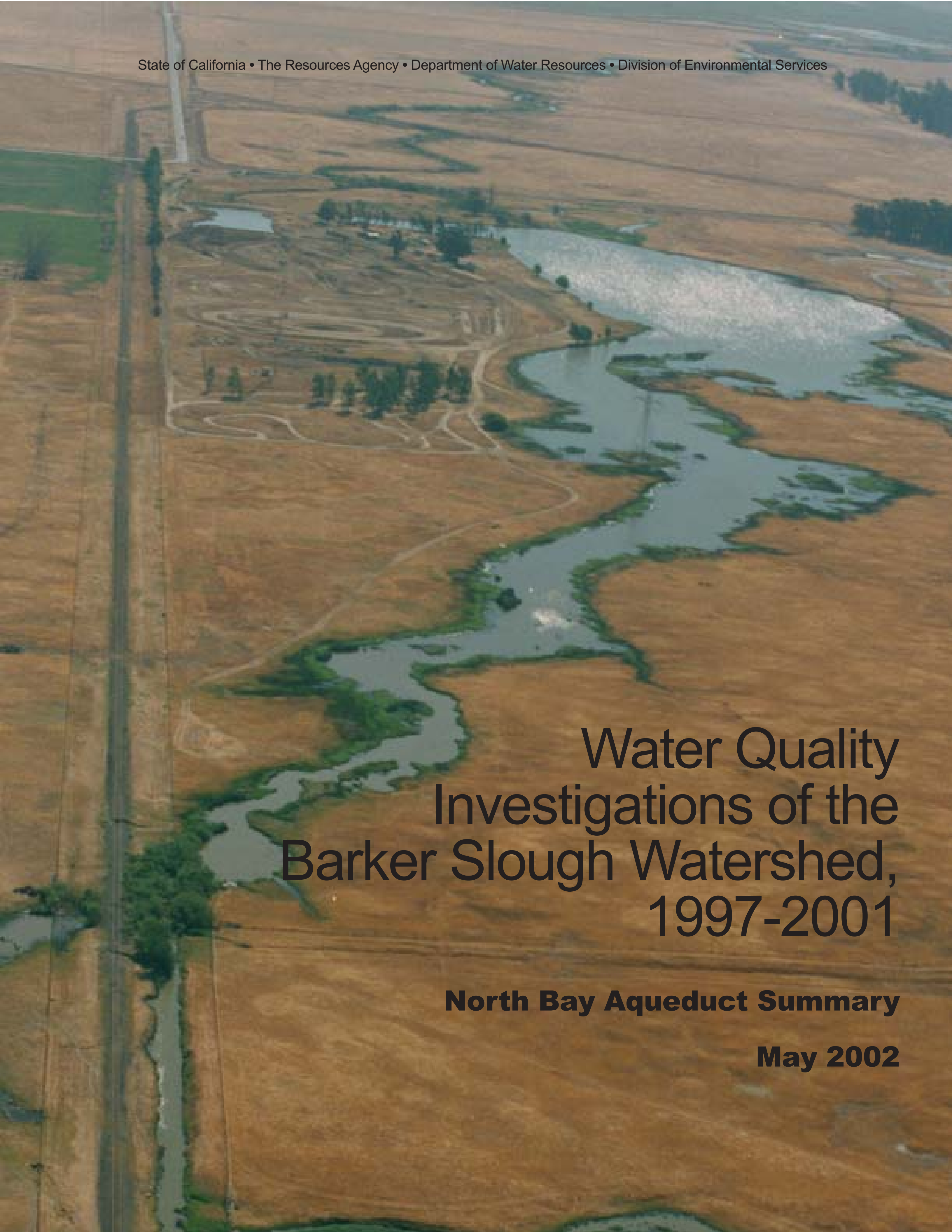

Water Quality Investigations of the Barker Slough Watershed, 1997-2001

North Bay Aqueduct Summary

May 2002

COVER PHOTO:
This aerial photo shows Barker Slough entering Campbell Lake (foreground) and leaving Campbell Lake towards the Barker Slough Pumping Plant (background). Photo courtesy of George Anderson of DWR's Delta Field Division.

State of California
The Resources Agency
Department of Water Resources
Municipal Water Quality Investigations Unit

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Foreword

The California State Water Project Sanitary Survey Update Report of 1996 was written to fulfill the California Department of Health Services' requirement of all large utilities to assess their source surface waters and appropriate watersheds. The State Water Project's sanitary survey was conducted by the Municipal Water Quality Investigations Program (MWQI) within the Division of Planning and Local Assistance of the California Department of Water Resources. (MWQI is now within the Division of Environmental Services.) The 1996 sanitary survey identified North Bay Aqueduct (NBA) drinking water quality as being perhaps the most vulnerable in the State Water Project.

The MWQI Committee (composed of the urban members of the State Water Contractors and staff from the US Environmental Protection Agency, California Department of Health Services, State Water Resources Control Board, and Department of Water Resources' Division of Planning and Local Assistance and Division of Operations and Maintenance) directed the MWQI Program to begin conducting follow-up activities in the NBA watershed to further assess the water quality and potential contaminant sources. Results of the first year of study (1996/97) were documented in a 1998 division report titled, *The North Bay Aqueduct Barker Slough Watershed Water Quality, Phase I Report*. This current report focuses on studies conducted by MWQI subsequent to the 1996/1997 study. The periods covered in this report are the winter sampling seasons of 1997/1998, 1998/1999, 1999/2000, and 2000/2001.

Both the Division of Operations and Maintenance and the NBA contractors provided monitoring assistance to collect data used in this report, including staff, equipment, and/or laboratory space. The NBA Technical Advisory committee, composed of DWR and NBA contractors, helped guide the development of these studies and the interpretation of the results.

Barbara McDonnell

Barbara McDonnell, Chief
Division of Environmental Services

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Technical Services Section
Dan Otis, Chief

PREPARED UNDER THE SUPERVISION OF

Richard S. Breuer, Chief
Municipal Water Quality Investigations Unit

PREPARED BY

Carol L. DiGiorgio, Staff Environmental Scientist, MWQI Unit

Jaclyn Pimental, Environmental Scientist, QA/QC Unit

EDITORIAL REVIEW, GRAPHICS, AND REPORT PRODUCTION

Brenda Main, Supervisor of Technical Publications

Marilee Talley, Research Writer

Nikki Blomquist, Research Writer

Alice Dyer, Research Writer

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These studies would have not been possible without their help.

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Executive Summary

The *Sanitary Survey Update Report 1996* concluded that the California Department of Water Resources North Bay Aqueduct (NBA) had more water quality problems than any other component of the State Water Project (DWR 1996). NBA contractors consistently list elevated levels or rapid changes in total organic carbon (TOC) and turbidity as their major challenges. In some cases, water treatment plants (WTPs) using only NBA water have been forced to shut down to avoid violating finished water turbidity and disinfection byproducts standards. Other NBA contractors blend or switch to an alternate water source to meet drinking water standards. Economically, the associated cost to treat NBA water during the winter can reach almost $200 per million gallons, approximately 2 to 4 times higher than waters with better water quality. To maintain water quality and meet evolving EPA drinking water standards, the NBA contractors would prefer to have NBA source water below 6 mg/L TOC and have average turbidity stabilized at 50 NTU with spikes not to exceed 200 NTU at the WTPs (Fleege pers comm 2000).

In response to *Sanitary Survey Update Report 1996*, the Municipal Water Quality Investigations Unit (MWQI) of the California Department of Water Resources (DWR) began studies in 1996 to understand the relative contributions of different surface waters on water quality at the NBA pumping plant. Results of this study indicated that temporally there were distinct seasonal differences in water quality, with the most severe problems occurring during the winter rainy season. Spatially, during the rainy months, the site farthest downstream from the pumping plant—Lindsey Slough—appeared to have little influence on water quality. Instead, results suggested that waters upstream of the pumping plant influenced the plant's water quality (DWR 1998b).

This report focuses on studies conducted by MWQI subsequent to the 1996/1997 study (DWR 1998b). The periods covered are the winter 1997/1998, 1998/1999, 1999/2000, and 2000/2001 sampling seasons. Throughout this period, the objectives have remained the same:

1. To understand the mechanics of the local watershed.
2. To determine where TOC and turbidity problems originate.
3. To determine whether TOC and turbidity sources and loads could be addressed through one or more Best Management Practices (BMPs).

Conclusions

Results from MWQI studies indicate that no single point source contributes to the Barker Slough watershed's high levels of organic carbon or turbidity; however, soil geochemistry may be an important component to the observed water quality. The soils in the watershed tend to be high in sodium and fall within the silt/clay size fraction (Singer and Eshel 2000). Consequently, soil particles are easily suspended, remaining in the water column for extended periods of time and creating a dispersive environment for organic carbon. With respect to autosampler results, limited sampling determined that TOC concentrations did not decrease in the upper reaches of the watershed. Stage weighted TOC averages at upstream sites were similar to stage weighted averages at downstream sites.

Mechanistically, 2 phenomena occur in the winter in the Barker Slough watershed. Both are related to rainfall: one directly, the other indirectly. With sufficient rainfall, a TOC and turbidity pulse travels down the watershed and creates a rapid increase in TOC and turbidity at the pumping plant. This results in the rapid increases in TOC and turbidity observed by many of the WTPs during storm events. Indirectly, after rainfall events, extended periods of discharge occur from Campbell Lake and, potentially, Calhoun Cut.

The result is the creation of a high carbon and turbidity reservoir at the forebay. Because of low pumping rates in the winter, this reservoir clears slowly, resulting in an extended period of high carbon and turbidity waters pumped into the NBA, even in the absence of rainfall. Loading calculations determined that, given the plant's pumping rate, carbon loads leaving the lake over a 4-week period in the 1999/2000 sampling season could have provided an amount equal to 90% and 400% of the carbon load pumped into the NBA.

Both autosampler and grab sample results emphasized the importance of relative flows in the watershed and the impact of Campbell Lake on the water quality observed at the pumping plant. Given sufficient rainfall and a saturated watershed, discharge from Campbell Lake occurs over a number of days or weeks, whereas upstream of the lake, discharge is measured in hours or at most a few days. Under low flows, Campbell Lake potentially serves as a shallow sink for the deposition of upstream loads of carbon and turbidity, but under high flows, unregulated flows from the lake result in extended periods of discharge. Grab sample and particle size analysis supports this hypothesis. Singer found that the particle size entering the lake was similar to the particle size exiting the lake (Singer and Eshel 2000). Studies conducted by MWQI found that TOC and turbidity concentrations entering the lake were significantly lower than concentrations exiting the lake, suggesting the input of resuspended bed load.

Statistical analysis of 1999/2000 grab samples determined that discharge dynamics from Campbell Lake were similar to those of the pumping plant but differed from sites upstream. Interaction analyses found that TOC and turbidity concentrations remained elevated at Campbell Lake and the pumping plant but returned to lower levels at sites upstream. The extended period of discharge from Campbell Lake compared to the relatively short period of discharge from sites upstream, explains why flow from Campbell Lake, and not sites upstream, affects water quality at the pumping plant for extended periods.

It has been hypothesized that one mechanism to account for the poor flushing at the pumping plant and the potential intermingling of Calhoun Cut water at the forebay is the formation of a hydrologic plug created by winter flooding of the Yolo Bypass. This hypothesis has not been investigated, but in the 2000/2001 sampling year, the Yolo Bypass did not flood, yet elevated levels of carbon and TOC were observed for many weeks at the pumping plant. It is possible that a hydrologic plug formed by the bypass may serve to exaggerate the observed phenomenon, but the plug is not necessary for the phenomenon to be created. Potentially, the higher winter levels of the Sacramento River may also serve as a hydrologic plug.

Hydro Science, a consulting firm retained by the Solano County Water Agency (SCWA), suggested a number of BMPs. The consulting firm and SCWA are studying the effectiveness of several selected BMPs. Hydro Science hypothesized that turbidity BMPs may be more effective than TOC BMPs but that for both analytes, reducing levels to those desired by the contractors may be difficult (Hydro Science 2001).

Recommendations

1. Regardless of watershed dynamics occurring upstream of Campbell Lake, management of Campbell Lake is a key issue. If carbon and/or turbidity can be reduced upstream, then Campbell Lake may require dredging to remove accumulated silt from previous year's runoff. If organic carbon and turbidity upstream of Campbell Lake cannot be reduced, then regulation of lake discharge or rerouting of discharge needs to be examined.

2. One aspect that has not been well studied is the potential for Calhoun Cut discharge to adversely affect water quality at the pumping plant. Circumstantial evidence suggests that this could occur. If true, water from Calhoun Cut may ultimately contribute to the pool of carbon created at the forebay. A more complete answer to this question could come from continuous flow studies.

3. If BMPs are unsuccessful in reducing variability or reducing TOC and turbidity levels to those more easily treatable by the WTPs, then locations for an alternate intake should be examined.

4. The difference in TOC results between the wet-oxidation and the combustion methods needs to be resolved. Results from the wet-oxidation method indicated that a decrease in turbidity might have little effect on TOC. This suggests that BMPs controlling turbidity would have little effect on TOC concentrations. In contrast, results from the combustion method indicate a higher fraction of the TOC is particulate in nature. If this is the case, then BMPs controlling turbidity might also reduce TOC levels. DWR's Quality Assurance/Quality Control (QA/QC) Unit has begun an investigation into the difference between the 2 methods.

5. Although the present impact of livestock on the watershed's TOC and turbidity is unknown, there is a health concern associated with livestock defecating in and around a drinking water supply. This is especially a concern for *Cryptosporidium,* which is more difficult to remove/inactivate than other pathogens. From a health perspective, livestock need to be fenced out of the slough and provided alternate drinking water sources.

Introduction

The *Sanitary Survey Update Report 1996* concluded that DWR's North Bay Aqueduct had more water quality problems than any other component of the State Water Project (DWR 1996). Treatment difficulties using NBA source water generally occur in the winter. Contractors consistently list elevated levels or rapid changes in total organic carbon (TOC) and turbidity as their major challenges. For example, in winter 1997, NBA source water rose from 60 NTU to 400 NTU in fewer than 8 hours (DWR 2001). Average winter TOC concentrations between 10 and 12 mg/L are not uncommon and concentrations as high as 38 mg/L have been recorded (DWR 2001). In contrast, monthly turbidity and weekly TOC measurements from the Sacramento River at Hood station between 1997 and 2001 have never exceeded 100 NTU or 4.5 mg/L, respectively (MWQI unpublished data). In some cases, WTPs using only NBA water have been forced to shut down or risk violating finished water turbidity and TOC standards. Other NBA contractors either blend or switch to an alternate water source to meet drinking water standards. Economically, the associated cost to treat NBA water during the winter can reach almost $200 per million gallons, approximately 2 to 4 times higher than waters with better water quality. To maintain water quality and meet evolving EPA drinking water standards, the NBA contractors would prefer to have NBA source water below 6 mg/L TOC and have average turbidity stabilized at 50 NTU with spikes not to exceed 200 NTU at the WTPs (Fleege pers. comm. 2000).

Watershed and Conveyance Description

The Barker Slough watershed drains an area of approximately 14.5 square miles in Solano County (Figure 1). The watershed has a Mediterranean climate, with the majority of annual rainfall occurring in the winter. Average annual precipitation is 16 inches (DWR 1998b). The lower part of the watershed is positioned within the northwest section of the Sacramento-San Joaquin Delta, but less than 10% of the watershed is within the boundaries of the legal Delta. The watershed is bounded by the City of Vacaville to the west and the Jepson Prairie, University of California Natural Reserve, to the southeast. Land use is primarily agriculture, divided between crop production and livestock grazing. The relatively poor soil conditions have restricted cultivated agriculture to the upper northwest corner of the watershed.

Although only a small part of the watershed is designated for urban development, there is considerable growth pressure on its western agricultural boundaries from the City of Vacaville. Storm drains from a Vacaville subdivision flow into an unnamed channel that probably is the old streambed of the slough. Storm drainage from the City of Vacaville and agricultural return water run through agricultural fields for approximately 2 miles before ending in the Noonan Main Drain.

In 1961, the Solano Irrigation District (SID) channelized part of the upper portion of Barker Slough to deliver Lake Berryessa irrigation water to local landowners. Known as the Noonan Main Drain, the combination of irrigation water and irrigation return water can result in the slough above the pumping plant flowing for most of the year. Flows normally drop dramatically in the fall following the end of water deliveries by SID and prior to the winter rainy season. As the drain continues down the watershed, it joins the D-1-C spill extension. Approximately half way down the watershed the Noonan Main Drain/ D-1-C spill extension ends and continues as an unmaintained drain. This drain gives way to the old slough bed and continues east to a 40-acre impoundment on the Argyll Park property known as Campbell Lake.

Tip in

Figure 1
Barker Slough Watershed and Land Use By Parcel

Fold per example in Printer's Guide
Full Color
11/17

Argyll Park is a 320-acre motocross racetrack operating in the watershed since 1972 (Geier and Geier 1994). Campbell Lake is approximately 1.5 miles upstream of the Barker Slough Pumping Plant. The dam forming Campbell Lake was constructed for agricultural purposes and engineered by the United States Department of Agriculture, Soil Conservation Service (Geier and Geier 1994). Water is released from the dam through the removal of stacked boards that form the dam barrier. Releases occur at the landowner's discretion. In the winter the boards are often removed to prevent the impounded slough from flooding the landowner's property. Although impounded behind a dam, the slough also flows out of the lake via a drain. From the drain at Campbell Lake, the slough continues downstream to the forebay of the pumping plant. Barker Slough and Calhoun Cut join approximately 1.5 miles downstream of the pumping plant to become Lindsey Slough, which is approximately 6 miles long. Approximately 1 mile upstream of the Sacramento Deep Water Ship Channel, Lindsey Slough and Cache Slough merge. Cache Slough continues for another 2 to 3 miles before joining the Sacramento River.

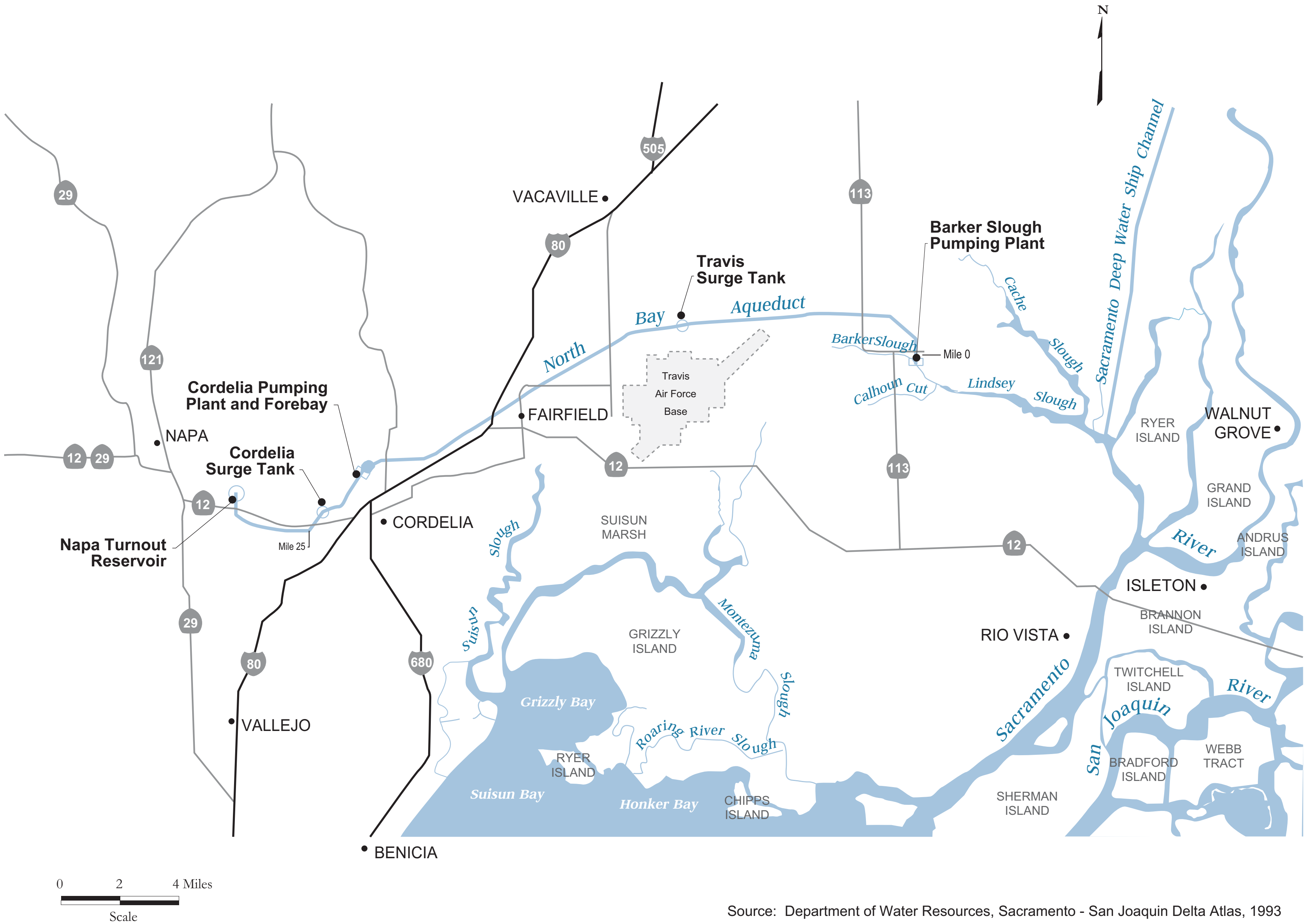
The Barker Slough Pumping Plant is near the downstream terminus of Barker Slough. The plant pumps water into the NBA, a 27-mile underground pipeline beginning at the pumping plant and ending at the Napa Turnout Reservoir (Figure 2). The NBA provides water for the cities of American Canyon, Benicia, Calistoga, Fairfield, Napa, Vacaville, Vallejo, and Yountville as well as Travis Air Force Base. These NBA contractors contract with either the SCWA or the Napa County Flood Control and Water Conservation District (NCFCWCD), which in turn contracts with DWR for NBA water.

In response to *Sanitary Survey Update Report 1996*, MWQI began studies to understand the relative contributions of different surface waters to the pumping plant's water quality. Samples were collected weekly for 1 year at sites upstream and downstream of the pumping plant to assess the temporal and spatial trends of key water quality parameters. Results of this study were published in 1998 and indicated that there were distinct seasonal differences in water quality, with the most severe problems occurring during the winter rainy season (DWR 1998b). Spatially, during the rainy months, the site farthest downstream from the pumping plant—Lindsey Slough—appeared to have little influence on water quality. Rather, the pumping plant's water quality appeared to be influenced by waters farther upstream.

This report focuses on studies conducted by MWQI subsequent to the 1996/1997 study (DWR 1998b). The periods covered are the winter 1997/1998, 1998/1999, 1999/2000, and 2000/2001 sampling seasons. Throughout this period, the objectives have remained the same:

1. To understand the mechanics of the local watershed.
2. To determine where TOC and turbidity problems originate.
3. To determine whether TOC and turbidity sources and loads could be reduced through one or more Best Management Practices (BMPs).

Figure 2 Location of the North Bay Aqueduct and Barker Slough Pumping Plant



Source: Department of Water Resources, Sacramento - San Joaquin Delta Atlas, 1993

Study Evolution

Each year of study has built upon previous year's results. Based on 1996/1997 results, the 1997/1998 study focused on collecting samples farther upstream of the pumping plant to determine if locations with lower TOC and turbidity levels existed within the watershed. Samples were collected immediately after several rainstorm events. Results of the 1997/1998 sampling suggested that water quality did not improve at the farthest upstream point sampled; therefore, 1998/1999 sampling focused on isolating land use practices in the watershed and used autosamplers to examine the dynamics of turbidity and TOC during storm events in the Barker Slough watershed. Weekly grab samples were also collected at the pumping plant to validate patterns seen in previous studies and to examine water quality patterns between storms. Results of the 1998/1999 sampling season suggested that 2 separate mechanisms were at work in the watershed. One was directly related to rainfall; the other, indirectly. Observations during this period also led to the hypothesis that the predominance of high sodium soils in the watershed, which renders most of the watershed ill-suited for row-cropping and by default is mostly used as rangeland, leaves the watershed predisposed to naturally high turbidity and TOC levels.

These 2 hypotheses were tested in 1999/2000 through a joint study with UC Davis. Weekly grab samples were collected at the same sites as in 1998/1999 and on different soil types identified near the sampling locations. The goal was to examine runoff from different soil types vs. the observed TOC and turbidity levels in the slough. Autosamplers were again used to verify the previous year's results. A number of technical challenges prevented comparisons between samples collected in the slough and samples collected on land. Therefore, the original hypothesis could not be tested, but valuable information on particle size was obtained. This report focuses only on the aquatic results from samples collected by DWR and NBA contractors. The reader is directed to a report published by UC Davis for the SCWA for terrestrial results from that period (Singer and Eshel 2000). Soil testing in the 1999/2000 sampling season strengthened the hypothesis that observed TOC and turbidity levels could be a natural byproduct of the watershed itself and not discharges from 1 or more point sources. Weekly grab samples at the pumping plant confirmed 1998/1999 results that TOC and turbidity levels remain elevated at the plant in the absence of rainfall. In conjunction with loading calculations, the weekly results suggested that because of a combination of low pumping rates and hydrologic conditions, elevated levels of turbidity and TOC remain near the pumping plant, potentially from the forebay to Calhoun Cut, and discharge from Campbell Lake played a key role in these observed concentrations.

To understand BMP options under a nonpoint source scenario, SCWA engaged the consulting firm Hydro Science to identify and develop BMPs for the Barker Slough watershed. A preliminary analysis by Hydro Science of Singer's results and sampling conducted by DWR and the NBA contractors led to the conclusion that turbidity BMPs would potentially be more effective than TOC BMPs, but that for both analytes, reducing levels to those desired by the contractors might be difficult (Hydro Science 2001).

In conjunction with the consulting firm of Brown and Caldwell, a dye study examining the hydrology from Lindsey Slough, Calhoun Cut, and Barker Slough was prepared for the 2000/2001 sampling season. Weekly samples were collected from the pumping plant to determine when TOC concentrations had reached a steady-state level. Because of that year's decreased rainfall, it was more difficult to determine when a steady-state level had been achieved; therefore, the dye study was not conducted. However, as shown in this report, 2000/2001 data did indicate that a steady-state level of TOC was again reached. These results, in conjunction with a drogue study conducted by Brown and Caldwell and SCWA (McDonald 2001), led SCWA to approve the installation of 2 real-time, telemetered flow meters to provide net flow calculations from 2 key sites. These installations will provide data to test whether water becomes trapped between the forebay and Calhoun Cut and at what times the watershed makes the largest contribution to the hypothesized hydrologic condition. At the time this report was written, this instrumentation was in the preliminary stages of installation. Hydro Science and SCWA have also installed and begun data collection on preliminary BMPs to examine their effectiveness.

The NBA contractors have consistently identified TOC and turbidity as the 2 most important water quality challenges facing the WTPs; therefore, this report focuses on these 2 parameters. Because turbidity can interfere with the removal of pathogens, bacteria data are also presented. Water quality parameters that were not a concern to NBA contractors, for example, temperature or electrical conductivity (EC), were collected as part of routine sampling but were not analyzed. Results for all parameters can be found in Appendices A through I.

DWR's Bryte Laboratory conducted all analyses with the exception of 1 year of bacterial data. As shown in the Quality Assurance/Quality Control section of this report, differences in sample preparation for TOC can result in laboratories reporting very different TOC concentrations even when using similar methods. In the final year of sampling, Bryte Laboratory began analyzing TOC by 2 methods, the combustion method and Bryte's historically used wet-oxidation method (both are under EPA method 415.1). Although the methods are considered equivalent, they can report very different TOC concentrations under high turbidity conditions. Because the majority of this report, as well as DWR historical measurements, have been made with the wet-oxidation method, analyses and conclusions for TOC were based on wet-oxidation measurements unless otherwise noted.

Materials and Methods

Figure 1 displays the location of all sites sampled in this report. Table 1 lists the type of sampling (either grab or autosampler), sampling frequency, and the analytes analyzed. The reader is referred to the 1998/1999 and 1999/2000 QA/QC documents for discussion of QA/QC requirements (DWR 1998a, DWR 1999).

1997/1998 Sample Collection

During the 1997/1998 sampling season, grab samples were collected from 6 sites: Lindsey Slough, Calhoun Cut, Barker Slough Pumping Plant, Cook Lane, Dally Road, and Hay Road. Samples were collected during or 24 hours after a rainfall event of 1 inch or greater. Samples were also collected once in September and October to serve as a baseline. Because of flooding, a number of samples upstream of the pumping plant could not be collected. Samples collected from the pumping plant occurred on different dates than samples collected at the remaining collection sites. Flow measurements were made by DWR staff on several occasions to assess loading. Because of flooding, flow measurements were limited.

1998/1999 Sample Collection

During the 1998/1999 sampling period, samples were collected from 4 sites: Leisure Town Road, Junction, below Campbell Lake, and the Barker Slough Pumping Plant. Site selection focused on inputs from the top to the bottom of the watershed. At the same time, selected sites also represented hydrologic inputs from different land uses in the watershed. The Leisure Town Road site was located approximately 9 miles upstream from the pumping plant. At this point, runoff into the slough consists of inputs from grazed fields, row crops, and urban influences. Selection of the Junction site was based on surface flow

Table 1 Overview of stations sampled by DWR, Sep 1997 to Apr 2001

Sampling period	Sample type(s)	Sample sites	Sampling frequency	Sampling variables
Sep 1997 to Mar 1998	Grab	Lindsey Slough Calhoun Cut @ Hwy 113 BSI PP Cook Lane bridge Dally Road Hay Road	Generally monthly as well as samples collected during 4 storm events of > 1". Samples collected either during or 24 hours after event. Not all sites sampled due to flooding.	TOC/DOC Turbidity *E. coli* Metals (dissolved) Pesticides Alkalinity THMFP Nutrients Bromide UVA-254
Nov 1998 to Apr 1999	Grab (BSI PP only) Autosampler (all sites)	BSI PP Below Campbell Lake Junction Leisure Town Road	3 rainfall events for autosampler. Weekly for grab samples.	TOC DOC Turbidity EC
Nov 1999 to Mar 2000	Grab (all sites) Autosampler (all sites)	BSI PP Below Campbell Lake Junction Leisure Town Road Calhoun Cut @ Hwy 113 Off-site pond by Campbell Lake	3 rainfall events for autosamplers. Weekly for grab samples.	TOC DOC Turbidity EC pH Temp
Nov 2000 to Apr 2001	Grab	BSI PP	Weekly	TOC (wet oxidation & combustion) DOC Turbidity Total coliform Fecal coliform *E. coli* pH UVA-254 EC Temp

hydrology maps produced by SCWA. Patterns of water movement suggested that a large portion of the upper watershed drains into the Junction site. Samples collected from the Junction site were approximately 4 miles upstream from the pumping plant and approximately 5 miles downstream from the Leisure Town Road site. The 3rd site was located approximately 2 miles below the Junction sampling point at the outfall of Campbell Lake. Campbell Lake covers an area of approximately 40 acres and serves as a source of summer irrigation water for the landowner. In the winter, boards that form the dam for the lake are removed, and runoff from the upper watershed flows unimpeded down the slough. The lake is approximately 1.5 miles upstream of the pumping plant. Finally, samples were collected at the Barker Slough Pumping Plant at the forebay immediately before the pumps.

Three rainfall events were sampled during the sampling period. In December, samples were collected prior to saturation of the area's soils. By the 2nd sampling event in February, soils in the area were saturated, and large-scale overland flooding was observed. Samples collected in February occurred during the largest rainfall event of the season. Soils may have begun drying out when samples were collected for the 3rd sampling event in March. Flooding was again observed at Campbell Lake during this sampling event.

To develop a hydrograph of the slough, samples were collected using ISCO™ 3700 autosamplers. Autosamplers were programmed to collect 24 hourly composited samples. An hourly composite sample consisted of 70 mL collected every 15 minutes. Four 70-mL samples were collected each hour. The inlet line from the stream to the autosampler's peristaltic pump consisted of either new or precleaned Teflon™-lined Tygon™ tubing. Because Teflon™ will not compress, silicone pump tubing was used in the peristaltic pump. Following a sampling event, all used tubing was exchanged with fresh Teflon™-lined and peristaltic pump tubing. Autosamplers were recalibrated in the field. Following calibration, all lines were back-flushed with deionized water. To prevent large pieces of debris from entering the sampler, a stainless-steel strainer was used to weight the end of the inlet line. Tubing was connected with stainless steel couplings. Used Teflon™-lined tubing was returned to the laboratory and cleaned by filling the line with hot soapy water and soaking for at least 1 hour. Following the soap solution, tubing was rinsed by flushing the tubing with a minimum of 3 tap water rinses followed by 3 deionized water rinses. New silicon tubing was used for each sampling event. Samples were collected in precleaned glass bottles. Glass bottles were cleaned similarly to Teflon™-lined tubing.

Autosamplers were triggered remotely based on telemetered rainfall and stream-height information at the Leisure Town and Junction sampling sites. Criteria for triggering a sampling event was approximately 1 inch of rain and an increase in stream height at the Leisure Town Road site of at least half a foot. Within 48 hours after collection of the first sample, sample bottles were retrieved and returned to the laboratory. Aliquots for TOC, turbidity and EC were collected from each hourly composite. In general, aliquots for DOC were collected from samples collected every 4th hour. Samples for TOC and DOC analysis were stored at 4 °C in certified VOA vials with concentrated H_3PO_4 added to a pH <2. Both TOC and DOC were analyzed within 2 weeks after collection. DOC is operationally defined as any organic substance that passes through a 0.45-micron filter. Immediately following sample collection, an aliquot of sample water was filtered with a Gelman 0.45-micron poly sulfone filter. Filters were prerinsed by filtering 250 mL of deionized water followed by approximately 10 mL of ambient sample. Previous laboratory experiments had determined that 250 mL was sufficient to flush any organic carbon associated with the filter to deionized water background levels. Following prerinsing, approximately 40 mLs were filtered for organic carbon analysis. Because of the high sediment loads, a 1-micron glass fiber prefilter was used subsequent to the December sampling event. Filter blanks with deionized water were run with every sampling event. With the autosampler, true replicate samples could not be collected. Therefore, at the time of sample retrieval a sample time and station was randomly selected, and a subsample was collected for replicate analysis. Because autosamplers remained in the field ready for sampling for up to 3 weeks between storm events, a 25th glass bottle was included as a field blank to examine background atmospheric carbon deposition. This bottle remained empty during a sampling event. Upon retrieval of samples, this blank was filled with deionized water and allowed to incubate at room temperature for at least 1 hour. Field blanks were then analyzed for the same parameters as the ambient waters. Turbidity was measured using a HACH turbidity meter. EC was measured with an Orion Electrical Conductivity meter.

SCWA installed telemetered in-line stage height and turbidity meters as well as tipping rain buckets for rainfall measurements at all sites except the pumping plant. The installation of equipment for Campbell Lake was made immediately above Campbell Lake (rather than immediately below) as bank morphology was more amenable to developing a rating curve. SCWA also provided software and equipment that allowed remote triggering of the autosamplers. Flow measurements were provided by SCWA based on telemetered stage height readings and rating curves developed by SCWA staff.

1999/2000 Sample Collection

Both autosamplers and grab samples were collected during the 1999/2000 season. Sampling locations and methodology for autosamplers were similar to the 1998/1999 season, with the following exceptions:

- To decrease the number of autosampler samples analyzed, water was collected hourly, but equal volumes of sample collected between 0-4 hours, 4-8 hours, etc. were combined in the laboratory to create a 4-hour composite for analysis. No DOC measurements were conducted.
- To capture a greater proportion of the downstream hydrographs, autosampler start times were staggered. Autosampler samples collected at Junction began 2 hours after sampling had begun at Leisure Town Road. Autosampler samples collected below Campbell Lake began 8 hours after sampling had begun at Leisure Town, and autosampler samples collected at the pumping plant began 16 hours after sampling had begun at Leisure Town.

After analysis of stage height data, SCWA installed another in-line stage recorder below Campbell Lake that was less affected by the rise in lake level during the winter season.

Grab samples were collected weekly in triplicate at the same sites as autosamplers. In addition, weekly grab samples were collected in March from Calhoun Cut, from immediately above Campbell Lake and from a pond receiving runoff from a dirt-bike hill in Argyll Park. Subsamples from each of the weekly samples were also given to UC Davis for their analyses.

2000/2001 Sample Collection

Weekly grab samples were collected in triplicate from the Barker Slough Pumping Plant. TOC samples were analyzed by Bryte Laboratory using both the combustion and wet-oxidation methods (EPA method 415.1). DOC samples were analyzed by the wet-oxidation method. BioVir analyzed bacterial samples using Standard Method 18;9221 B for total coliform, Standard Method 18;9221 E for fecal coliform, and Modified MUG for *E. coli* (Greenberg and others 1992). All samples were transported from the pumping plant to BioVir on ice. BioVir received all bacterial samples within 8 hours of sample collection.

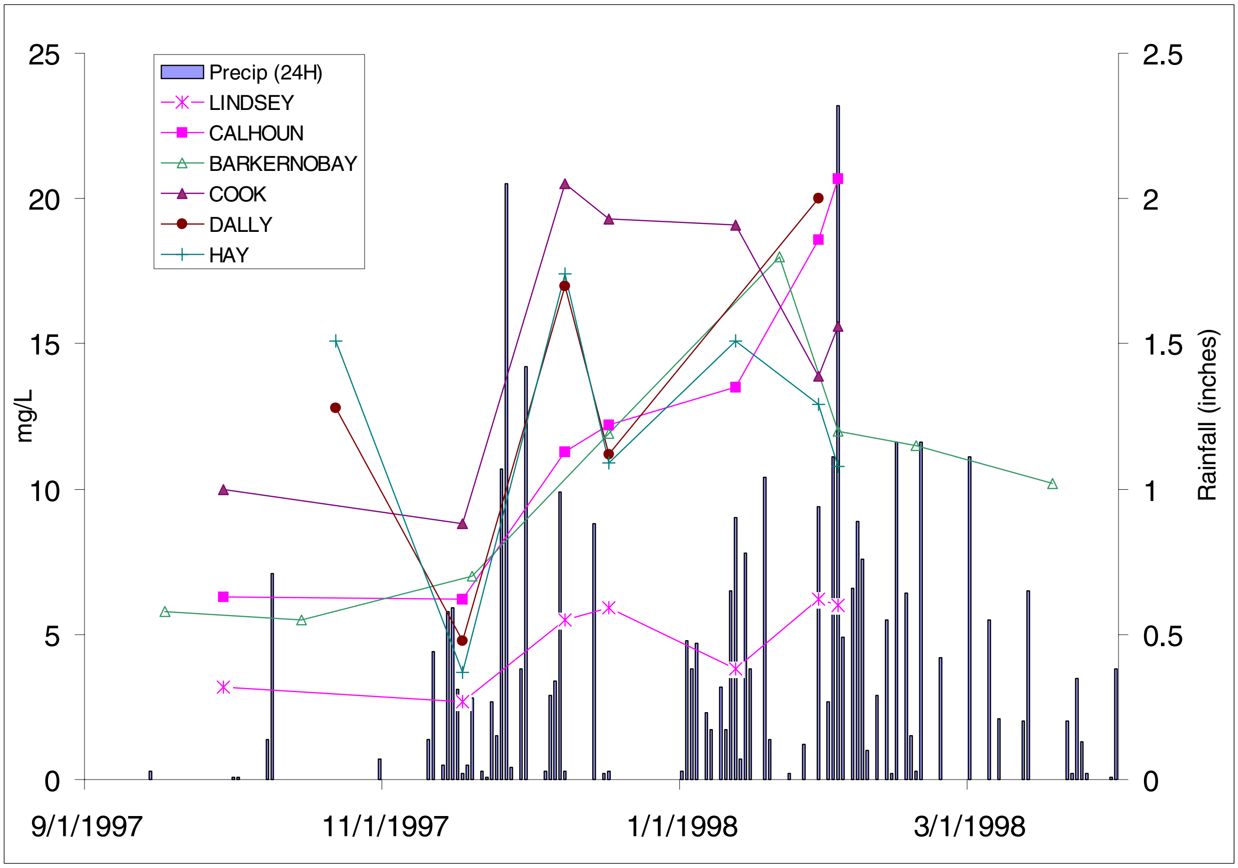


Figure 3 TOC vs. rainfall, 1997/1998

Statistical Analysis

Samples were analyzed statistically using either Statistica or Minitab software packages. All data sets were checked to determine if parametric assumptions were met. In cases where assumptions were not met, nonparametric statistics were used.

Results

Grab Sample Results

Comparisons between Organic Carbon and Turbidity

For most stations, organic carbon and turbidity concentrations collected during the height of the 1997/1998 rainy period (late November through March) were generally higher than baseline samples collected in September and October (Figures 3 and 4). Exceptions occurred at Lindsey Slough and Calhoun Cut. At these 2 sites, turbidity (but not TOC) remained low regardless of rainfall event. Overall, average TOC concentrations at Lindsey Slough were lower than upstream sites (Table 2), but because of the patchy distribution of sample collection during the 1997/1998 sampling year, it was difficult to confirm this statistically (Figure 5). Between September 1997 and March 1998, 14 samples were collected for TOC and DOC while 15 samples were collected for turbidity. Total and dissolved organic carbon samples were collected at all 6 sites on 17 December 1998, while direct turbidity comparisons between all sites were

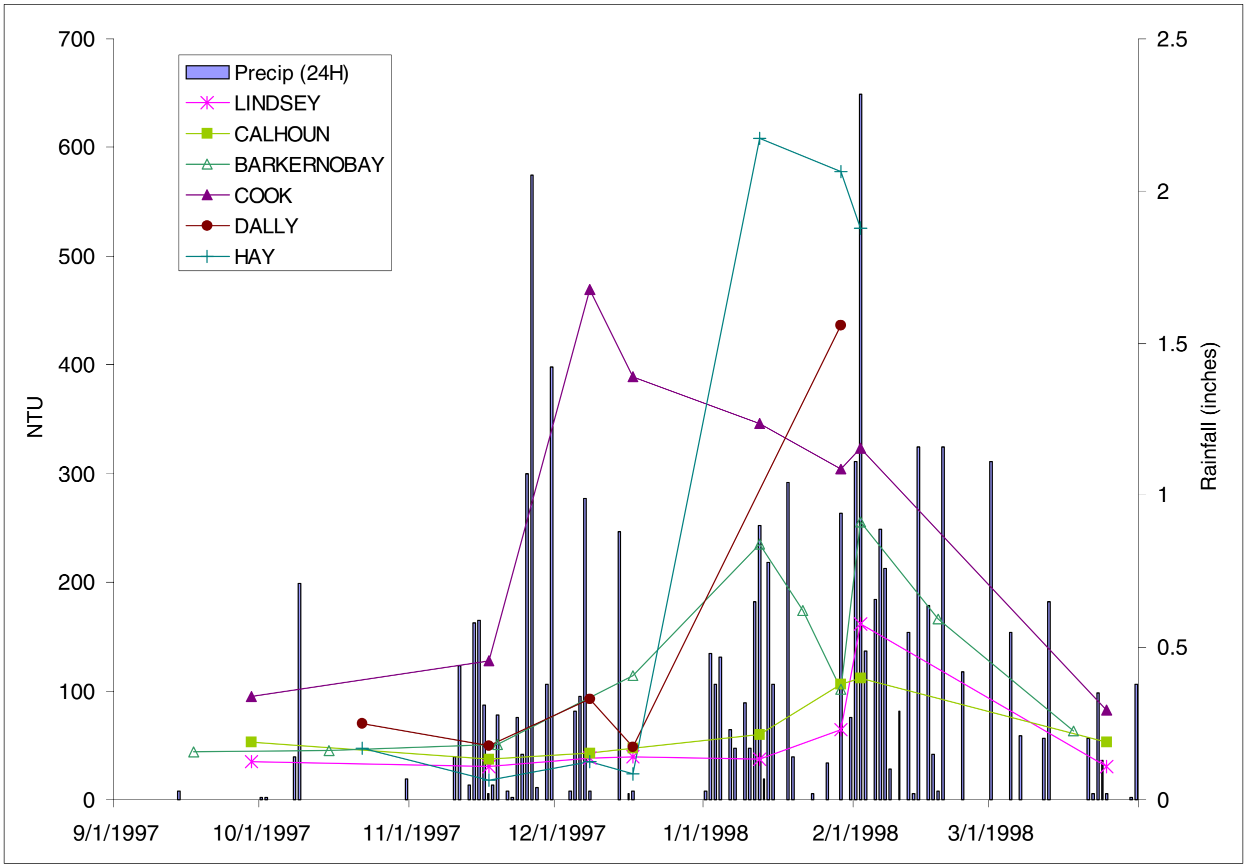


Figure 4 Turbidity vs. rainfall, 1997/1998

only possible on 2 occasions (17 December 1997 and 29 January 1998). The absence of samples collected on the same day precluded robust statistical analyses.

To facilitate statistical comparisons, collection dates with 2 or fewer sampled sites were removed from the analysis. This produced a data set where the majority of samples were collected on the same day. With these adjustments, results were generally similar to the 1996/1997 sampling season. Average TOC and DOC concentrations at Lindsey Slough were lower than those upstream, but for both variables, concentration differences between all stations were not significantly different (Figure 6 and Table 3a and 3b). With the exception of Calhoun Cut, turbidity patterns were also similar to the 1996/1997 sample year, with average turbidity generally increasing upstream of Lindsey Slough. Unlike organic carbon, turbidity differences between sites were significantly different; however, individual differences between sites were not resolvable statistically. Of the samples shown in Figure 6, only 4 dates could be compared statistically; therefore, given the variability of the data, statistics conducted on this small data set may have lacked the resolving power necessary to discern differences.

Tidal influence complicated any interpretation of Calhoun Cut data. Average turbidity concentrations at Calhoun Cut were similar to those observed at Lindsey Slough, but organic carbon concentrations at Calhoun Cut appeared similar to upstream sites (see Table 3a and 3c). Because samples collected at Calhoun Cut did not isolate effluent inflow from the cut's watershed, runoff water quality from the Calhoun Cut watershed is unknown. Samples collected under tidal influence potentially reflect the

Table 2 Overall summary statistics TOC, DOC, and turbidity

(a) TOC (mg/L), Sep 1997 to Mar 1998

	Lindsey	Calhoun Cut	Barker Sl PP	Cook Lane	Dally	Hay
Mean	4.8	12.7	10.2	15.3	13.2	12.3
Min	2.7	6.2	5.5	8.8	4.8	3.7
Max	6.2	20.7	18.0	20.5	20.0	17.4
10 - 90 percentile	3.0-6.1	6.3-19.4	5.7-13.8	9.5-19.8	7.4-18.8	8.0-16.0
Detects/total sampled	7/7	7/7	8/8	7/7	5/5	7/7

(b) DOC (mg/L), Sep 1997 to Feb 1998

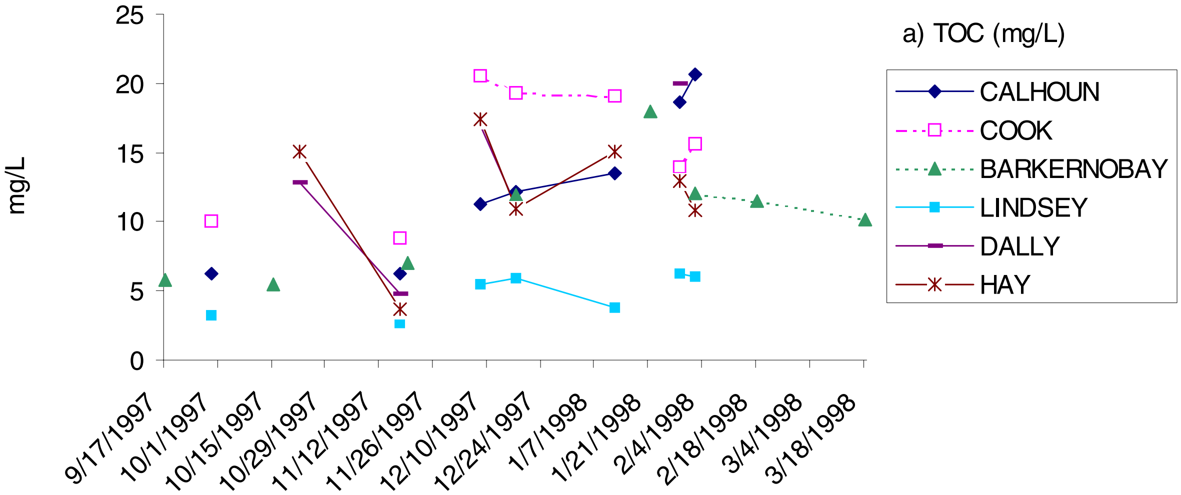
	Lindsey	Calhoun Cut	Barker Sl PP	Cook Lane	Dally	Hay
Mean	4.2	10.2	6.3	10.1	10.5	9.6
Min	2.0	4.4	3.4	6.0	4.0	3.4
Max	5.5	15.9	9.5	12.8	15.0	16.1
10 - 90 percentile	2.2-5.5	4.9-14.8	3.9-8.8	6.2-12.7	6.2-14.0	5.0-15.3
Detects/total sampled	7/7	7/7	3/3	7/7	5/5	7/7

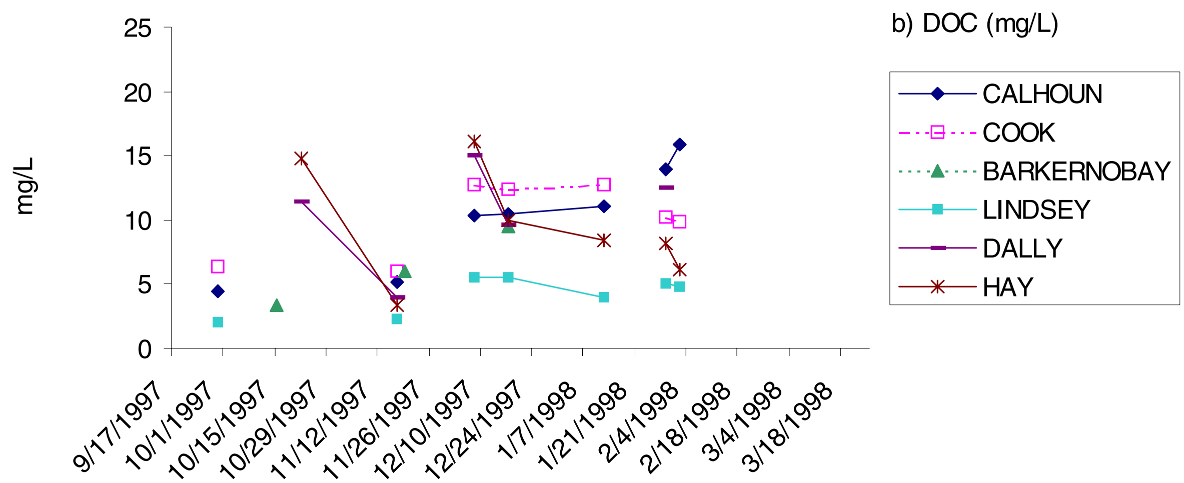
(c) Turbidity (NTU), Sep 1997 to Mar 1998

	Lindsey	Calhoun Cut	Barker Sl PP	Cook Lane	Dally	Hay
Mean	55	64	125	267	140	262
Min	31	37	44	82	49	18
Max	162	112	256	469	436	608
10 - 90 percentile	31-94	41-108	45-237	91-413	49-299	21-590
Detects/total sampled	8/8	8/8	10/10	8/8	5/5	7/7

commingling of water from Barker Slough, Lindsey Slough and Calhoun Cut; therefore, comparisons between Calhoun Cut samples and other sites are misleading. In many respects a similar argument could be made for water quality measurements at the pumping plant; however, as discussed in the Autosampler Results section under Spatial and Temporal Patterns, immediate storm water effects at the pumping plant are a reflection of input from the Barker Slough watershed.

Based on 1996/1997 sampling results (DWR 1998b) and visual inspection of the 1997/1998 data, Lindsey Slough's impact to the pumping plant's winter water quality was considered minor, and sampling efforts focused on organic carbon and turbidity sources contributed by the Barker Slough watershed.





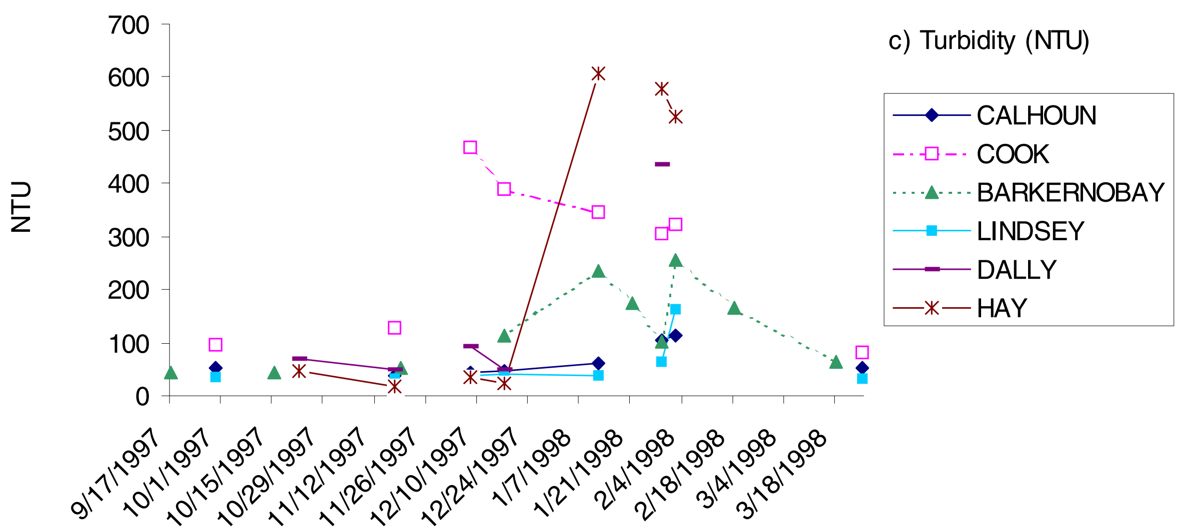


Figure 5 Comparison between all samples collected for TOC, DOC, and turbidity, Phase II Sep 1996 to Mar 1998

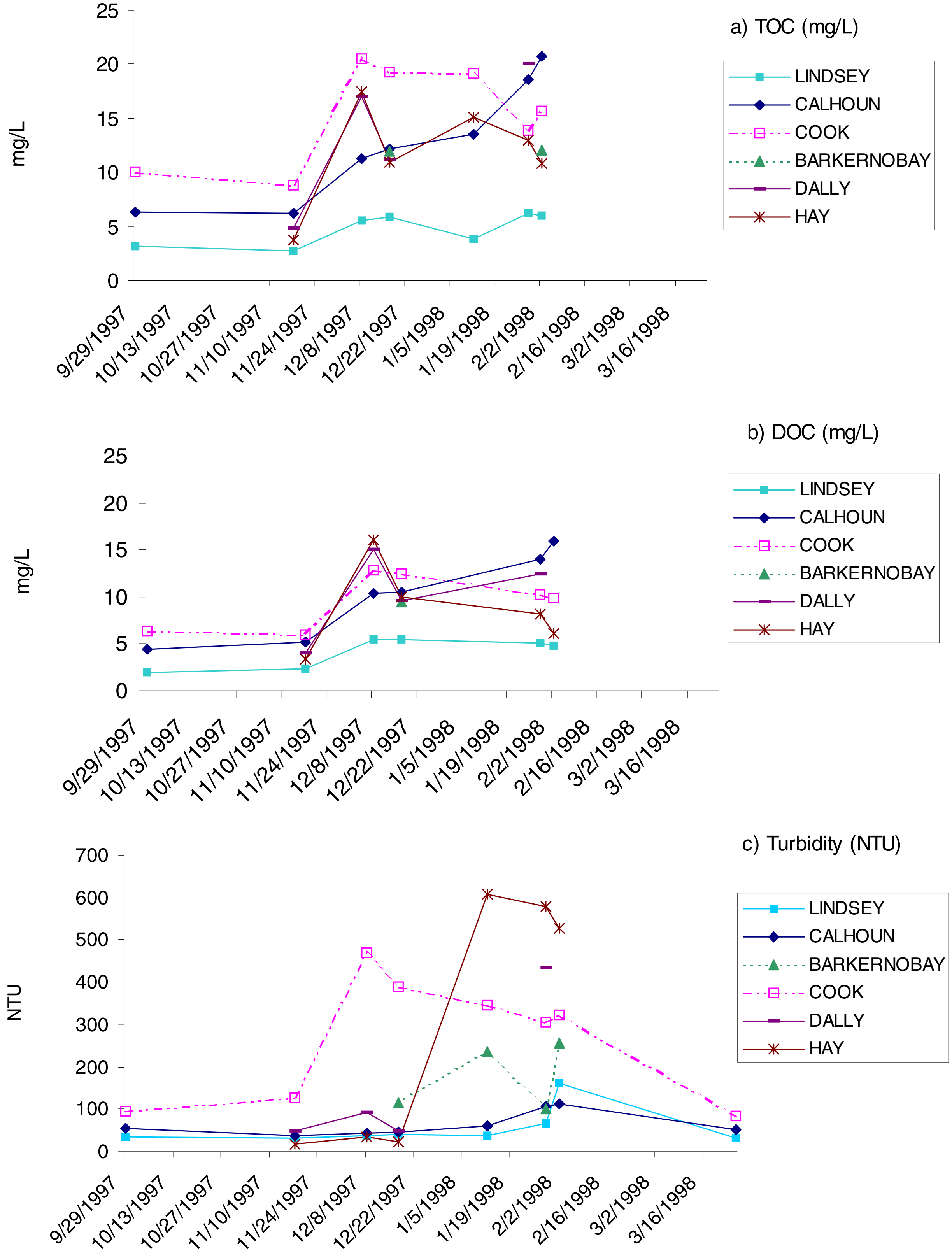


Figure 6 TOC/DOC and turbidity between 3 or more sites with generally same day analyses, Phase II Sep 1996 to Mar 1998

Table 3 Summary statistics for TOC, DOC, and turbidity measurements collected on the same day

(a) TOC (mg/L) collected from Nov 1997 to Dec 1997 and Jan 1998, n = 4

	Lindsey	Calhoun Cut	Barker Sl PP	Cook Lane	Dally	Hay
Mean	5.1	12.1	NS	15.6	13.3	11.2
Standard error	1.6	5.1	NS	5.4	6.7	5.7
Min	2.7	6.2	NS	8.8	4.8	3.7
Max	6.2	18.6	NS	20.5	20.0	17.4
10-90 percentile	3.5-6.1	7.7-16.7	NS	10.3-20.1	6.7-19.1	5.9-16.1

(b) DOC (mg/L) collected from Nov 1997 to Dec 1997 and Jan 1998, n = 4

	Lindsey	Calhoun Cut	Barker Sl PP	Cook Lane	Dally	Hay
Mean	4.6	10.0	NS	10.4	10.3	9.4
Standard error	1.5	3.6	NS	3.1	4.7	5.3
Min	2.3	5.2	NS	6.0	4.0	3.4
Max	5.5	14.0	NS	12.8	15.0	16.1
10-90 percentile	3.1-5.5	6.7-13.0	NS	7.3-12.7	5.7-14.3	4.8-14.3

(c) Turbidity (NTU) collected from Dec 1997 to Feb 1998, n = 4

	Lindsey	Calhoun Cut	Barker Sl PP	Cook Lane	Dally	Hay
Mean	76	81	177	341	NS	434
Standard error	59	32	80	37	NS	276
Min	38	48	102	304	NS	23
Max	162	112	256	389	NS	608
10-90 percentile	38-133	51-110	106-250	310-376	NS	174-599

NS = not sampled, or not sampled on the same day as other sites

Weekly grab samples were collected from a number of sites in the 1999/2000 winter sampling season. Between November 1999 and March 2000, weekly grab samples were collected from Leisure Town Road, Junction, below Campbell Lake, and the Barker Slough Pumping Plant. Additionally, during March, samples were collected from above Campbell Lake, from a small pond that receives runoff from a hill used by dirt bikes at Argyll Park, and from Calhoun Cut. Tables 4 and 5 show average TOC (no DOC collected) and turbidity concentrations.

Table 4 TOC summary statistics (mg/L) for grab samples collected Nov 1999 to Mar 2000

	Leisure Town	Junction	Above Campbell Lake	Below Campbell Lake	Barker Slough PP	Calhoun Cut @ Hwy 113	Off-site pond
Mean	7.3	9.0	10.3	11.5	7.5	18.4	26.4
Standard error	4.3	3	4.7	4.6	5.8	1.8	2.2
Min	2.5	5.2	5.8	6.4	2.1	16.0	24.0
Max	20.0	16.4	17.0	23.4	17.9	21.6	30.0
10-90 percentile	2.8-12.2	5.8-13.7	5.8-16.4	6.9-16.9	2.4-16	6.2-20.8	24.1-29.7
Detects/total sampled	66/66	66/66	14/14	65/65	66/66	15/15	12/12

For comparative purposes, data were divided into 3 periods: pre-rainy, rainy, and post-rainy (Tables 6 and 7). The pre-rainy season covered the months of November through the beginning of January. The 1999/2000 rainy season fell between mid-January and early March. The post-rainy season covered the few weeks of sampling following the end of the rainy season. Approximately 13 inches of rain fell in the watershed during the rainy period while approximately 1 inch or less fell in the watershed during the pre- and post-rainy periods (Figure 7).

Results from the 1999/2000 sampling season suggested that TOC dynamics varied depending on site and season. Differences between TOC concentrations were analyzed by site and season using a nonparametric 2-way ANOVA. Interaction in the 2-way ANOVA was significantly different ($p < 0.001$). Interaction

Table 5 Turbidity summary statistics (NTU) for samples collected Nov 1999 to Mar 2000

	Leisure Town	Junction	Above Campbell Lake	Below Campbell Lake	Barker Slough PP	Calhoun Cut @ Hwy 113	Off-site pond
Mean	24	84	32	140	48	75	626
Standard error	26	71	7	90	35	14	186
Min	4	7	18	43	18	61	445
Max	102	245	40	409	151	101	900
10-90 percentile	5-67	10-225	21-40	57-223	21-99	61-99	446-870
Detects/total sampled	66/66	65/65	14/14	66/66	67/67	15/15	12/12

Table 6 Average TOC (mg/L) concentrations by season for samples collected Nov 1999 to Mar 2000

	Leisure Town	Junction	Above Campbell Lake	Below Campbell Lake	Barker Slough PP	Calhoun Cut @ Hwy 113	Off-site Pond
Pre-rainy	6.6	8.5	NS	8.1	3.2	NS	NS
Rainy	9.3	10.7	16.0*	15.4	10.3	18.9*	26.1**
Post-rainy	4.2	6.7	7.2	14.0	16.1	18.1	26.5
Overall average	7.3	9.0	10.3	11.5	7.5	18.4	26.4

NS = not sampled
Pre-rainy = 3 Nov 1999 to 12 Jan 2000, n = 11 sample events
Rainy = 19 Jan to 8 Mar, n = 8 sample events
Post-rainy = 15 Mar to 29 Mar, n = 3 sample events
*n = 2 sample events
**n = 1 sample event

would occur if TOC did not behave consistently across all sites and/or all seasons. Interaction is often the most important component of a 2-way ANOVA and is best understood graphically. Figure 8a presents the graphical analysis of the TOC interaction effects from the nonparametric 2-way ANOVA. Nonparallel lines indicate a lack of consistent response across the factor. Two distinct TOC response patterns occur. The upstream sites, Leisure Town Road and Junction, show one response pattern while the downstream sites, below Campbell Lake and the Barker Slough Pumping Plant, show another. The strongest difference with respect to the behavior of TOC is found in the post-rainy season. During the post-rainy season, TOC concentrations remained elevated at the downstream sites while upstream TOC concentrations returned to relatively low, pre-rainy levels. Although the Campbell Lake and Barker Slough sites behaved similarly in the post-rainy season, there were differences to their patterns. Finally, the lowest post-rainy TOC concentrations were found at the upstream sites, while the highest post-rainy TOC concentrations were found at the downstream sites. These patterns are also shown in Table 6.

Table 7 Average turbidity (NTU) value by season for samples collected Nov 1999 to Mar 2000

	Leisure Town	Junction	Above Campbell Lake	Below Campbell Lake	Barker Slough PP	Calhoun Cut @ Hwy 113	Off-site pond
Pre-rainy	19	98	NS	96	29	NS	NS
Rainy	36	93	37*	206	73	86*	446**
Post-rainy	9	9	29	127	57	67	686
Overall average	24	84	32	140	48	75	626

NS = not sampled
Pre-rainy = 3 Nov 1999 to 12 Jan 2000, n = 11 sample events
Rainy = 19 Jan to 8 Mar , n = 8 sample events
Post-rainy = 15 Mar to 29 Mar, n = 3 sample events
*n = 2 sample events
**n = 1 sample event

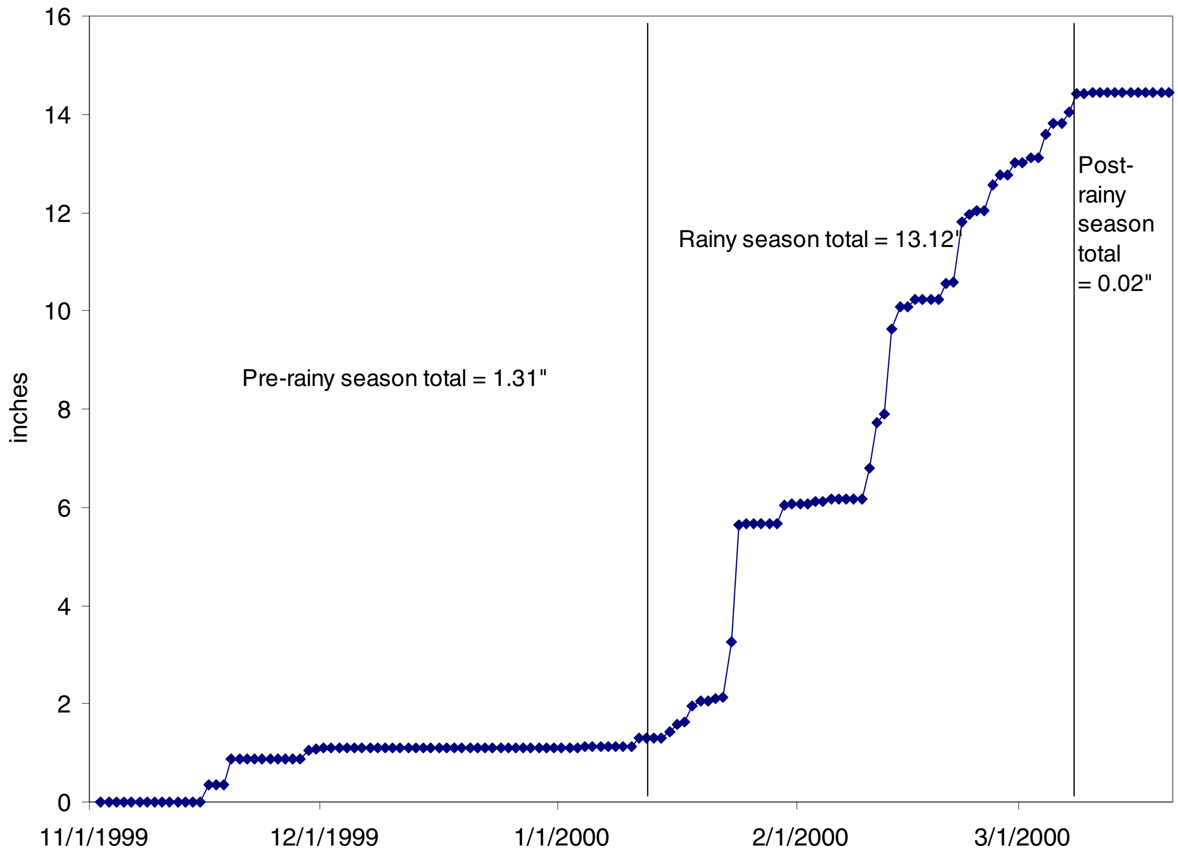


Figure 7 Cumulative rainfall measured at the Barker Slough Pumping Plant, Nov 1999 to Mar 2000

Turbidity dynamics also depended on the site and the season. Like TOC, the interaction between turbidity, site, and season was significantly different (nonparametric 2-way ANOVA $p < 0.001$). Similar to TOC, turbidity below Campbell Lake and at the pumping plant remained high following the rainy season, while turbidity levels at the uppermost sites fell during this same period (Figure 8b). Unlike TOC, turbidity patterns at the uppermost sites did not behave similarly across the seasons. Turbidity at 3 of the 4 sites increased during the rainy season and decreased during the pre-rainy season. However, at Junction pre-rainy turbidity was higher than either its rainy or post-rainy samples. One explanation for this behavior may be the localized effects of livestock on turbidity. Junction is located at one of the largest cow wallows in the watershed; therefore, the pre-rainy pattern recorded at Junction may have been a function of livestock activity.

Samples were only collected above Campbell Lake during the month of March; therefore, pre-rainy and rainy samples could not be compared statistically. However, in the post-rainy period, significant differences were detected between water entering and water leaving the lake. Both the TOC and turbidity of water exiting the lake in the month of March were significantly higher than the TOC and turbidity of water entering the lake $p < 0.02$. Potentially, during high flow, water entering the lake disturbs accumulated silt and clay particles resulting in higher concentrations exiting the lake.

The interaction results from the 2-way ANOVA, in conjunction with samples collected above and below Campbell Lake, suggest that regardless of upsteam dynamics Campbell Lake plays a key role in the water quality observed at the pumping plant's forebay. As noted in Tables 6 and 7, the TOC and turbidity

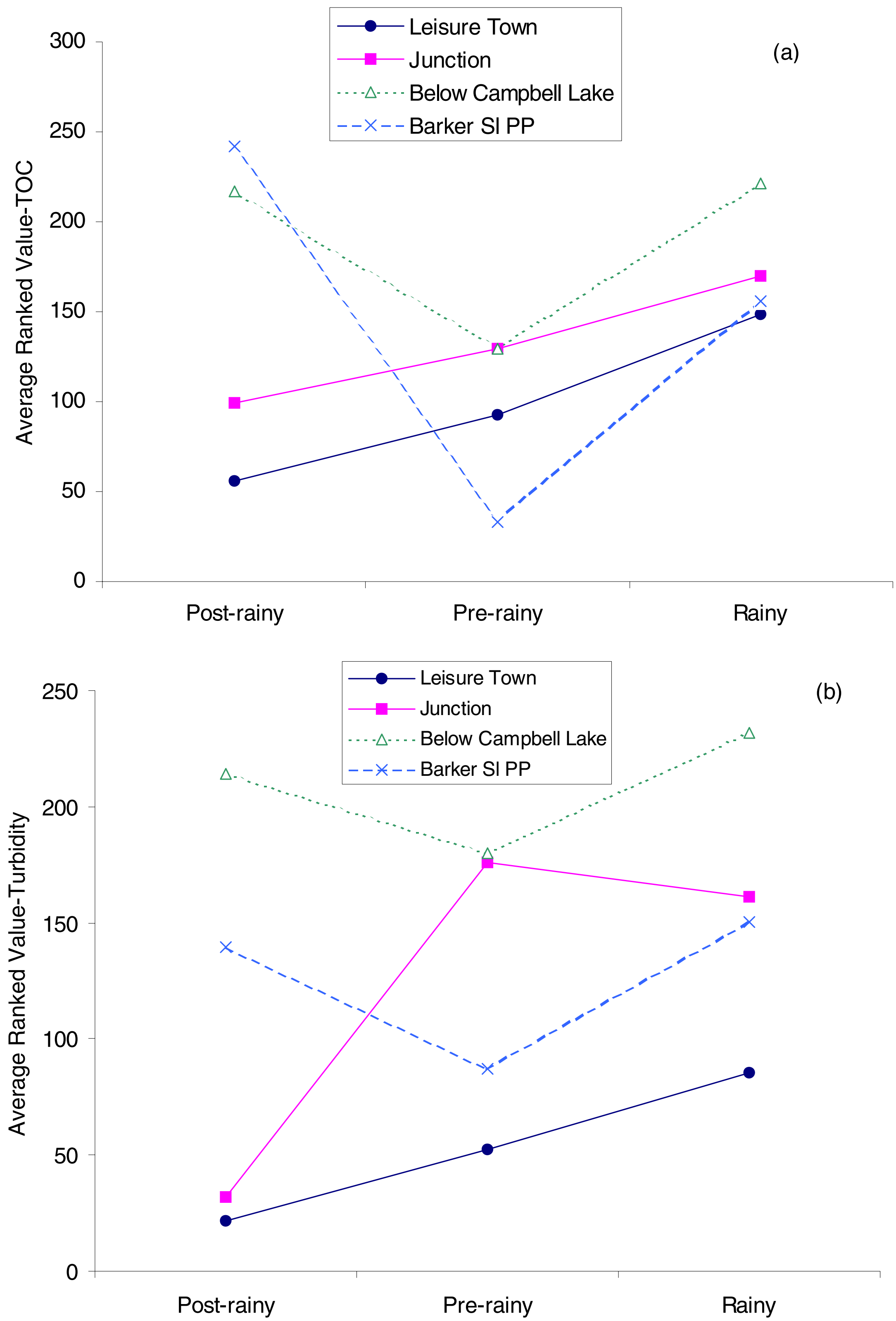


Figure 8 Interaction plot, Nov 1999 to Mar 2000, (a) TOC response and (b) turbidity response by season and by site

concentrations from the receiving pond near the dirt-bike hill on average had the highest levels of any of the sites sampled. This pond's contribution to the pumping plant's water quality cannot be ruled out because under heavy rainfall, runoff from this pond may join the slough below Campbell Lake. However, observations suggest that runoff from this pond into the slough is transient, while runoff from Campbell Lake can continue for several weeks past the last rainfall event.

Correlations between TOC and Turbidity

Like ANOVA results, correlations between organic carbon and turbidity suggested that organic carbon and turbidity behaved differently depending on the season and/or the site. At the pumping plant, turbidity and TOC were fairly well correlated (Figure 9). Spearman-ranked r-values were 0.80, 0.73, and 0.62 for the 1998/1999, 1999/2000, and 2000/2001 sampling years, respectively. All correlations were significant. However, correlations between TOC and turbidity were not as common upstream of the pumping plant. In the 1999/2000 sample year, when weekly samples were collected upstream of the pumping plant, correlations between TOC and turbidity at Junction and below Campbell Lake were 0.4 and 0.5, respectively. At the Leisure Town Road site, turbidity was again able to explain TOC ($r = 0.7$). All correlations were significant.

Examination of TOC and turbidity by season found that the lack of correlation between variables occurred primarily in the pre-rainy season (Figure 10). At Junction and below Campbell Lake, which showed little correlation over the overall sampling period, correlation between TOC and turbidity was either low or not significant in the pre-rainy season. During the rainy season, the correlation between the variables improved below Campbell Lake but fell further at Junction. Correlations in the post-rainy season were not examined because of the small sample size ($n=3$).

The patterns between pre-rainy and rainy correlations suggest that at some sites, pre-rainy season movement of TOC and turbidity are not tightly linked. In general, turbidity and TOC may be better correlated in the winter due to rainfall overriding outside influences. However, if this were always the case, rainy season correlations would have increased at Junction. As discussed with turbidity and interaction at Junction, outside factors such as livestock may influence sample concentrations.

Total Organic Carbon vs. Dissolved Organic Carbon

The average proportion of TOC composed of DOC remained constant regardless of the season or methodology. Using the wet-oxidation method, approximately 90% of the pumping plant's TOC, on average, was DOC, regardless of whether ratios were examined in the dry or rainy season (Table 8). Using the wet oxidation method, the proportion of TOC composed of DOC varied by no more than 16% during the winter rainy season (Figure 11). Using the combustion method, 60% of the pumping plant's TOC, on average, was composed of DOC. Results of the combustion method and the wet-oxidation method showed that season had no impact on the relative proportions. Overall the correlation between TOC and DOC was very high (see Table 8). The dry season of this study encompassed the period after SID had stopped delivering irrigation water and before the winter storms had commenced. Therefore, the summer dry season, when agricultural return water would also enter the slough, was not characterized.

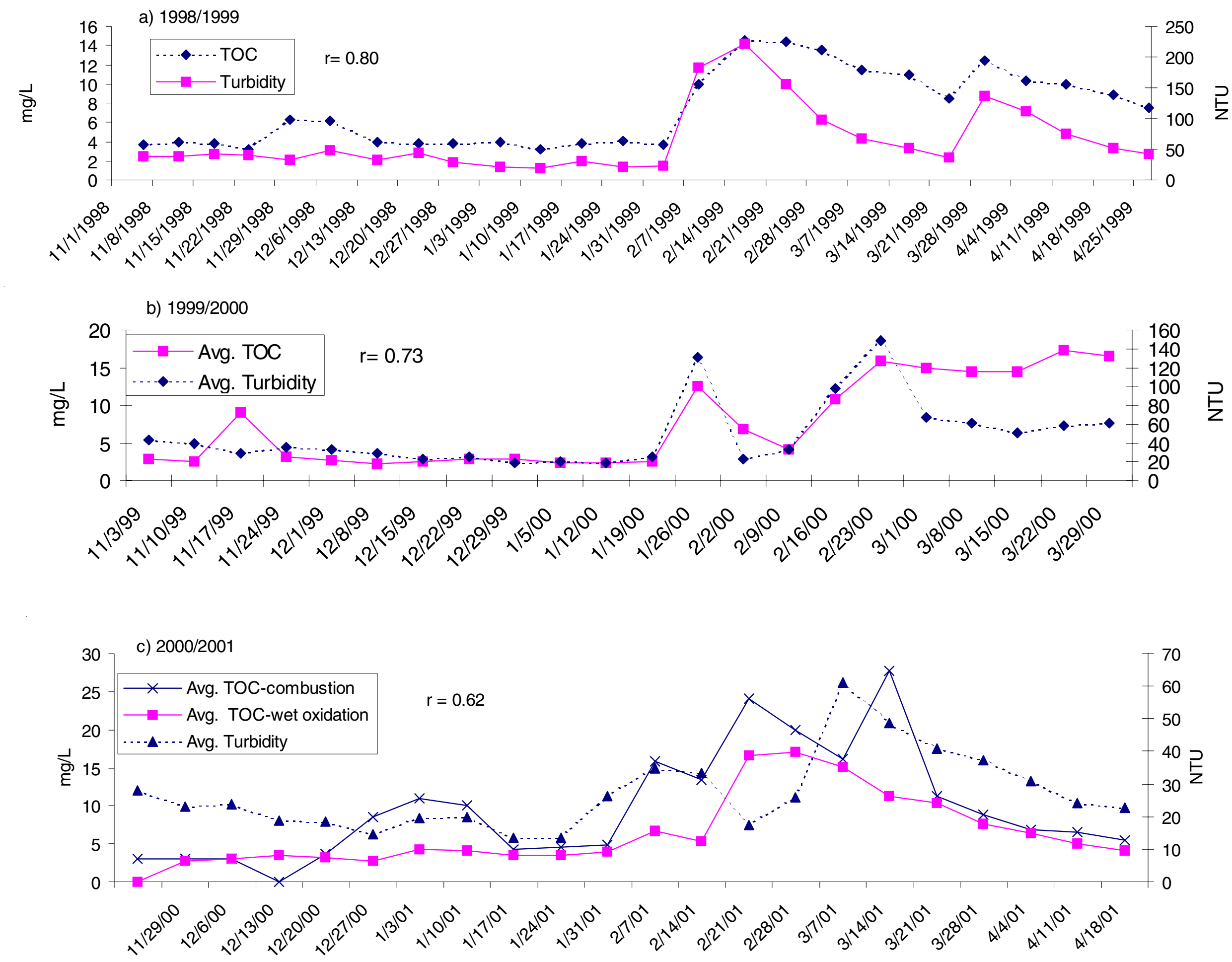
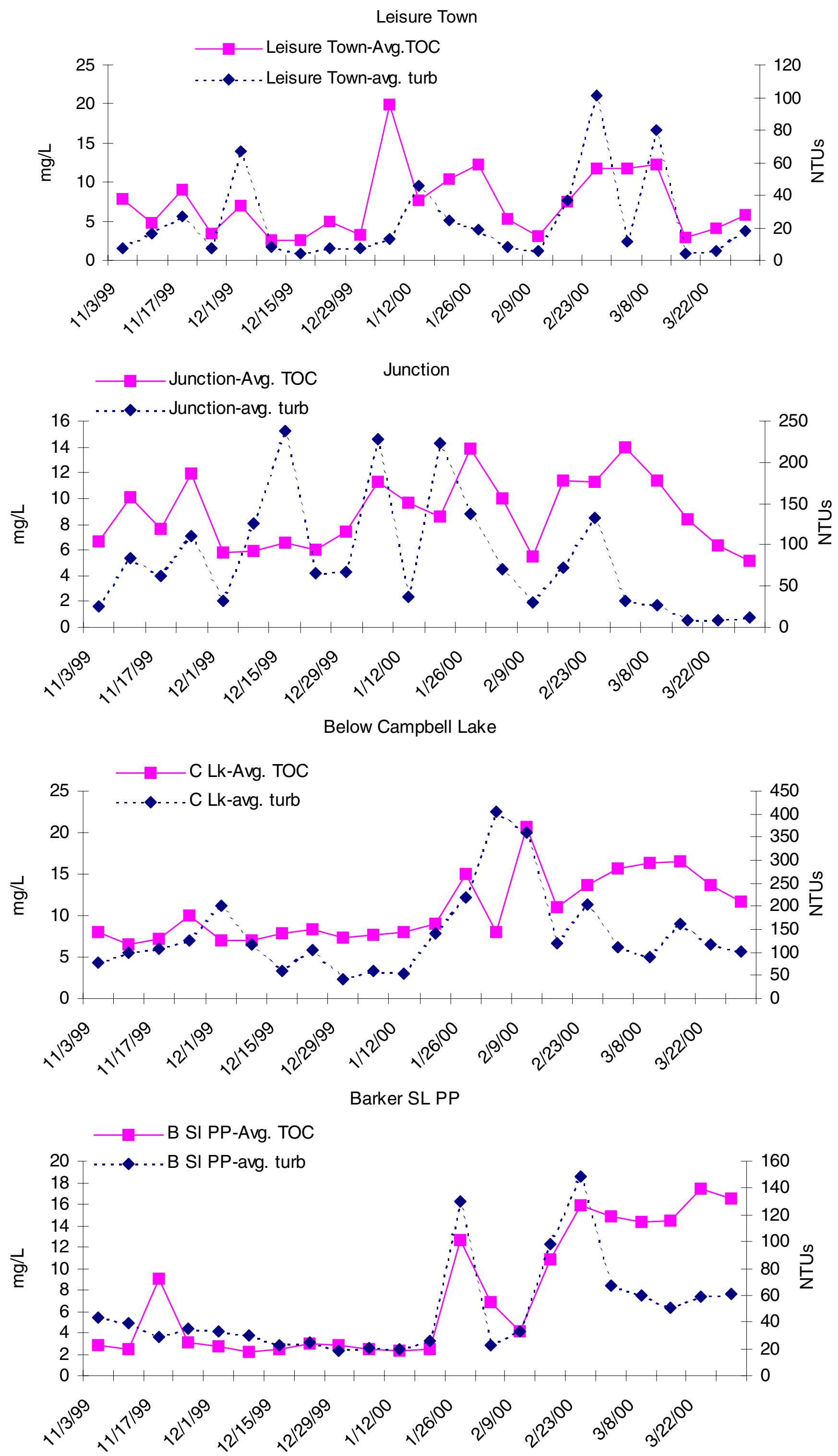


Figure 9 Correlation between TOC and turbidity at the Barker Slough Pumping Plant

The only other sample period where grab samples were analyzed for both TOC and DOC was the 1997/1998 winter sampling season. Over the course of that sampling period, between 1 and 6 samples were collected at any 1 site. Based on this small data set, it appeared that prior to the rainy season, the DOC proportion for all sites sampled were similar (Figure 12). As rainfall began in November 1997, differences began to emerge. Generally, particulates made the least contribution to organic carbon at Lindsey Slough and the greatest contribution at Cook Lane. Sites upstream of Cook Lane (Dally and Hay roads) as well as those downstream of Cook Lane (Calhoun Cut) generally had levels that fell between the boundaries of Lindsey Slough and Cook Lane.

Specific Absorbance and UVA-254

The specific UV absorbance (SUVA), which is computed by the ratio of the UVA-254 nm reading (per cm) to the DOC concentration (mg/L) multiplied by 100, is used as a semiqualitative and semiquantitative indicator of the humic fraction of DOC in water. Humic substances are known to form carcinogenic trihalomethanes and are characteristic of highly aromatic compounds. SUVA values above 3.0 generally indicate organic carbon from terrestrial sources. Higher SUVA values reflect the generally higher lignin composition found in terrestrial-based carbon. SUVA values of approximately 2 are considered indicative of aquatic origin carbon.



Correlation values

Leisure Town

pre-rainy	rainy	overall
0.6	0.6	0.7

Junction

pre-rainy	rainy	overall
0.4*	0.001*[a]	0.4*

* log values used for correlations

r = Pearson's r coefficient

[a] correlation not significant

Below Campbell Lake

pre-rainy	rainy	overall
-0.2[a]	0.6	0.5

[a] correlation not significant

Barker SL PP

pre-rainy	rainy	overall
0.3[a]	0.7	0.7

[a] correlation not significant

Pre-rainy = 3 Nov 1999-12 Jan 2000; rainy = 19 Jan-8 Mar 2000; post-rainy not analyzed due to small sample size.
Used wet-oxidation values for 2000/ 2001 correlations.

Figure 10 Correlation between TOC and turbidity by site in the pre-rainy and rainy season, 1999/2000

Table 8 Summary statistics for samples collected at the Barker Slough Pumping Plant, Dec 2000 to Apr 2001 (3 replicates/variable/week)

(a) Season total summary statistics, 29 Nov 2000 to 25 Apr 2001

	TOC-wet ox (mg/L)	TOC-comb (mg/L)	DOC (mg/L)(wet)	% DOC/TOC (wet ox)	% DOC/TOC (comb)	Correlation TOC (ox) vs. DOC
Average	6.7	10.1	6.0	90	60	1.00
Minimum	2.6	2.9	2.4			
Maximum	17.2	28.8	14.4			
0.1-0.9 percentile	3.0-15.2	3.1-20.3	2.7-13.9			
Count	63/63	63/63	66/66			

(b) Dry season summary statistics, 29 Nov 2000 to 7 Feb 2001

	TOC-wet ox (mg/L)	TOC-comb (mg/L)	DOC (mg/L)(wet)	% DOC/TOC (wet ox)	% DOC/TOC (comb)	Correlation TOC (ox) vs. DOC
Average	3.5	5.6	3.3	93	59	1.00
Minimum	2.6	2.9	2.4			
Maximum	4.8	11.2	4.2			
0.1-0.9 percentile	2.7-4.2	3.0-10.5	2.6-4.0			
Count	30/30	30/30	33/33			

(c) Wet season summary statistics, 14 Feb 2001 to 25 Apr 2001

	TOC-wet ox (mg/L)	TOC-comb (mg/L)	DOC (mg/L)(wet)	% DOC/TOC (wet ox)	% DOC/TOC (comb)	Correlation TOC (ox) vs. DOC
Average	9.6	14.2	8.8	92	62	0.99
Minimum	4.0	5.2	3.9			
Maximum	17.2	28.8	14.4			
0.1-0.9 percentile	4.8-16.8	6.2-24.2	4.1-14.0			
Count	33/33	33/33	33/33			

comb = combustion method for TOC analysis
wet ox = wet oxidation method for TOC analysis

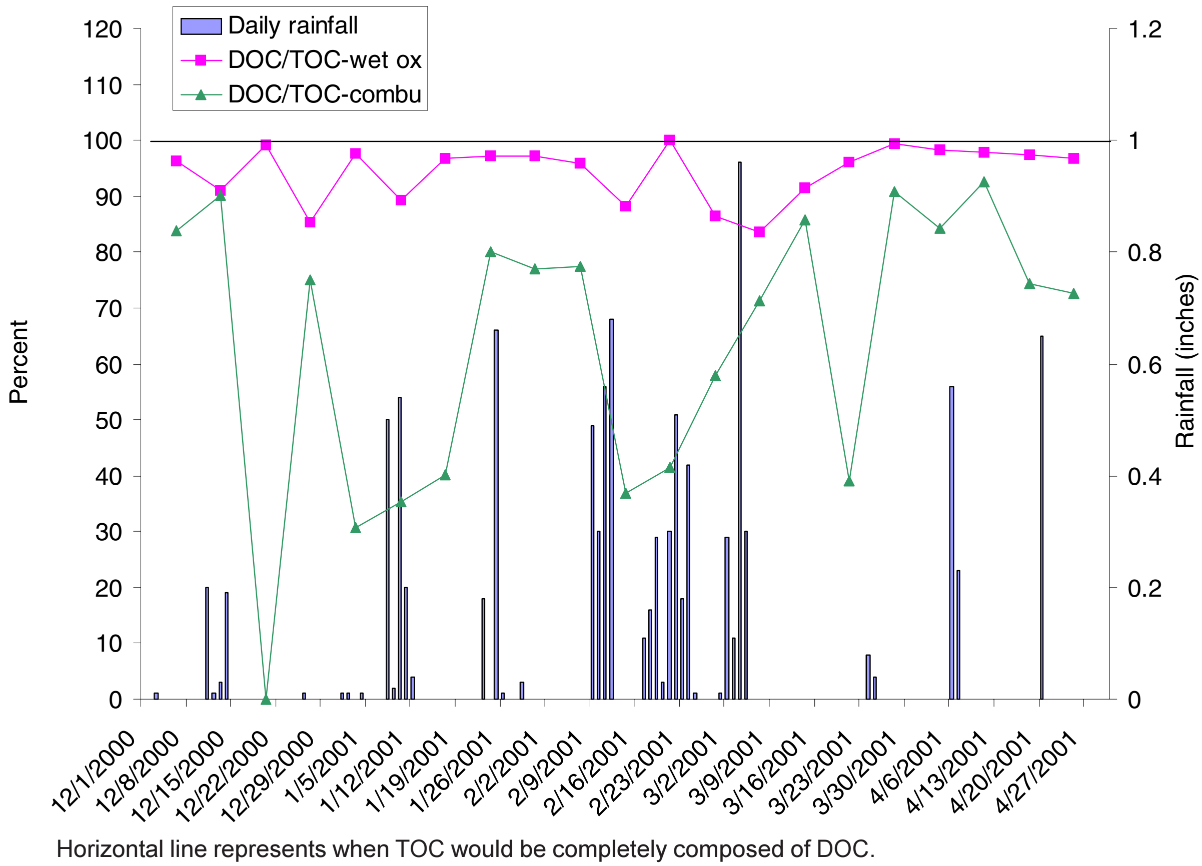
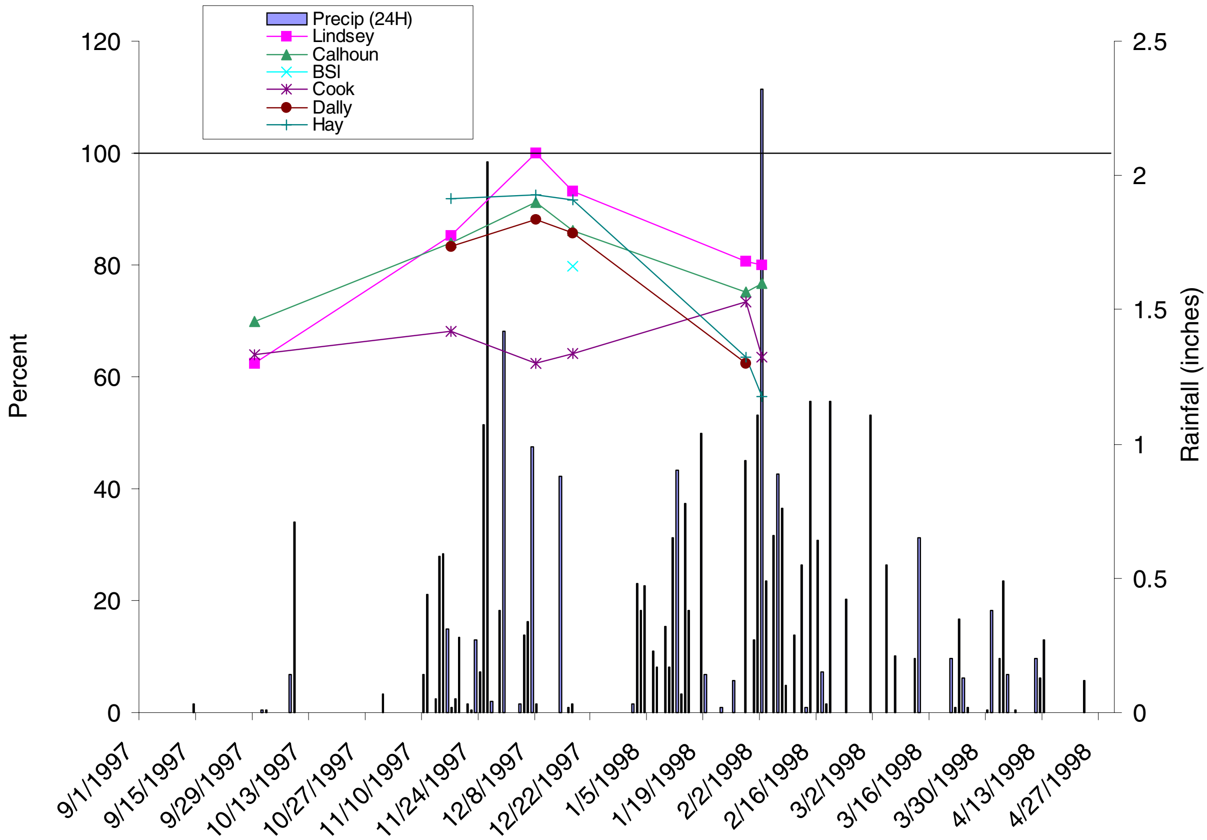


Figure 11 Ratio of DOC to TOC at the Barker Slough Pumping Plant

In 1996/1997, no strong SUVA pattern emerged from samples collected once a month, but in the 2000/2001 sampling year, carbon quality varied seasonally at the pumping plant (Table 9, Figure 13). In Figure 13, the generalized baseline of aquatic vs. terrestrial SUVA measurements is provided for comparison to calculated SUVA values. Prior to approximately 8 inches cumulative rainfall, average SUVA values at the pumping plant were 2.64, suggesting that prior to saturation, the carbon at the forebay was a mixture of aquatic and land-based carbon. Following approximately 8 inches of cumulative rainfall, the nature of the organic carbon changed. Average SUVA values increased above 3, indicating runoff from the terrestrial carbon sources. In the absence of rainfall, SUVA values at the pumping plant remained above 3 for nearly 2 months, suggesting that winter runoff was cleared slowly by the pumping plant and/or prolonged discharge of storm water occurred from surrounding sites (for example, Campbell Lake).

Correlation between UVA-254 and DOC was quite high. A significant Spearman rank correlation between the 2 parameters was 0.98.



Horizontal line represents when TOC would be completely composed of DOC.

Figure 12 Ratio of DOC to TOC by site, 1997/1998

Table 9 Summary statistics for specific absorbance (absorb/cm) by season at the Barker Slough Pumping Plant, 2000/2001

	Dry season	Wet season	Entire season
Avg	2.64	3.25	2.94
Min	2.33	2.63	2.33
Max	3.26	3.83	3.83
0.1-0.9 percentile	2.45-2.87	2.89 - 3.53	2.50 - 3.49
Count	33	33	66

Dry season = 29 Nov 2000 to 7 Feb 2001
Wet season = 14 Feb to 25 Apr 2001

Patterns at Barker Slough Pumping Plant

As discussed under Grab Sample Results in the Comparisons between Organic Carbon and Turbidity section, post-rainy levels of TOC and turbidity at the pumping plant and below Campbell Lake remained elevated relative to upstream sites. Elevated TOC and turbidity levels were not confined to the 1999/2000 sampling year or to the post-rainy season. Weekly samples were collected at the Barker Slough Pumping Plant in 3 of the 4 winter/spring sampling periods of this report (November 1998 through April 1999, November 1999 through March 2000, and December 2000 through April 2001). Organic carbon in the 1998/1999 sampling season remained elevated at the pumping plant in the absence of significant rainfall for approximately a 4-week period between mid-February and mid-March (Figure 14).

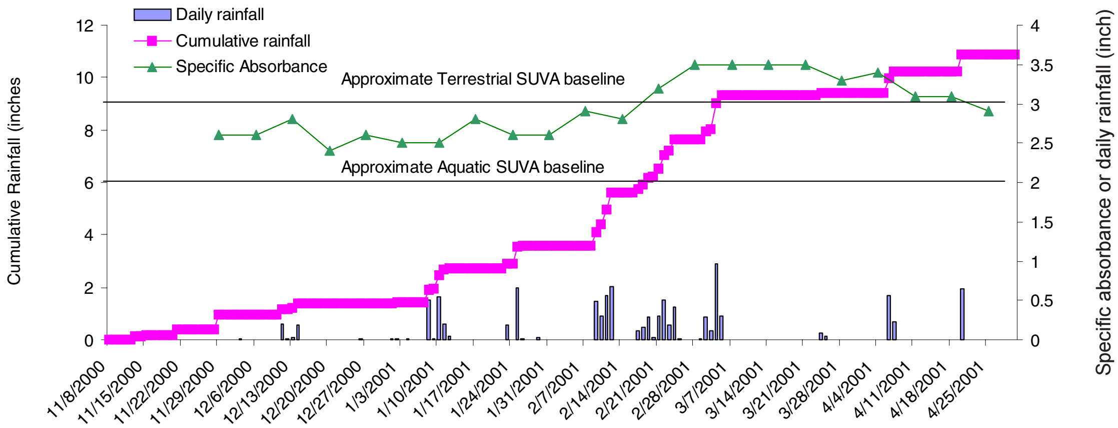


Figure 13 Average specific absorbance (absorbance/cm) vs. rainfall at Barker Slough Pumping Plant, Nov 2000 to Apr 2001

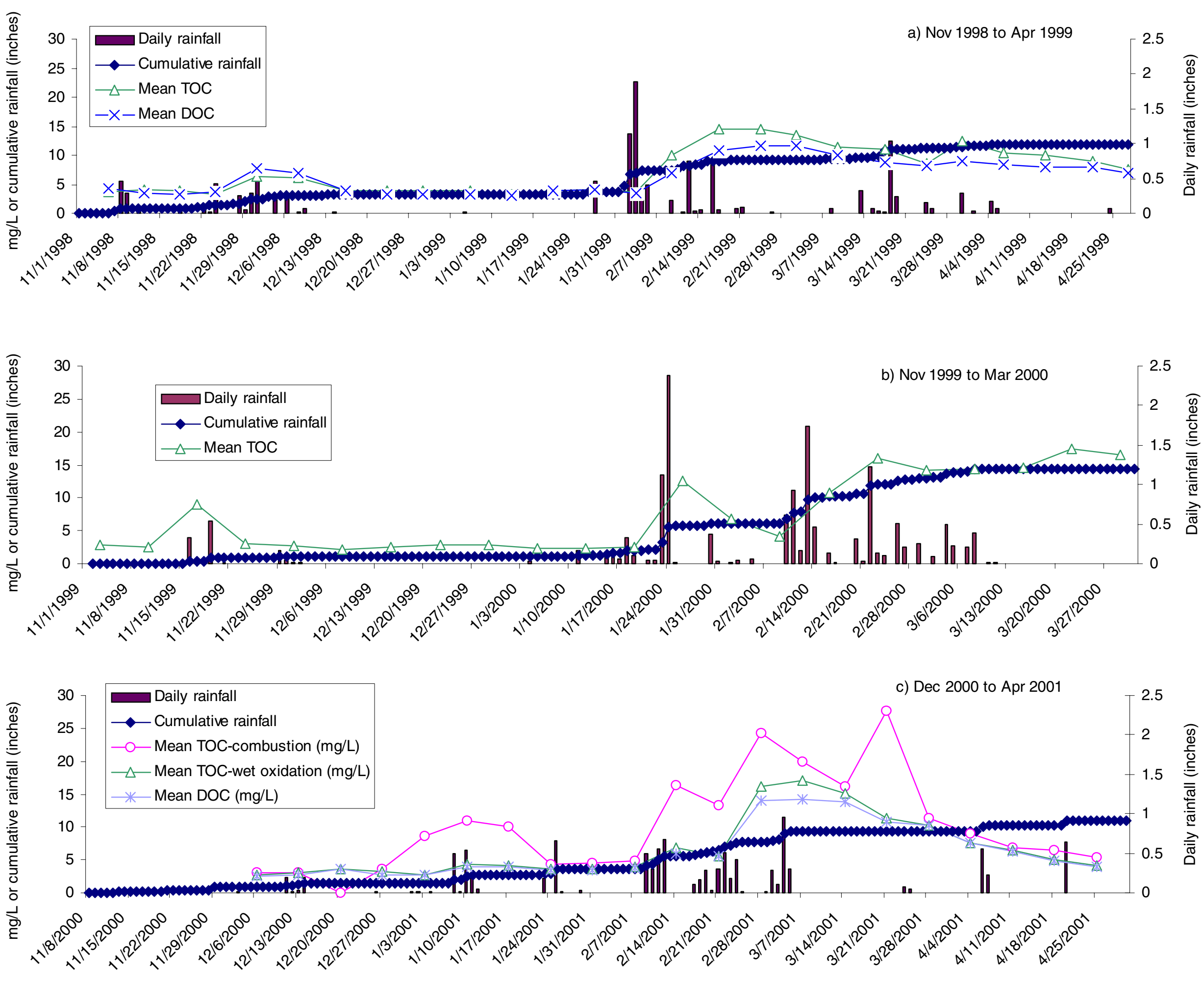


Figure 14 Comparison of TOC/DOC vs. rainfall at the Barker Slough Pumping Plant

Table 10 Total rainfall (inches) for periods sampled

Sample year	Rainfall (inches)	Comparable sampling period	Rainfall (inches)
9/97-3/98	33.6	11/97-3/98	32.6
11/98-4/99	11.9	11/98-3/99	11.5
11/99-3/00	14.5	11/99-3/00	14.5
11/00-4/01	10.9	11/00-3/01	9.4

Concentrations also remained elevated following the last major storm of the season through the end of the collection period in late April. In the 2000/2001 winter sampling season, virtually no rain fell for a 5-week period between March and April. Despite this, carbon levels remained elevated at the pumping plant for approximately 4 weeks, falling gradually to pre-rainy conditions. Rainfall levels were lower in the 2000/2001 sampling year (Table 10). Extended periods of elevated carbon concentrations are probably related to the amount of rainfall in the watershed, which influences the level of runoff to the forebay. As would be expected from variables that were fairly well correlated at this site, elevated levels of turbidity also occurred during periods of little or no rainfall (Figure 15).

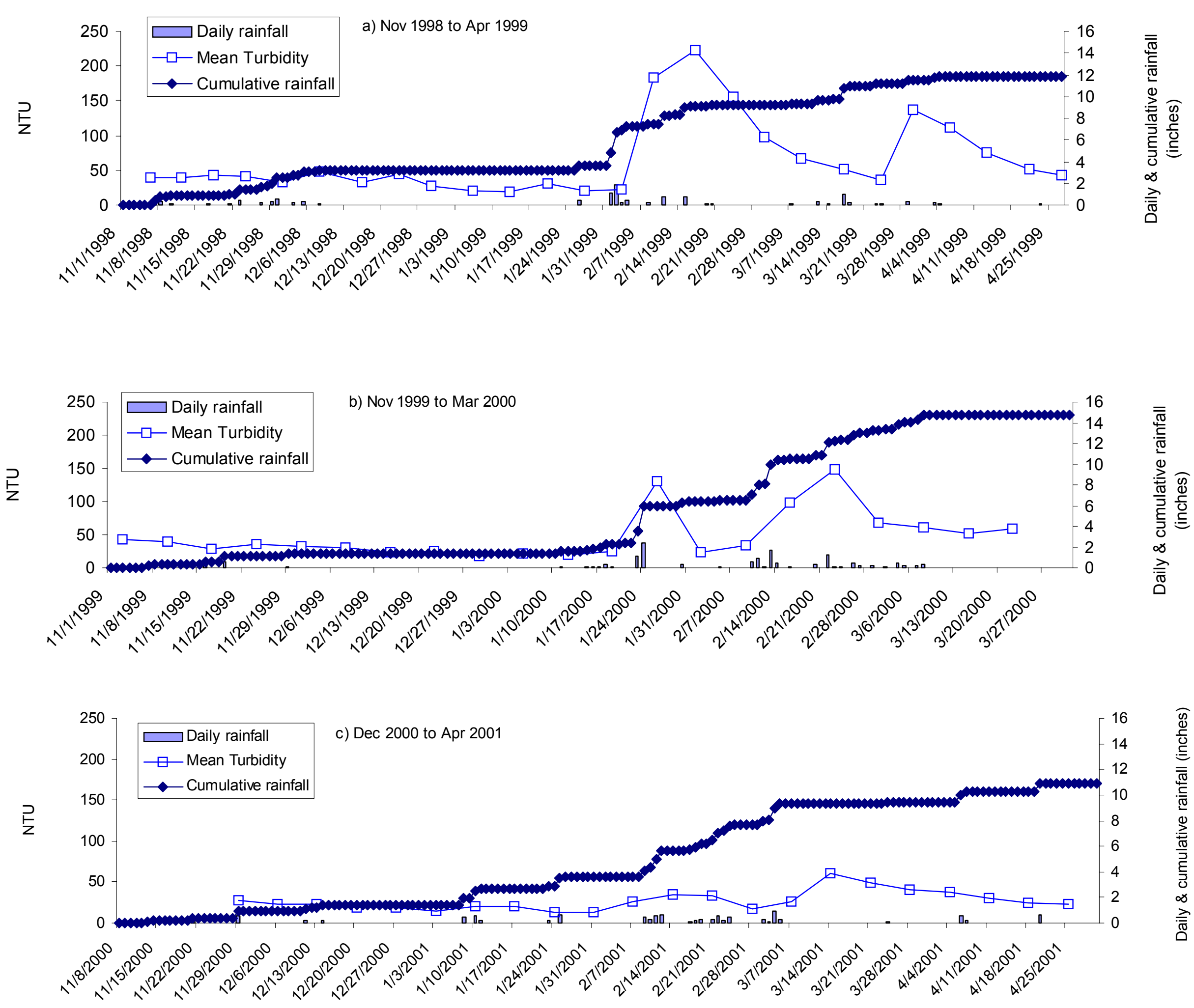


Figure 15 Comparison of turbidity vs. rainfall at the Barker Slough Pumping Plant

Table 11 Carbon loading (lbs/day) at Cook Lane

	Site	cfs	TOC (mg/L)	Loading (lbs/day)	24 hr. rainfall (inches)
12 Jan 1998	Cook Lane	294	19.1	30,214	0.9
2 Feb 1998	Cook Lane	471	15.6	39,535	2.3

Analysis of the pumping plant's weekly samples indicated that during the pre-rainy season, low amounts of rainfall could cause temporary increases in organic carbon concentrations, but sustained, elevated levels of organic carbon only occurred following 4 to 8 inches of cumulative rainfall (see Figure 14). This cumulative amount may represent the soil saturation point allowing bank sloughing, overland flow, or runoff from other sources to reach the pumping plant. As discussed in the previous section, SUVA patterns also reflected this shift to overland flows. Analysis of data collected between 1991 and 1996 reached a similar conclusion, suggesting that the watershed may become saturated after approximately 7 inches of cumulative rainfall (DWR 2000).

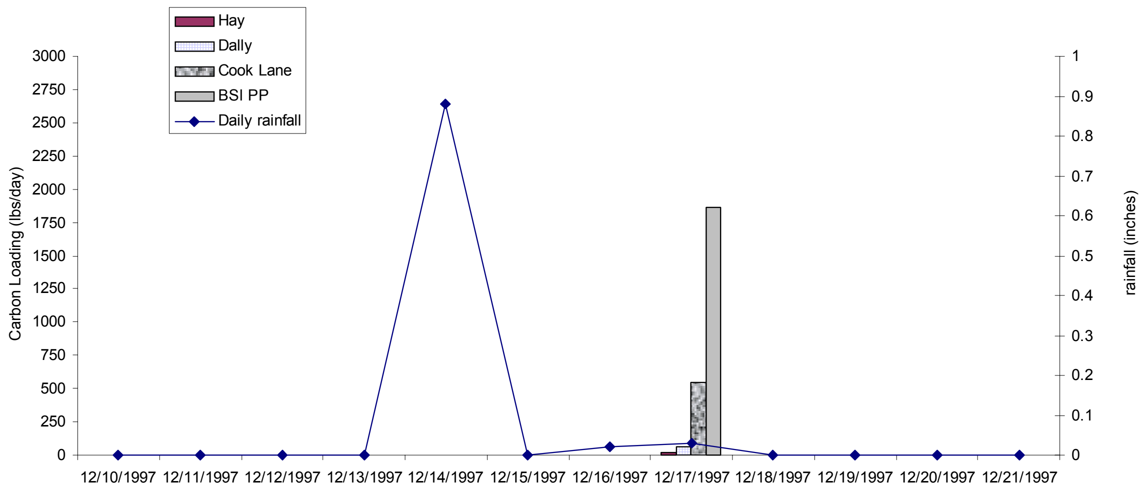
Loading

Loading calculations from the 1997/1998 sampling year suggested that the watershed was capable of producing very high carbon loads. During or immediately after large storm events, calculated flow at Cook Lane was measured at 294 cfs in January and 471 cfs in February. Carbon loads at Cook Lane associated with the events were 30,000 and 40,000 lbs/day for January and February, respectively (Table 11). At the time of the January measurements, 2.4 inches had fallen in the previous week and on the date of sampling, 0.9 inches fell during the 24-hour period. February sampling followed an intense storm period of approximately 1 month. Since monthly sampling dates at the Barker Slough Pumping Plant did not coincide with the storm measurements collected at Cook Lane, comparisons could not be made between the loads leaving Campbell Lake and the loads pumped into the NBA.

At the height of the storm season, samples were not collected at sites upstream of Cook Lane because of flooding, but loading calculations from samples collected earlier in the season suggested that carbon loads increased in an upstream to downstream direction. TOC concentrations were similar at the Hay and Dally road sites, but with increased flow, loads increased at Dally and increased further still downstream at Cook Lane (Figure 16). At the pumping plant, where load is affected by the rate of pumping and not natural flow, approximately 1,800 lbs of carbon per day were pumped into the NBA. Cumulatively, beginning in November 1997, approximately 2 inches of rain had fallen in the watershed, and a large rainstorm had occurred 3 days before on 14 December 1997.

Like the 1997/1998 season, carbon loads calculated from 1999/2000 data determined that carbon loading increased in an upstream to downstream direction in the watershed (Figure 17). Loading at the pumping plant did not represent the natural loading into the plant's forebay but the dynamics of the plant's pumping rate into the NBA. For this reason, loading patterns were different from upstream watershed sites.

As suggested by the 1997/1998 data, flow rather than concentration was often the most powerful influence determining the level of carbon loading. For example, on 23 February and 1 March 2000 carbon concentrations were similar at Junction and below Campbell Lake yet in both cases loading at Campbell Lake was higher than at Junction (see Figure 17). The same pattern was observed between



Site	cfs	TOC (mg/L)	Loading (lbs/day)
Hay	0.26	10.9	15
Dally	1.03	11.2	62
Cook	5.26	19.3	547
Barker Sl PP	29	11.9	1,860

Note: On 17 Dec 1997, TOC for Calhoun Cut and Lindsey Slough was 12.2 and 5.9 mg/L, respectively.

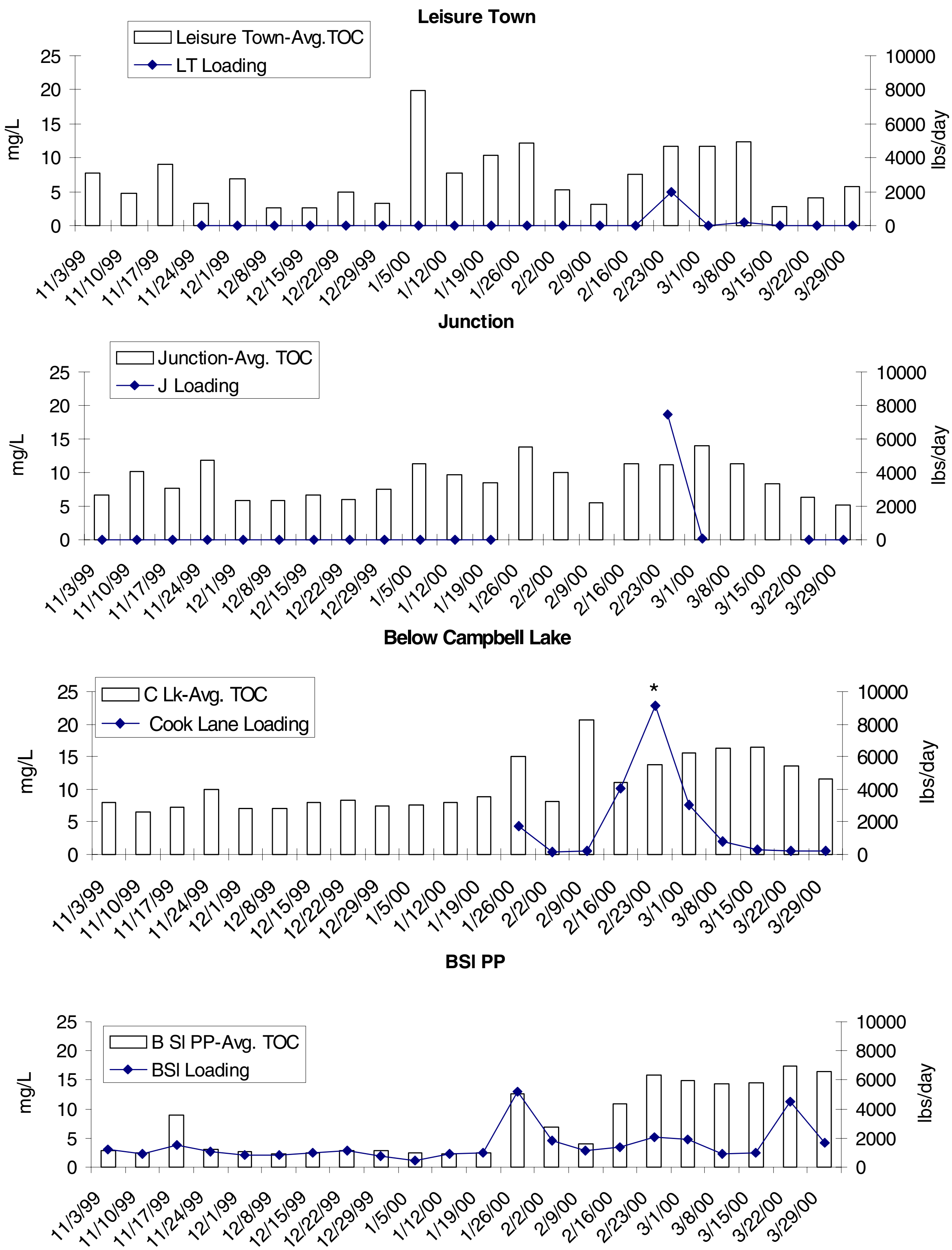
Figure 16 Carbon loading (lbs/day) on 17 Dec 1997 from 4 sites in the Barker Slough watershed

Junction and Leisure Town Road. Carbon loads also fell gradually at downstream sites while carbon loads fell more abruptly at sites farther upstream (for example, Leisure Town vs. below Campbell Lake).

The discharge from Campbell Lake suggested that, regardless of the dynamics occurring upstream, the extended period of discharge from the lake controlled the carbon load entering the pumping plant's forebay and provided a mechanism to explain elevated carbon levels at the pumping plant in the absence of rainfall. As discussed under Grab Sample Results in Patterns at Barker Slough Pumping Plant section, carbon concentrations at the pumping plant remained elevated for several weeks or months, after the end of winter rainfall.

Carbon loads exported from Campbell Lake were compared to carbon loads pumped into the NBA by the pumping plant (Figure 18, Table 12). Loading calculations determined that, given the plant's pumping rate, carbon loads leaving the lake over a 4-week period in the 1999/2000 sampling season could have provided between 90% and 400% of the carbon load pumped into the NBA. These results suggested that the excess carbon discharged from Campbell Lake to the forebay created a "reservoir" of carbon in the forebay, which the pumps drew from until the pool was "cleared" via continued pumping.

Campbell Lake's loading results explained the interaction pattern observed with the 2-way ANOVA and underscored the importance of Campbell Lake on the pumping plant's water quality. In the absence of other imports, the size of the carbon pool contributed by Campbell Lake is probably related to the seasonal rainfall in the watershed. Wetter years create a longer runoff period resulting in a longer period of discharge from Campbell Lake. Confounding this phenomenon, pumping rates generally decrease in



* Estimated value using Junction cfs. Water overflowed bank on this date.

Figure 17 Average TOC concentration (mg/L) and carbon loading (lbs/day) by site

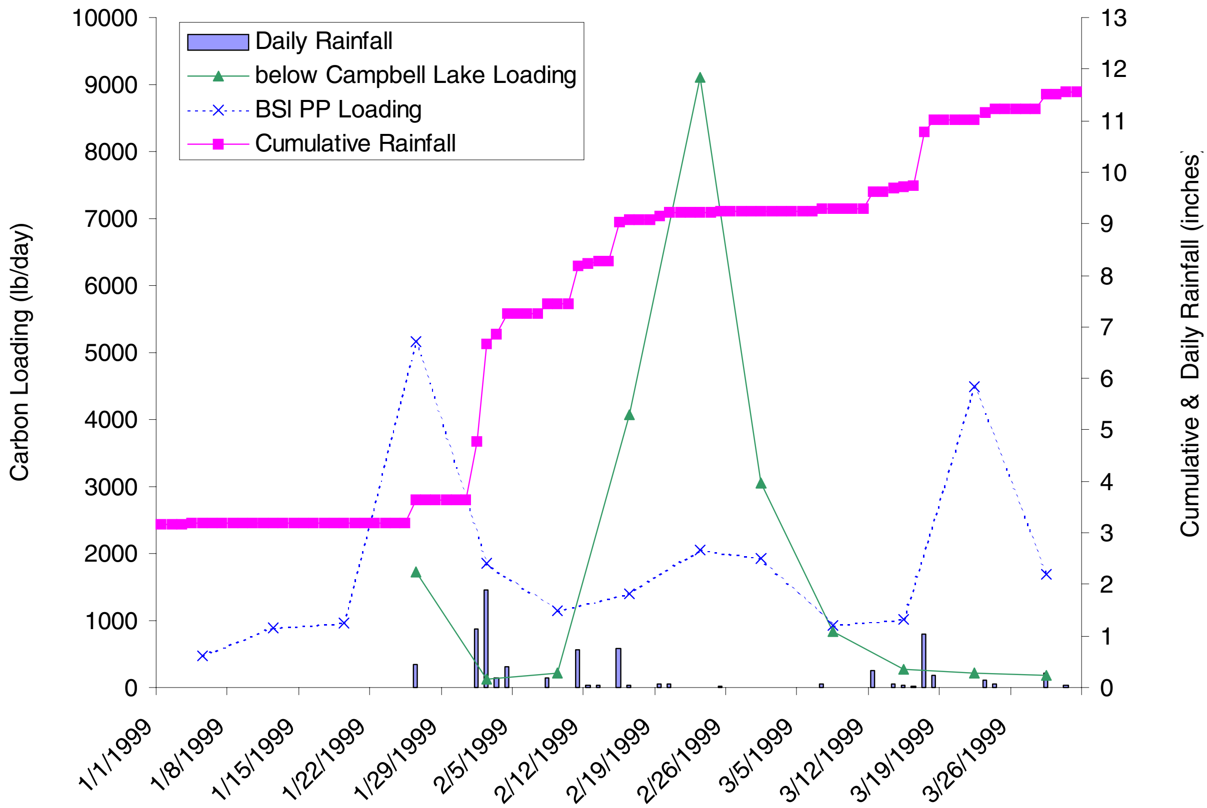


Figure 18 TOC loading below Campbell Lake and the Barker Slough Pumping Plant

Table 12 Percent of TOC load provided by Campbell Lake to the Barker Slough Pumping Plant, winter 2000

	Campbell Lake (lbs/day)	Barker Slough (lbs/day)	% Contribution by Campbell Lake
26 Jan	1,727	5,162	33
2 Feb	131	1,860	7
9 Feb	223	1,149	19
16 Feb	4,064	1397	290
23 Feb	9,104*	2,057	443
1 Mar	3,054	1,928	158
8 Mar	833	930	90
15 Mar	268	1,016	26
22 Mar	221	4,494	5
29 Mar	189	1,690	11

* Estimated value using Junction cfs. Water overflowed bank at Campbell Lake measuring station.

the winter, resulting in a longer clearance period of the high carbon reservoir.

One hypothesis to explain the creation of a high carbon pool at the forebay and the lack of flushing at the plant is the formation of a hydrologic plug created in the winter by a flooded Yolo Bypass. While this could reinforce winter hydrologic patterns, it is not necessary to invoke a hydrologic plug to create a reservoir pool of carbon. For example, during winter 2000/2001, the Yolo Bypass never filled with water, but carbon levels at the pumping plant in the 2000/2001 sampling season showed a similar pattern to previous years when the bypass had flooded (see Figure 14). This argues that other potentially localized factors play an important role in the creation of a reservoir pool of carbon.

In the absence of outside forces, the plant's pumping rate would determine how quickly the pool of carbon created from Campbell Lake

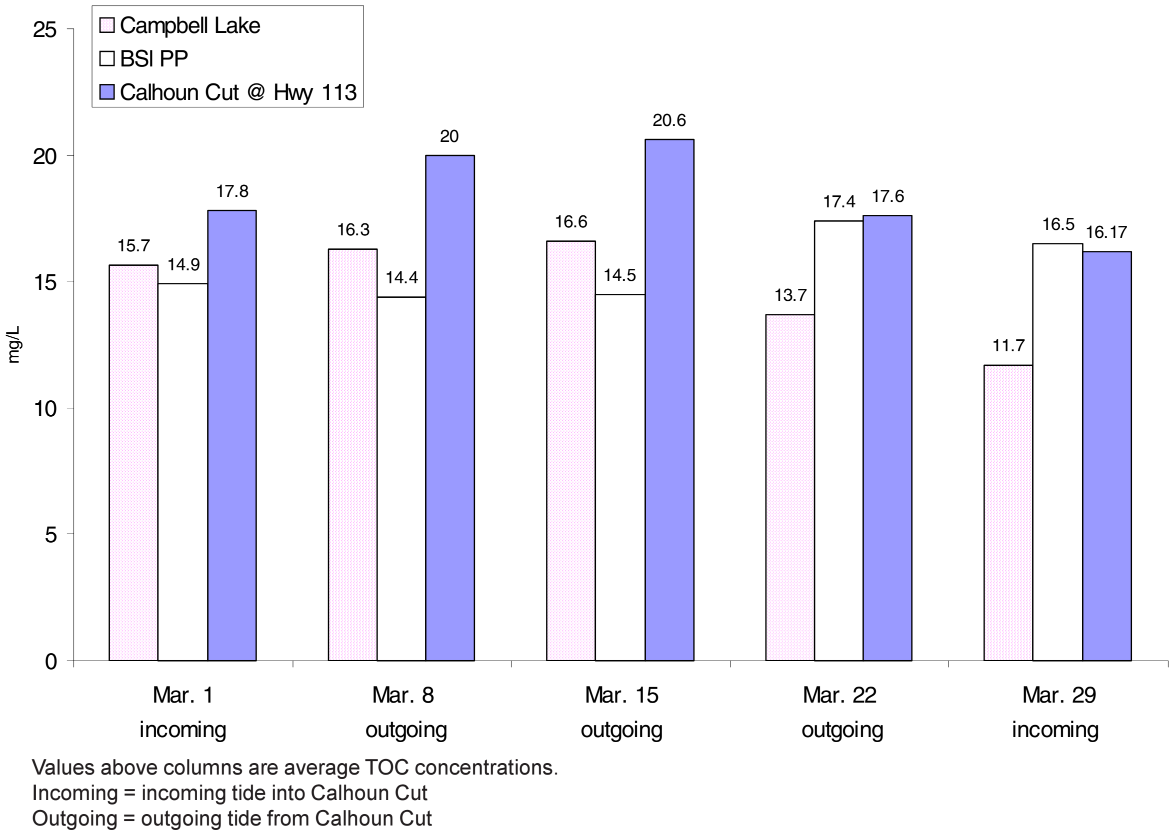


Figure 19 Average TOC concentrations (mg/L), Mar 1999, by site: below Campbell Lake, Barker Slough Pumping Plant, and Calhoun Cut

exports becomes exhausted, but the forebay's water quality may also be influenced by waters downstream of the pumping plant. Samples were collected from Calhoun Cut beginning 1 March 2000. No attempt was made to isolate the cut's watershed from tidal effects, but on both an incoming and outgoing tide, carbon concentrations in Calhoun Cut remained relatively stable (Figure 19). Because the 1st year of sampling suggested that waters as far downstream as Lindsey Slough may not affect winter Barker Slough water quality, the lower pumping rate or the potential formation of a hydrologic plug from a flooded Yolo Bypass may serve to keep water discharged from Calhoun Cut near the pumping plant. The hydrology of Calhoun Cut, Lindsey Slough, and the Yolo Bypass in the winter has not been examined. If Calhoun Cut's soil and runoff dynamics are similar to those of the Barker Slough watershed, then depending on whether the cut's water is drawn to the pumping plant, Calhoun Cut may also contribute to the reservoir pool of carbon. Hydrology studies are required to determine if this hypothesis is correct.

Bacteria

In the 1997/1998 sampling year 6 samples, at most, were collected at any site for *E. coli* analysis. With so few samples, it was difficult to establish patterns between the occurrence of rainfall and/or turbidity on *E. coli* numbers (Figures 20 and 21). For example, data in Figure 21 suggest that at some sites (Lindsey, Dally, and Hay), *E. coli* densities increased with turbidity; however, at other sites, the evidence was inconclusive (for example, at the Barker Slough PP) or showed no correlation with turbidity (Calhoun Cut or Cook).

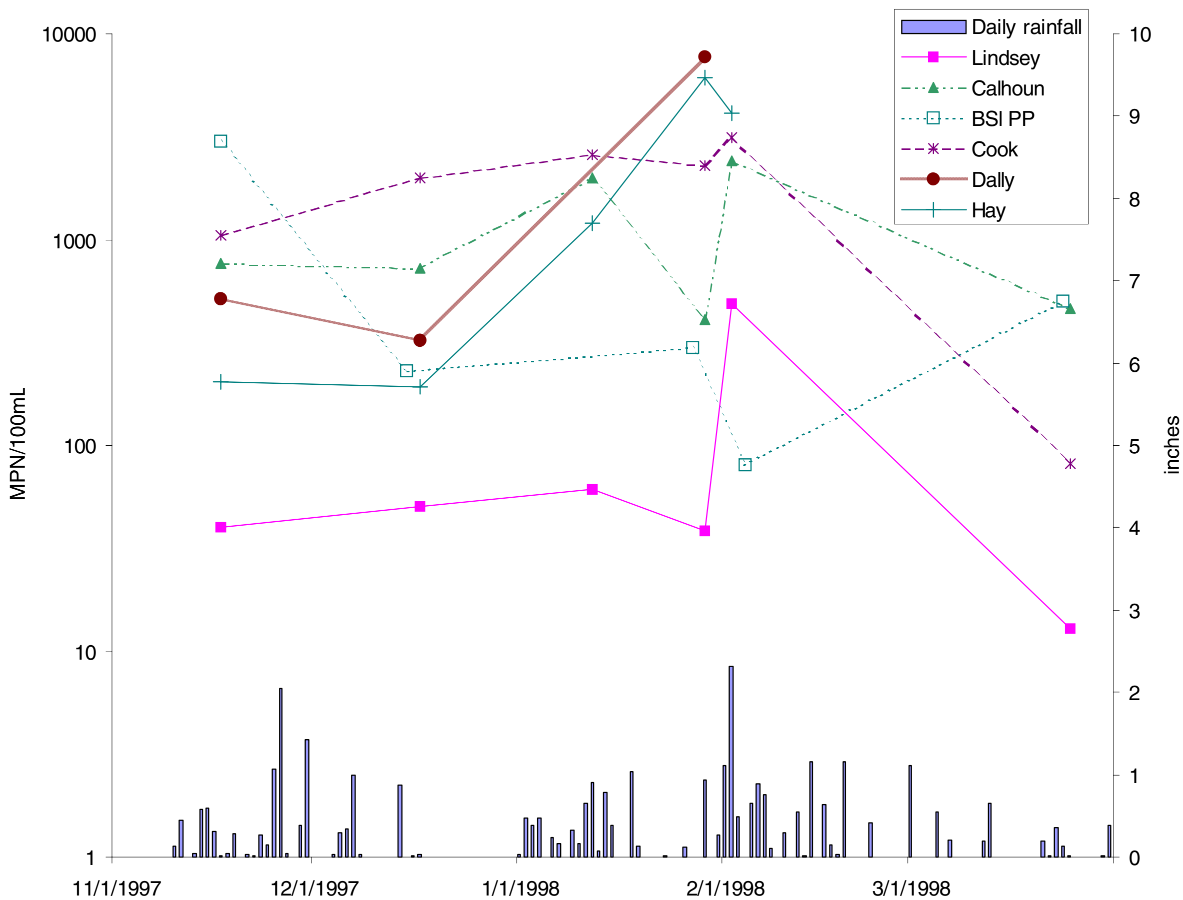


Figure 20 *E. coli* (MPN/100 mL) vs. rainfall

Although little bacteria data were collected in the 1997/1998 sample year, comparisons of *E. coli* densities between sites provided further evidence that Lindsey Slough had little impact on pumping plant winter water quality. Of the 5 samples that were directly comparable, the median *E. coli* densities at Lindsey Slough were lower by at least an order of magnitude from bacterial densities encountered upstream (Table 13). Large differences between Lindsey Slough bacterial densities and upstream sites were also observed the previous year (DWR 1998b). Median *E. coli* densities were consistently the highest at Cook Lane while the highest maximum densities occurred at Dally and Hay roads (see Table 13).

Weekly samples for total, fecal, and *E. coli* were collected at the pumping plant in the 2000/2001 winter sampling season (Table 14). For each bacterial group, median densities remained similar regardless of the season. Variability, however, increased during the winter, reflecting changes in bacterial numbers due to rainfall events. As expected, bacterial densities increased after storm events (Figure 22). Nondetects only occurred in the non-rainy season. Because so few samples were collected at Barker Slough in the 1997/1998 sampling season (n=3), no trend comparisons between the 2 sampling years were possible.

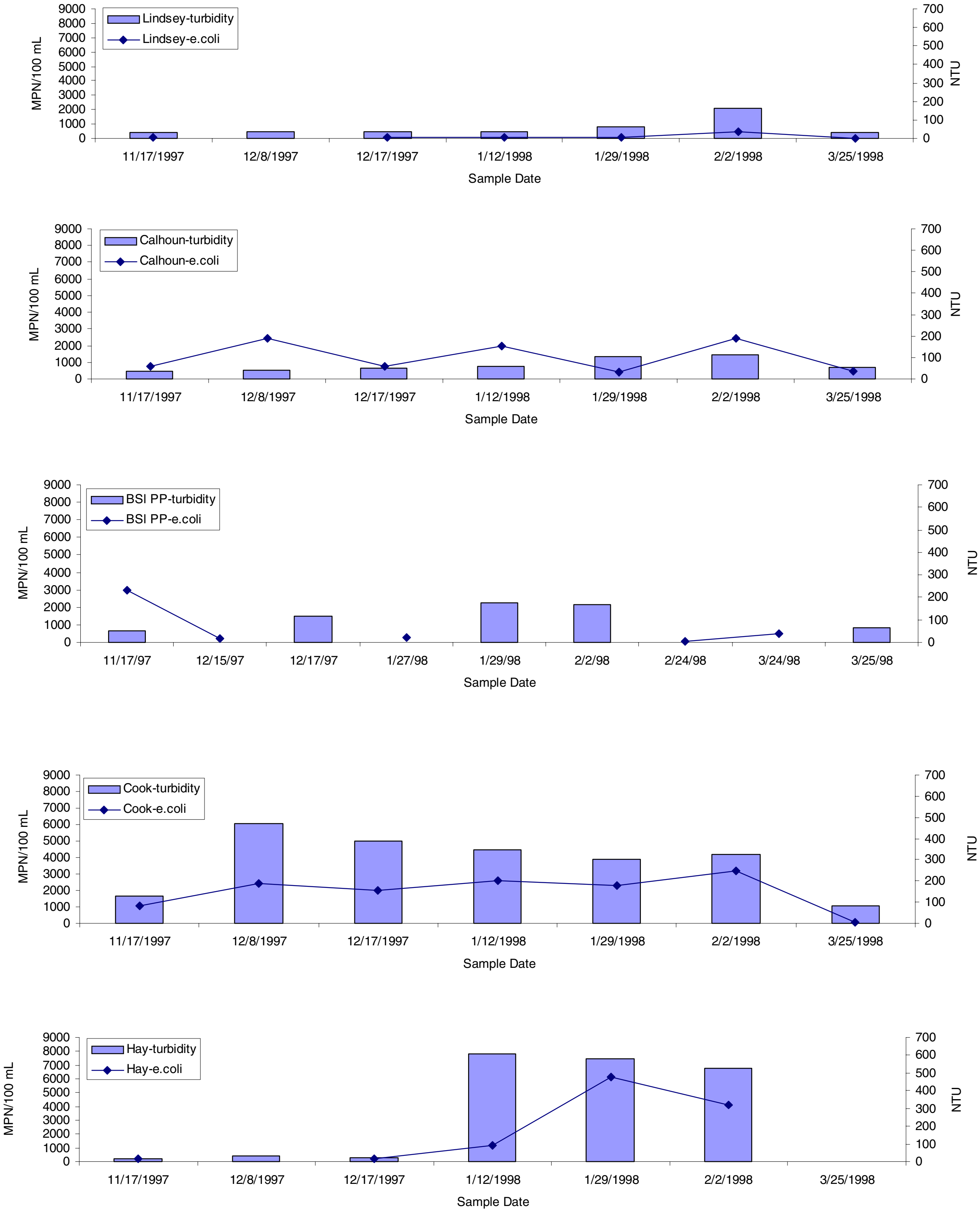


Figure 21 *E. coli* (MPN/100 mL) vs. turbidity (NTU), 1997/1998 sampling year

Table 13 Summary statistics of *E. coli* (MPN/100 mL), Nov 1997 to Feb 1998

	Lindsey Slough	Calhoun Cut	Barker Slough PP*	Cook Lane	Dally Road**	Hay Road
Median	50	770	300	2282	517	1203
Minimum	38	411	230	1046	326	192
Maximum	488	2419	3000	3148	7701	6131
10-90 Percentile	39-317	537-2246	244-2460	1422-2929	364-6264	197-5321
n	5	5	3	5	3	5

* Samples not directly comparable to other sites. Samples collected on different days from other sampling sites.
** Samples not directly comparable to other sites. Some samples not collected due to flooding.

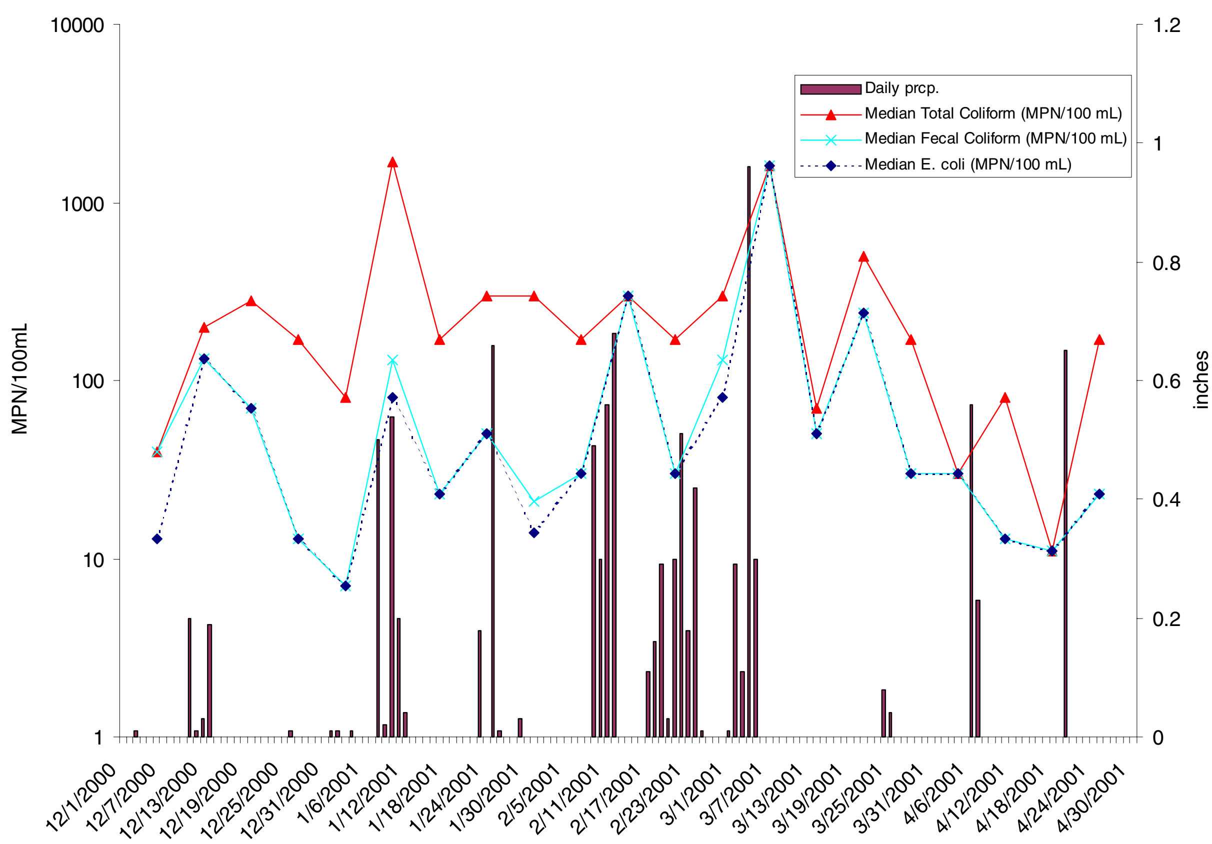


Figure 22 Median bacteria densities vs. rainfall, 1 Dec 2000 to 30 Apr 2001

Table 14 Barker Slough Pumping Plant bacterial summary statistics (MPN/100 mL) for 2000/2001 winter sampling season

(a) Season total summary statistics, 29 Nov 2001 to 25 Apr 2001

	Total coliform*	Fecal coliform*	*E. coli** (modified MUG)
Median	170	40	30
Minimum	11	0	0
Maximum	9,000	1,600	1,600
10-90 percentile	35-1250	12-240	9.5-220
Detects/total samples	66/66	65/66	64/66

(b) Dry season summary statistics, 29 Nov 2000 to 7 Feb 2001

	Total coliform*	Fecal coliform*	*E. coli** (modified MUG)
Median	170	30	30
Minimum	20	0	0
Maximum	9000	200	200
10-90 percentile	72-820	9-130	7-126
Detects/total samples	33/33	32/33	31/33

(c) Wet season summary statistics, 14 Feb to 25 Apr 2001

	Total coliform*	Fecal coliform*	*E. coli** (modified MUG)
Median	170	50	50
Minimum	11	4	4
Maximum	1,600	1,600	1,600
10-90 percentile	30-1,380	13-1,340	13-1,340
Detects/total samples	33/33	33/33	33/33

* For statistics, values < DL changed to 0.
Values > the upper DL changed to upper DL.

Autosampler Results

Background

In order to understand organic carbon or turbidity patterns during a rainfall event, it was desirable that real-time sampling (a) capture the full hydrograph to examine the complete pattern during a storm, (b) capture a large enough storm to examine the connections between the watershed and the slough as opposed to smaller localized effects, and (c) collect enough samples throughout the storm to clearly discern patterns.

The use of autosamplers presented technological challenges that often led to incomplete data sets and complicated data interpretation. Table 15 lists the sites and dates sampled by autosamplers. Table 16

Table 15 Summary of autosampler history

(a) 1998/1999 sampling season

	5 Dec to 6 Dec 1999	6 Feb to 7 Feb 1999	24 Mar to 25 Mar 1999
Leisure Town Road	x	Equipment problems- no samples collected	x
Junction	Equipment problems- no samples collected	x	Equipment problems- no samples collected
Below Campbell Lake	x	x	x
Barker Slough PP	x	x	x

(b) 1999/2000 sampling season

	23 Jan to 24 Jan 2000	11 Feb to 12 Feb 2000	4 Mar to 6 Mar 2000
Leisure Town Road	x	x	x
Junction	x	x	Equipment problems- no samples collected
Below Campbell Lake	Equipment problems- no samples collected	Equipment problems- no samples collected	x
Barker Slough PP	Equipment problems- no samples collected	No sample between 20 and 24 hours	x

x = all samples collected

contains a summary of the degree to which the hydrograph was captured and the intensity of rainfall measured at the Barker Slough Pumping Plant, 24 hours prior and during autosampler activation. For comparative purposes all 24-hour rainfall data used the start time for autosampler initiation at the Leisure Town Road site to determine storm intensity.

Of the samples listed in Table 16, samples collected on 6 February 1999, 24 March 1999 and 4 March 2000 captured all or most of a storm hydrograph. Of these 3 events, the 6 February 1999 samples were collected when the watershed was saturated and during one of the largest storms of the 2 sampling seasons. This sampling event provided the best data linking the watershed with the slough. For this reason conclusions were developed primarily from the results of this storm event. The conclusions were then examined against the remaining storm events with semi-complete hydrograph data (24 March 1999 and 4 March 2000). The lack of hydrographic data at the remaining sites made data interpretation problematic because no relationship could be established between the stream and the analyte, but for comparative purposes, all hydrographic data were included in Appendix I.

Spatial and Temporal Patterns

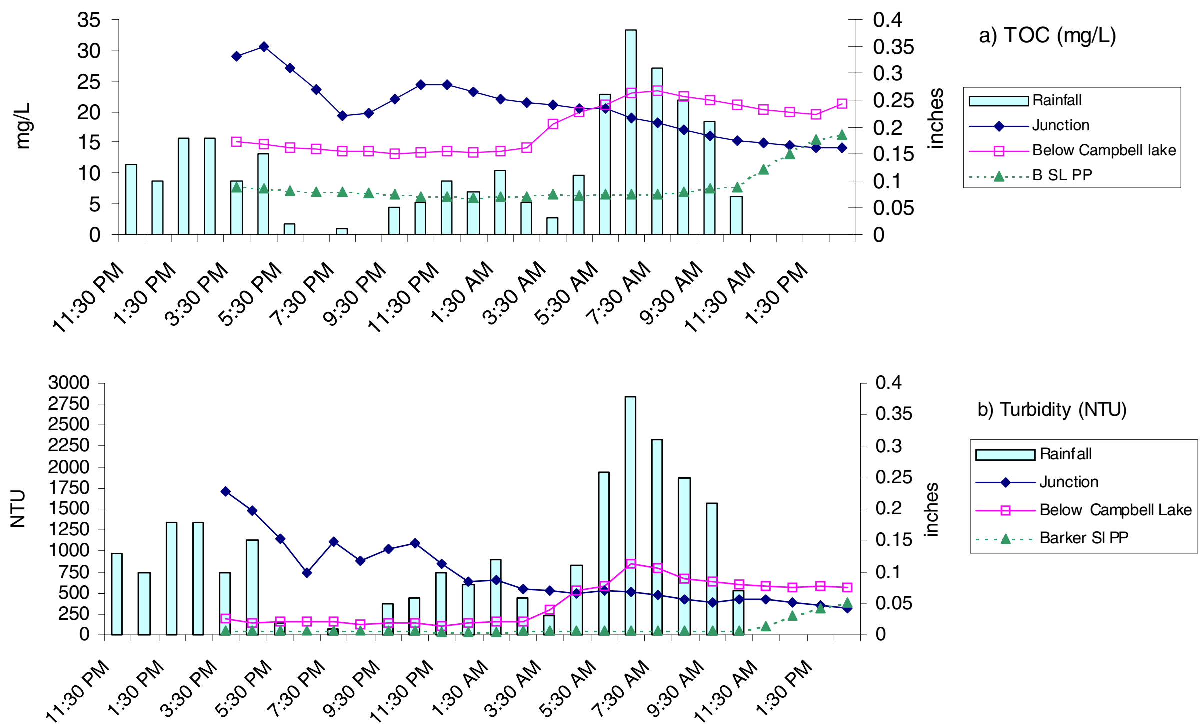
Under saturated conditions and rainfall of an inch or more, TOC and turbidity dynamics during a rainstorm exhibited a distinct pulsed effect that began at the top of the watershed and moved progressively downstream. In February 1999, TOC and turbidity at Junction were initially captured at high levels,

Table 16 Hydrographic summary of autosamplers with flow/stage height data

Sampling event	Rainfall* (inches) 24 hours prior	Rainfall* (inches) 24 hours during	Sample site	Hydrograph summary
5 Dec to 6 Dec 1998	0.09	0.28	Leisure Town Road	No change in storm hydrograph. Storm magnitude too small.
			Below Campbell Lake	Flow equipment off-line or instrument error. No hydrograph captured.
6 Feb to 7 Feb 1999	0.65	2.55	Junction	Captured full storm hydrograph.
			Below Campbell Lake	Captured rising limb of storm hydrograph.
24 Mar to 25 Mar 1999	0.92	0.53	Leisure Town Road	Missed rising limb of storm hydrograph.
			Below Campbell Lake	Missed falling limb of storm hydrograph.
23 Jan to 24 Jan 2000	0.58	2.81	Leisure Town Road	Flow equipment off-line or instrument error. No hydrograph captured.
			Junction	Flow equipment off-line or instrument error. No hydrograph captured.
11 Feb to 12 Feb 2000	0.32	0.8	Leisure Town Road	Flow equipment off-line or instrument error. No hydrograph captured.
			Junction	Flow equipment off-line or instrument error. No hydrograph captured.
4 Mar to 6 Mar 2000	0	0.28	Leisure Town Road	Captured full storm hydrograph.
			Below Campbell Lake	Missed rising limb of storm hydrograph.

* Rainfall determined from Barker Slough Pumping Plant rainfall gage.
Used initiation time at Leisure Town Road for all 24-hour rainfall data.

which fell as sampling progressed (Figure 23). Approximately 12 hours after the detection of peak concentrations at Junction, an increase in TOC and turbidity was observed downstream below Campbell Lake. Farther downstream at the pumping plant, TOC and turbidity began increasing approximately 20 hours after the initial pulse recorded at Junction. A similar pattern was observed a month later. In the case of the storm event captured on 24 March 1999, data from Junction were not available, but the pulse that began at Leisure Town Road in the early morning of 25 March appeared downstream below Campbell

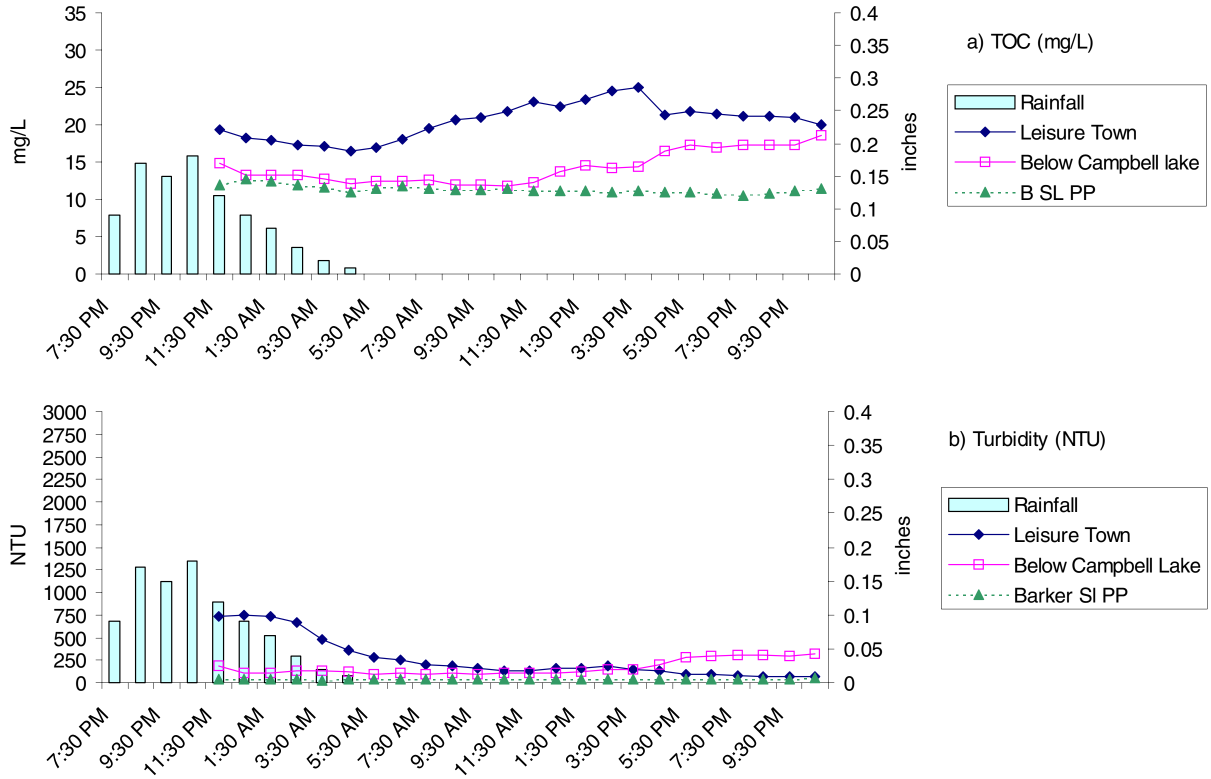


Rainfall collection times moved up 0.5 hours to correspond to trigger times of autosamplers.

Figure 23 TOC and turbidity autosampler results by site, 6 Feb to 7 Feb 1999

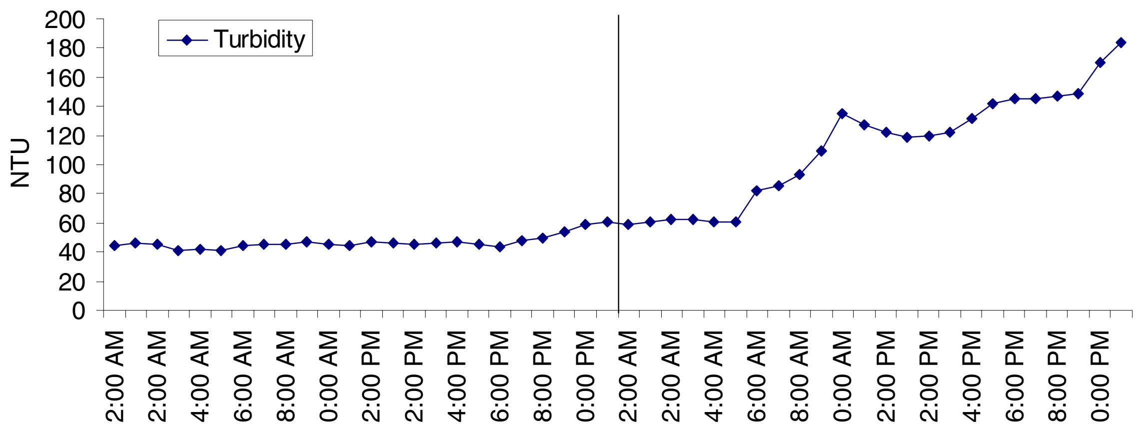
Lake approximately 7 hours later (Figure 24). No pulse was captured farther downstream at the pumping plant, but the plant's online records record a turbidity pulse arriving at the pumping plant approximately 7 hours after the autosampler had completed its 24-hour sampling program (Figure 25). No pulses were recorded for the 4 March 2000 sampling event, but 48-hour rainfall totals were only 0.28 inches. There may have been too little rainfall to generate a pulse or create a linkage between the watershed and the stream. These dynamics suggest that during a strong enough rainfall event, under saturated conditions, the initial TOC and turbidity rise experienced at the pumping plant occurs as a result of upstream processes.

Concentration data in combination with hydrologic data suggested that both analytes were flushed from the watershed. The relationship was best observed in samples collected below Campbell Lake in February 1999. Initially TOC and turbidity rose as the hydrograph rose, but their levels decreased as discharge continued to increase (Figure 26). This pattern is typical of toxicants that are flushed from a watershed. The same pattern may have occurred a month later below Campbell Lake, but autosampling ended before concentrations presumably decreased (Figure 27). Samples collected at Junction in February 1999 missed the initial rise of the hydrograph, but like samples collected downstream, both TOC and turbidity fell as discharge continued to increase (Figure 28). In March 2000, samples collected below Campbell Lake also displayed the same concentration decline as discharge continued to increase (Figure 29). At Leisure Town Road, turbidity concentrations may have fallen more rapidly than those of TOC (Figure I-11 in Appendix I). It is not known whether an outside source supplies carbon to Leisure Town or whether this was an artifact of sampling.



Rainfall collection times moved up 0.5 hours to correspond to trigger times of autosamplers.

Figure 24 TOC and turbidity autosampler results by site, 24 Mar to 25 Mar 1999



Vertical line indicates end of autosampler sampling period.

Figure 25 Online turbidity recorder at the Barker Slough Pumping Plant during 24 Mar to 25 Mar 1999 autosampling

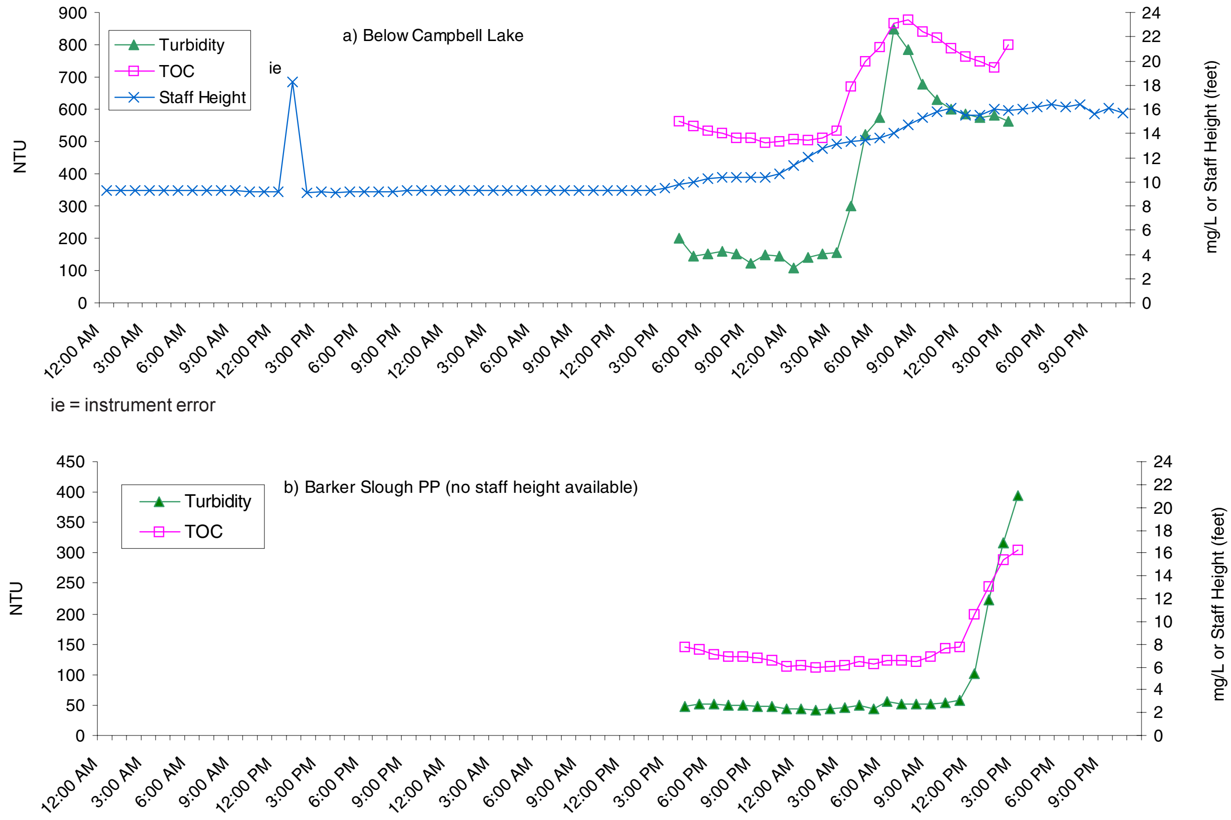
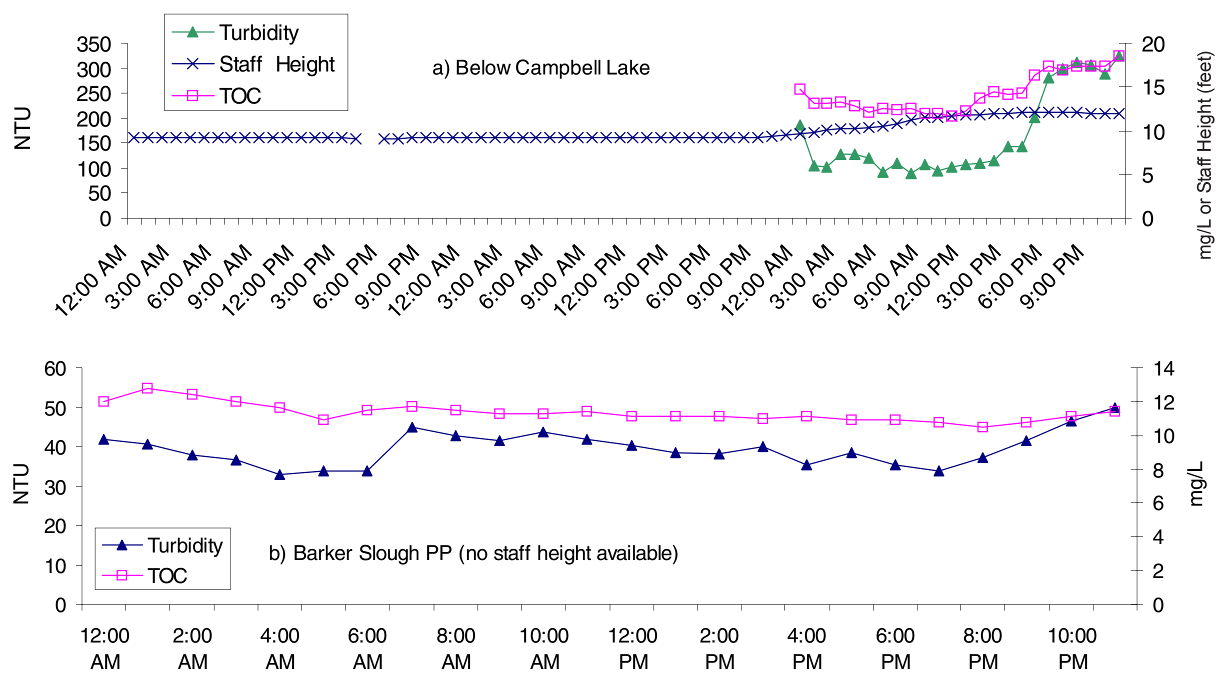


Figure 26 Staff heights vs. TOC and turbidity, 6 Feb 1999



Autosampler trigger times moved forward 0.5 hr. to correspond to flow measurements.

Figure 27 Staff height vs. TOC & turbidity, 24 Mar 1999

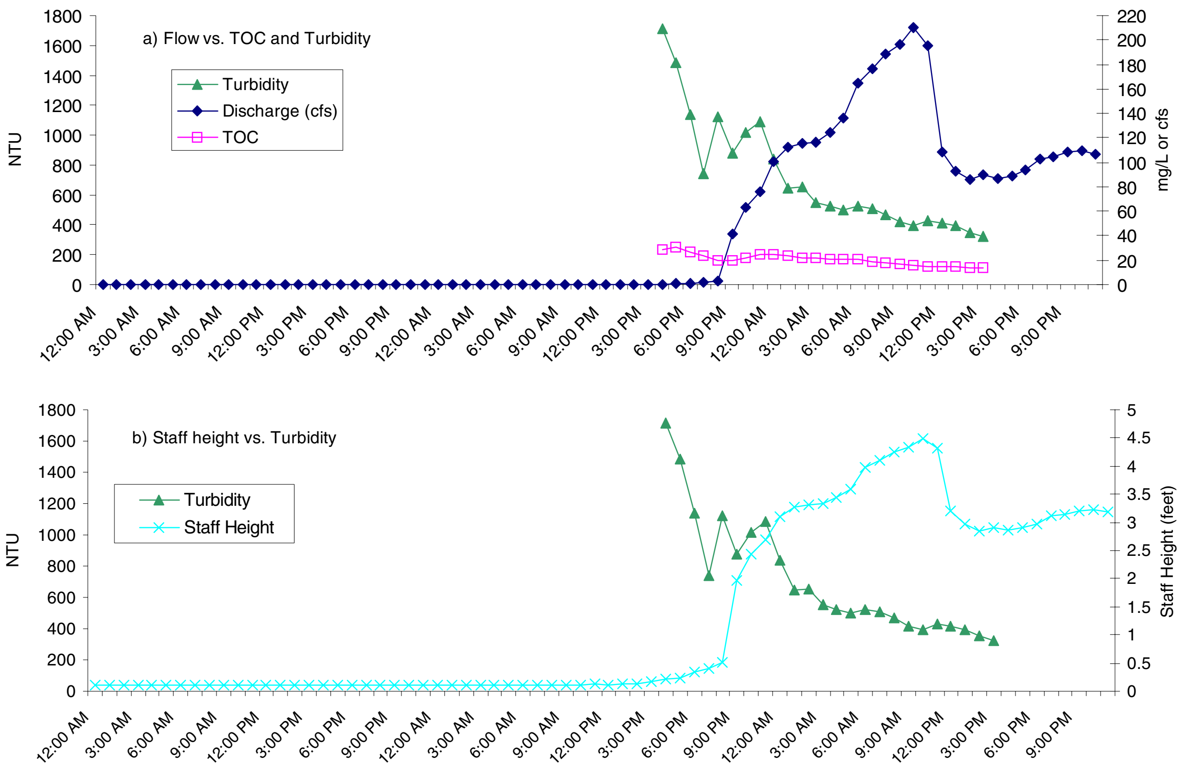


Figure 28 Junction flow and staff height vs. TOC and turbidity, 6 Feb 1999

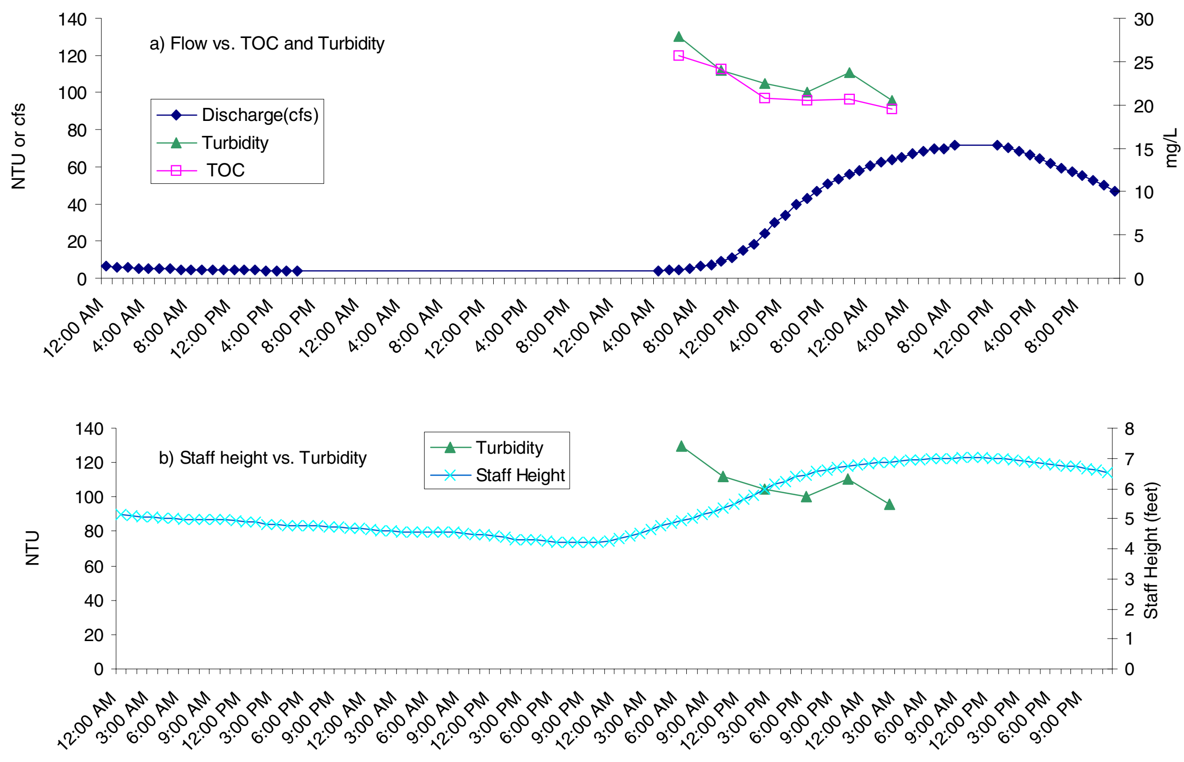


Figure 29 Below Campbell Lake flow and staff height vs. TOC and turbidity, 5 Mar 2000

Table 17 Correlations between TOC and turbidity from autosample samples

(a) 1998/1999 sampling season

	5 Dec to 6 Dec 1999	6 Feb to 7 Feb 1999	24 Mar to 25 Mar 1999
Leisure Town Road	0.77	Equipment problems- no samples collected	-0.61
Junction	Equipment problems- no samples collected	0.88	Equipment problems- no samples collected
Below Campbell Lake	0.96	0.92	0.85
Barker Slough PP	ns	0.83	ns

(b) 1999/2000 sampling season

	23 Jan to 24 Jan 2000	11 Feb to 12 Feb 2000	4 Mar to 6 Mar 2000
Leisure Town Road	ns	ns	ns
Junction	ns	ns	Equipment problems- no samples collected
Below Campbell Lake	Equipment problems- no samples collected	Equipment problems- no samples collected	0.81
Barker Slough PP	Equipment problems- no samples collected	0.97	-0.82

ns = correlation not significant at $p < 0.05$

Correlations between TOC and Turbidity

Unlike weekly grab samples, autosampler samples of TOC and turbidity were generally highly correlated with rainfall events (Table 17). With few exceptions, correlations between TOC and turbidity were above 0.8 for samples with the most complete data sets (6 February 1999, 24 March 1999, and 4 March 2000). It is likely that during a storm event the water column becomes fairly well mixed, which could eliminate the sampling issues discussed previously for grab samples.

Two samples were negatively correlated (Leisure Town, 24 March 1999; Barker Slough, 4 March 2000), and no significant correlation was observed for 1 sample collected at Barker Slough (24 March 1999). The reason for the negative correlation at Leisure Town was unknown; however, the negative and nonsignificant correlations recorded at Barker Slough may have occurred due to random fluctuations prior to the pulse reaching the forebay.

Total Organic Carbon vs. Dissolved Organic Carbon

Dissolved organic carbon concentrations increased after the passage of a turbidity pulse. For example, at Junction, at the height of the turbidity pulse, DOC comprised only 40% of the TOC, but as the turbidity pulse decreased, the proportion of DOC increased (Figure 30). Downstream, a similar dynamic was observed below Campbell Lake and at the pumping plant. Below Campbell Lake, the pulse was not

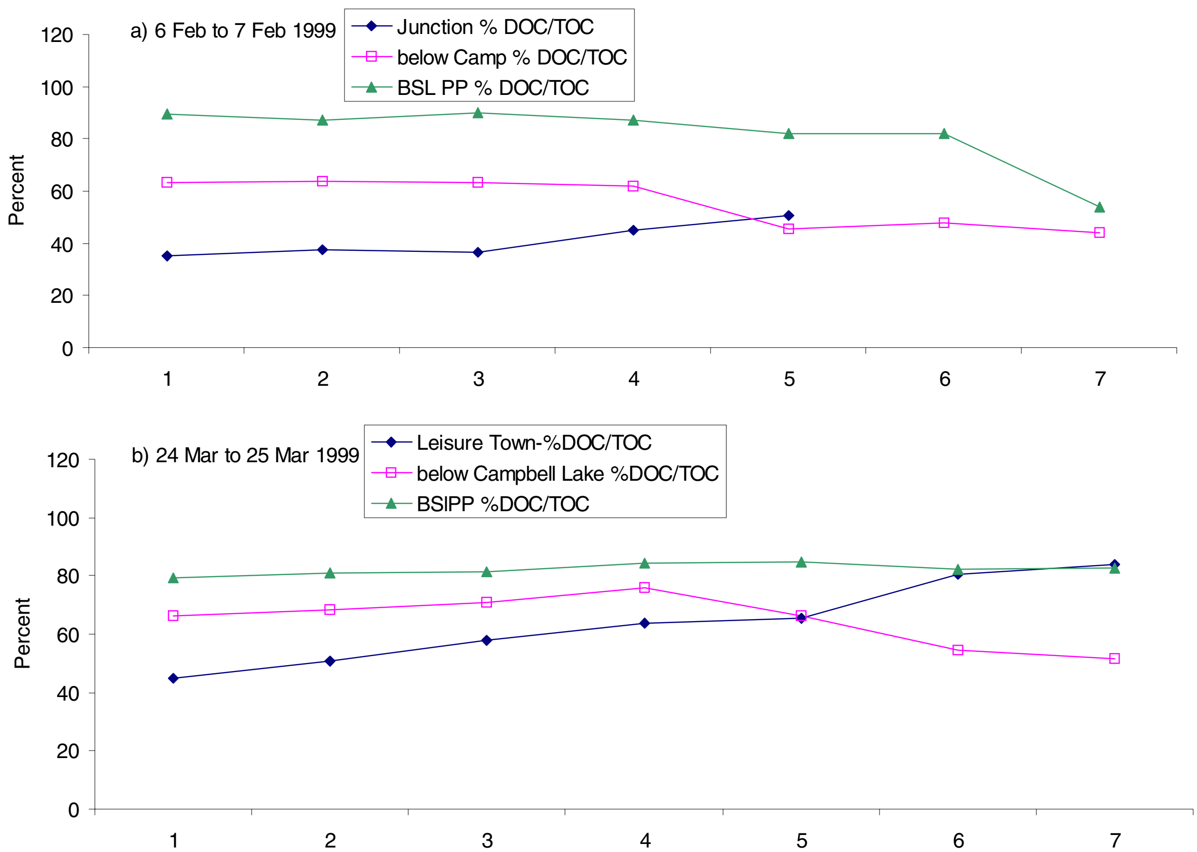


Figure 30 Ratio of DOC to TOC by site for autosamplers (a) Feb 1999 sampling event and (b) Mar 1999 sampling event

captured by the autosampler until the last few hours of sampling. Prior to the pulse's arrival, DOC comprised approximately 60% of the lake's TOC. As the pulse reached the lake, the proportion of DOC fell to approximately 40% of the TOC (see figures 23 and 30). A similar pattern was observed downstream at the pumping plant. The hydrograph was not captured as completely with the March 1999 storm, but comparisons between the occurrence of the pulse and the change in the TOC quality can also be observed (see figures 24 and 30b).

Concentration Differences between Sites

Concentrations of TOC were compared between sites using stage weighted averages. Flow weighted averages were not used as discharge calculations were unavailable for all 3 analyzed events. Stage weighted averages were calculated by the following equation, where *a* equals the value for a sample collected at time "a" and *t* equals time.

$$\text{Stage Weighted TOC concentration (mg/L)} = \sum_{t=0}^{t=24} \text{TOC}_a * \text{Stage Height}_a / \text{Total Stage Height}_{\text{24 hours}}$$

Stage heights were estimated in cases where the stage recorder had stopped recording and resumed a few hours later.

Table 18 Total organic carbon stage weighted averages (mg/L) for selected autosampler events

	Leisure Town Road	Junction	Below Campbell Lake
Feb 1999		19.1	18
Mar 1999	19.6		14.4
Mar 2000	17.2		21.6*

* New gaging station below Cook Lane used for this calculation.

Table 19 Turbidity stage weighted averages (NTU) for selected autosampler events

	Leisure Town Road	Junction	Below Campbell Lake
Feb 1999		566	412
Mar 1999	344		170
Mar 2000	119		108

* New gaging station below Cook Lane used for this calculation.

Discharge is an exponential function of depth in the channel. Therefore, using stage height to calculate weighted TOC averages will underemphasize, to some degree, the impact of high flows. With this caveat, the use of stage weighted means was still preferable over the use of arithmetic averages because if only a few high concentrations at the beginning or end of the hydrograph are collected, arithmetic averages will disproportionately represent baseline concentrations.

During storm events, there was no evidence that TOC concentrations decreased with distance upstream from the pumping plant or as the sampling season progressed. Additionally, no patterns were discernable between sites (Table 18). In the case of comparisons between Leisure Town Road and below Campbell Lake, stage weighted averages were greater upstream than downstream. On another occasion, the results were reversed. Statistical comparisons were not made because samples from the various sites were collected at different stages of the hydrograph. Between sites, concentrations varied by no more than 4.4 mg/L, suggesting that flow was the most important factor determining carbon output.

Stage weighted turbidity averages were inconclusive (Table 19). In all cases turbidity was lower at downstream sites then at upstream sites. Statistical comparisons were not made because samples from the various sites were collected at different stages of the hydrograph.

Loading

Stage weighted TOC concentrations suggested that flow, not concentration, was the most important factor controlling storm-related carbon inputs into the watershed. This hypothesis was examined using loading data. Unfortunately, because of the lack of discharge data, loading could not be calculated for all sites analyzed. See Table 20 for a summary of the data available for loading calculations. Loading calculations for the pumping plant reflect the rate of pumping of the pumping plant and are representative of carbon loads pumped into the NBA at a given time. Only samples collected between 4 March and 6 March 2000 had a complete set of flow data that allowed examination of relative loading inputs from the top to the bottom of the watershed.

Although the storm captured between 4 March and 6 March 2000 was potentially too small to allow runoff from the top of the watershed to reach the pumping plant, loading results suggested that upstream sites contributed less carbon to the watershed than downstream sites and that Campbell Lake had the greatest impact to carbon loading in the system. Carbon concentrations between Leisure Town Road and

Table 20 Summary of data available for autosampler loading calculations

(a) 1998/1999 sampling season

	5 Dec to 6 Dec 1999	6 Feb to 7 Feb 1999	24 Mar to 25 Mar 1999
Leisure Town Road	cfs = 0, no loads calculated	Equipment problems-no sample collected	Loads only calculated for some collection times due to qr or ie
Junction	Equipment problems-no sample collected	Calculated all loads	Equipment problems-no sample collected
Below Campbell Lake	Unable to calculate loads due to qr or ie	Flows outside of rating curve	Flows outside of rating curve
Barker Slough PP	Calculated all loads	Calculated all loads	Calculated all loads

(b) 1999/2000 sampling season

	23 Jan to 24 Jan 2000	11 Feb to 12 Feb 2000	4 Mar to 6 Mar 2000
Leisure Town Road	Unable to calculate loads due to qr or ie	Unable to calculate loads due to qr or ie	Loads only calculated for some collection times due to qr or ie
Junction	Unable to calculate loads due to qr or ie	Unable to calculate loads due to qr or ie	Equipment problems-no sample collected
Below Campbell Lake	Equipment problems-no samples collected	Equipment problems-no samples collected	Calculated all loads
Barker Slough PP	Equipment problems-no samples collected	No sample between 20 and 24 hours	Calculated all loads

qr = questionable reading
ie = instrument error or off-line

below Campbell Lake differed on average by 4 mg/L (see Table 18). Online flow instrumentation recorded an increase and decrease in flow at Leisure Town Road over approximately an 8-hour period (Figure 31). Downstream, below Campbell Lake, flow recorders reported increasing flow for at least 24 hours. At both sites, maximum loads could not be calculated; however, the maximum load captured from autosampler sampling was approximately 3,000 lbs/day from Leisure Town and approximately 6,600 lbs/day from Campbell Lake. Given that discharge was still increasing below Campbell Lake and that the duration of maximum discharge was greater below Campbell Lake than at Leisure Town, it is likely that the carbon load leaving Campbell Lake would have a greater impact to overall watershed carbon loading than carbon discharge from Leisure Town Road. Grab samples verify that discharge from Campbell Lake was still occurring from Campbell Lake on 8 March, 2 days after autosampling had ceased, while upstream carbon discharges to the system were essentially zero (see Figure 17). Given that changes in discharge from Leisure Town appear to be the shortest of any of the sites sampled, it is likely that this site has the least impact to carbon in the system.

Although loading could not be calculated at all sites for the 6 February 1999 and 24 March 1999 sampling events, the extended period of discharge from Campbell Lake again suggested that the lake would make the greatest contribution to carbon loading. Using flow duration patterns, loading contributions from

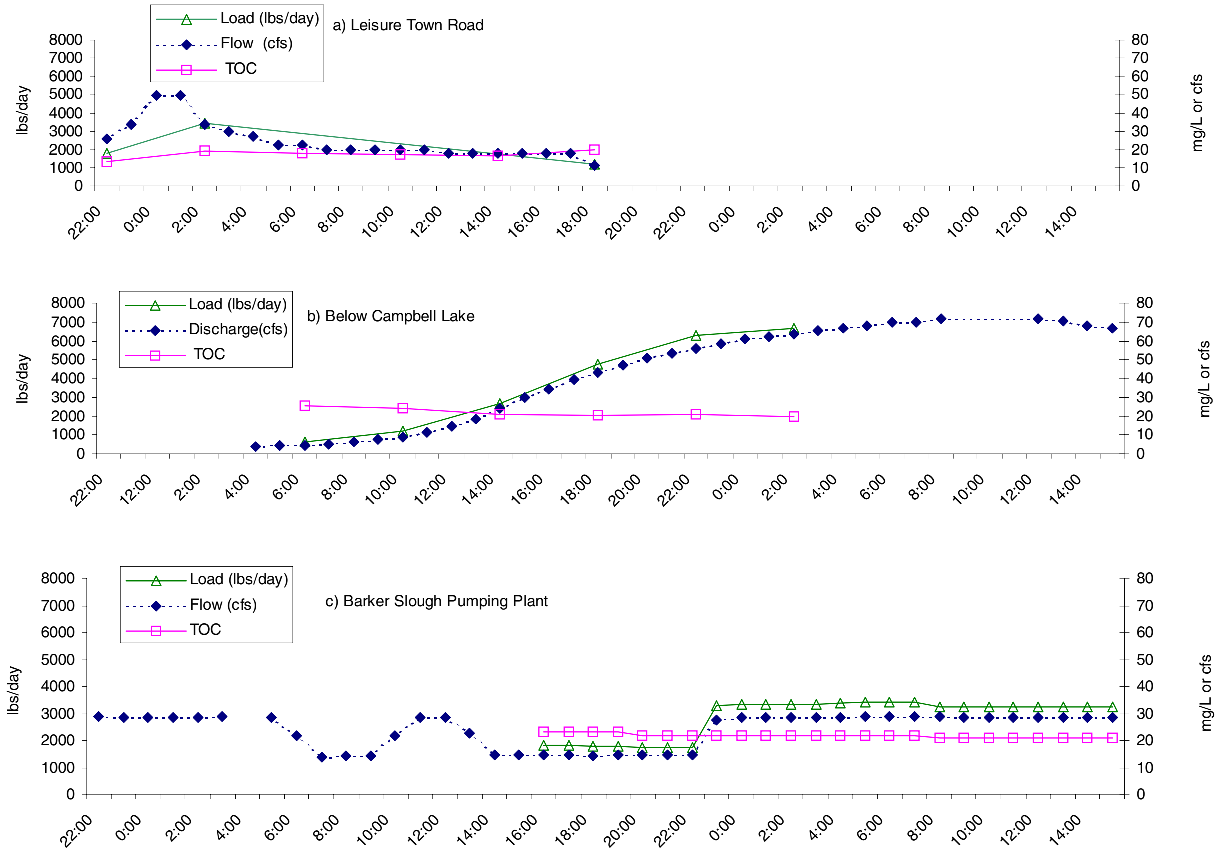


Figure 31 Time sequence of autosampler loading, 4 Mar to 6 Mar 2000

Junction would be expected to lie between those made by Campbell Lake and Leisure Town Road (for example see Figure 17).

Quality Assurance/Quality Control

Grab Samples—Particulates and QA/QC Experiments

At the beginning of the 1998/1999 sampling season, split samples of the 1st autosampler sampling event were analyzed by NBR and Bryte Laboratory. Large differences in TOC concentrations were observed in side-by-side analyses conducted by the 2 laboratories. Differences between the laboratories were most pronounced at sites with the highest measured TOC concentrations (Leisure Town Road) and least noticeable at the site with the lowest TOC concentrations (Barker Slough PP) (Figure 32). Differences between labs were not observed in DOC samples. Both results suggested that sediment properties accounted for the laboratory differences. Analytical procedures between the 2 labs were identical with the exception that during oxidation, sediment remained suspended via a stream of N_2 gas in the DWR laboratory, whereas depending on the time elapsed, sediment could settle out in the NBR laboratory reaction chamber. Using the same water sample, both laboratories analyzed TOC using settled and suspended methods. Samples allowed to settle 24 hours averaged 6.6 and 6.7 mg/L TOC for the Bryte and NBR laboratories, respectively (Figure 33). Samples where particulates remained in suspension averaged 9 mg/L (see Figure 33).

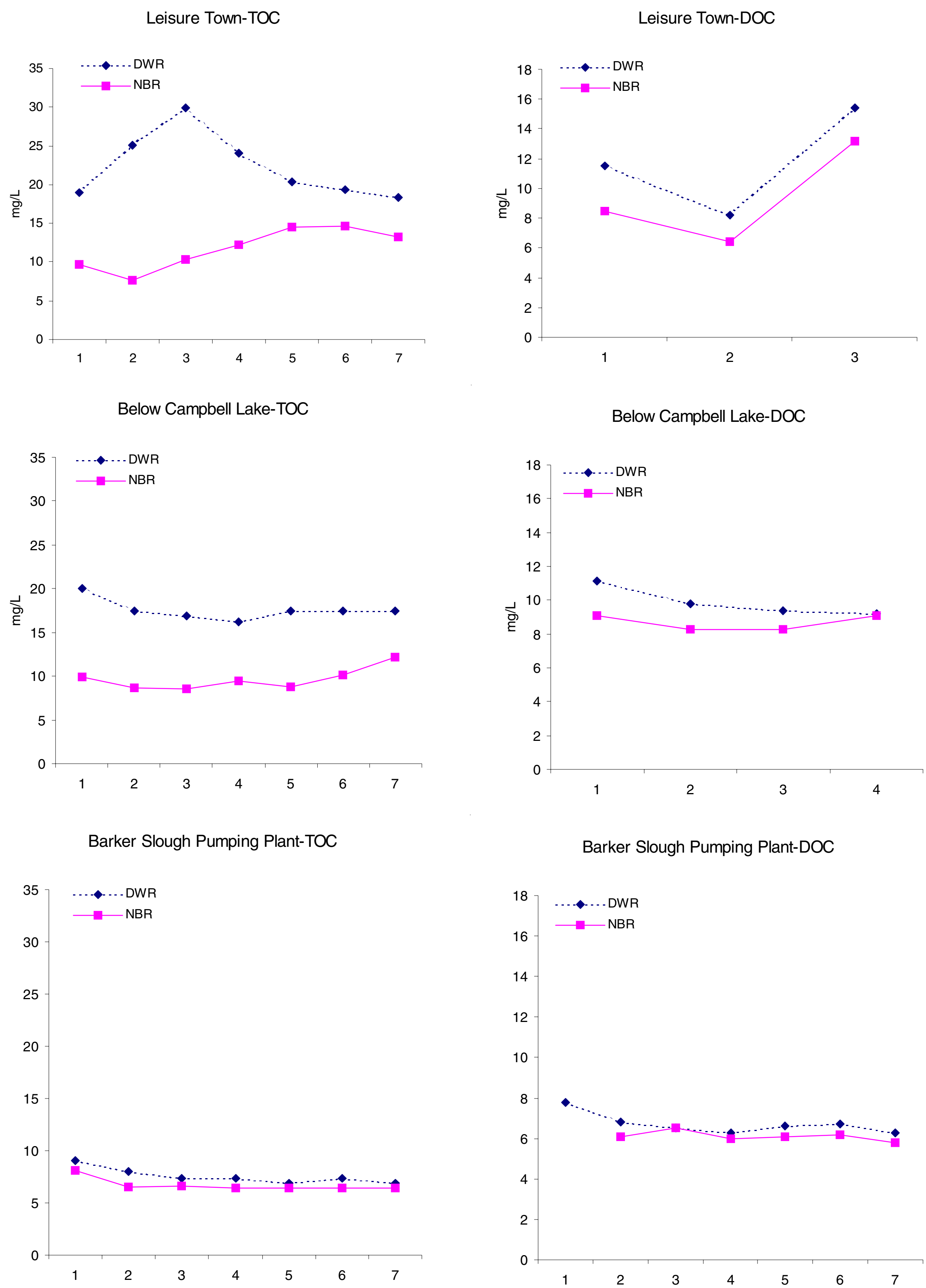


Figure 32 Comparisons between the TOC and DOC by laboratory and site, Dec 1998

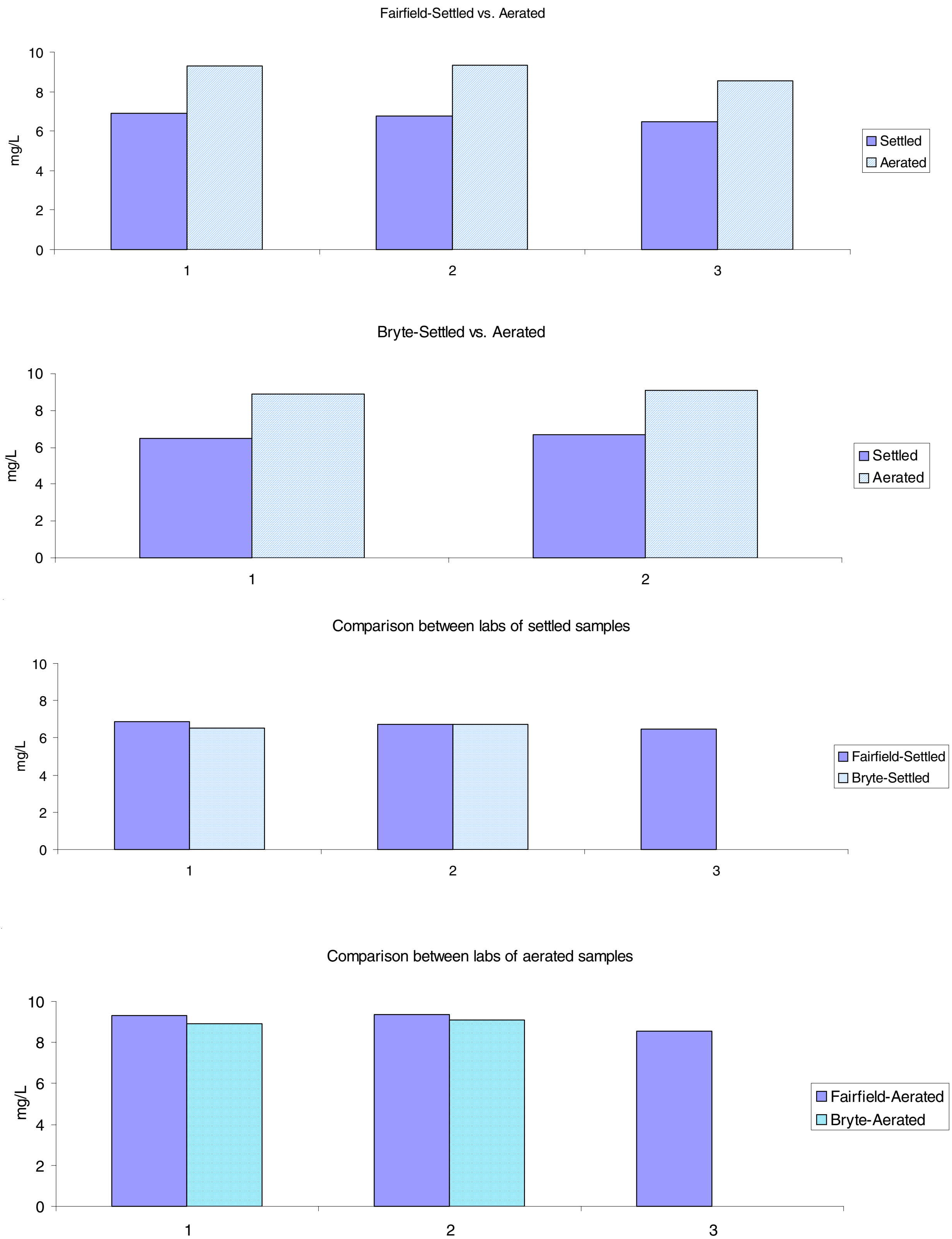


Figure 33 Settled vs. aerated experiments for TOC (mg/L), comparison of methods and laboratories

These results confirmed that the differences between the laboratories were associated with the treatment of the particulate fraction of the carbon. Because DWR Laboratories suspends all particles prior to sample analysis, the DWR laboratory conducted all subsequent analyses.

QA/QC Results—Data Quality Review

This data quality review covers the Barker Slough watershed project from September 1997 to April 2001. The project consisted of 4 study periods. The periods were September 1997 to March 1998, November 1998 to April 1999, November 1999 to March 2000, and November 2000 to April 2001. This data review is for the combined period from September 1997 to April 2001.

The data review was performed utilizing the available quality control data stored in the DWR Field and Laboratory Information Management System (FLIMS) database. The database was used to retrieve the data and flag the analyses that were outside established control limits.

The data quality review indicated that overall the 1997 to 2001 Barker Slough watershed project data were of acceptable quality. A few analyses were outside the control limits, but they were not considered to have a significant impact on the overall data quality of the project. The results of the review are presented below.

Field Procedures Quality Control

Field Duplicates. Field duplicates are replicate samples taken at a randomly selected station during each field run to evaluate precision of field procedures. The results of field duplicate analyses are evaluated by calculating relative percent differences and comparing the relative percent differences (RPDs) with established control limits. During the study period, 784 field duplicate analyses were performed, and none of the RPDs exceeded the acceptable control limits. The results indicate that field procedures were of acceptable precision for the project.

Field Blanks. Field blanks are purified water samples taken to the field and filtered or left unfiltered. Filtered blanks help check for contamination from field sample processing procedures. Unfiltered blanks check for contamination from containers and preservatives.

In the study period, 114 field blank batches were performed, and only 13 (11.4%) exceeded the control limit (Table 21). The analytes that had field blank contamination were DOC, TOC, and total Kjeldahl nitrogen. The contamination levels ranged between 0.2 and 0.4 mg/L, and most were TOC/DOC samples from autosamplers. Field autosamplers are complex systems with lengthy amounts of tubing. The blank exceedances were considered to be within expected levels for the autosamplers and, therefore, did not affect the overall data quality for the project.

Internal Quality Controls

Internal quality controls are procedures used in the laboratory to ensure that the analytical methods are in control. Environmental samples are grouped together in “batches,” with approximately 20 samples per batch. Generally, one of each quality control measure such as method blank, matrix spike, etc. is performed with each batch to confirm that the analytical method is in control.

The total number of internal quality control analyses performed per analyte is shown in Table 22. The following is a review of the internal QC for the project.

Table 21 Field blank contamination

Analyte	Sample number	Sample description	Collection date	Result (mg/L)	Limit (mg/L)
Dissolved Organic Carbon	CB0199A0706	Autosampler	2/7/1999	0.4	0.1
Dissolved Organic Carbon	CB0199A0654	Autosampler	2/7/1999	0.3	0.1
Dissolved Organic Carbon	CB0199A0680	Autosampler	2/7/1999	0.4	0.1
Dissolved Organic Carbon	CB0199A0681	Filter blank	2/8/1999	0.2	0.1
Dissolved Organic Carbon	CB0199A0707	Filter blank	2/8/1999	0.3	0.1
Dissolved Organic Carbon	CB0399A1114	Filter blank	3/24/1999	0.2	0.1
Dissolved Organic Carbon	CB0399A1113	Autosampler	3/25/1999	0.2	0.1
Total Kjeldahl Nitrogen	CB0198A0053	Unfilt nutrient blk	1/29/1998	0.3[a]	0.1[a]
Total Kjeldahl Nitrogen	C0198A0072	C980072	1/29/1998	0.3[a]	0.1[a]
Total Organic Carbon	CB0199A0654	Autosampler	2/7/1999	0.2	0.1
Total Organic Carbon	CB0199A0706	Autosampler	2/7/1999	0.4	0.1
Total Organic Carbon	CB0199A0680	Autosampler	2/7/1999	0.4	0.1
Total Organic Carbon	CB0399A1139	Autosampler	3/25/1999	0.2	0.1

[a] mg/L as N

Sample Holding Times. Holding time is the time during which a sample can be stored after collection and preservation without significantly affecting the accuracy of its analysis. During the 1997 to 2001 study period, approximately 2,269 environmental analyses were conducted, and 56 analyses (2.4%) exceeded the holding time. The analyses that exceeded the holding times are listed in Table 23. The analytes that exceeded holding times were ammonia, Kjeldahl nitrogen, total phosphorous, and turbidity. Although the frequency of these exceedances was low, the results of the specific analysis should be interpreted with caution.

Method Blanks. The purpose of method blanks is to detect and quantify contamination introduced through sample preparation or analytical procedures in the laboratory (some “background noise” is allowed). A total of 411 method blanks were performed from September 1997 to April 2001, and 8 (1.9%) exceeded the control limits (see Table 22).

Eight batches had method blanks outside of the control limits. The analytes were chloroform, dissolved organic carbon, and total organic carbon (Table 24). There were only 2 chloroform method blank batches in the study, and both exceeded the control limits. Because chloroform is so prevalent in the laboratory environment and because only 2 method blanks were performed, the results are not considered to have a significant impact on the overall data quality of the project.

The frequency of samples outside of the control limits was 2.4% for dissolved organic carbon and 1.5% for total organic carbon analyzed by the oxidation method. Organic carbon exceedances were mainly

Table 22 Total internal QC batches grouped by analyte

Analyte	Method	LCS recovery	RPD-LCS duplicate	Matrix spike	RPD- Matrix spike	Method blank	RPD sample duplicate
2-Bromo-1-chloropropane	DWR THMFP (Buffered)	0	0	2	1	0	0
Alkalinity	Std Method 2320 B	10	2	32	10	0	0
Ammonia	EPA 350.1	16	8	16	8	8	0
Boron	EPA 200.7 (D)	18	9	32	16	9	0
Bromide	EPA 300.0 28d Hold	24	12	50	14	12	0
Bromodichloromethane	DWR THMFP (Buffered)	0	0	6	1	2	0
Bromoform	DWR THMFP (Buffered)	0	0	6	1	2	0
Calcium	EPA 200.7 (D)	18	9	32	16	10	0
Chloride	EPA 325.2	20	10	44	15	10	0
Chloroform	DWR THMFP (Buffered)	0	0	6	1	2	0
Coliform (total)	Colilert	0	0	0	0	0	0
Coliform (fecal)	Fecal Coliform - Colilert	0	0	0	0	10	0
Conductance (EC)	Std Method 2510-B	0	0	0	0	7	43
Dibromochloromethane	DWR THMFP (Buffered)	0	0	6	1	2	0
Dissolved Organic Carbon (DOC)	EPA 415.1 (D) Ox	85	40	0	0	41	76
E. coli	Colilert	0	0	0	0	0	0
Total Kjeldahl Nitrogen (TKN)	EPA 351.2	18	9	8	4	9	0
Magnesium	EPA 200.7 (D)	18	9	32	16	10	0
Nitrate	EPA 300.0 28d Hold	8	4	10	4	5	0
Nitrate	Std Method 4500-NO3-F	8	4	12	6	8	0

Table 22 continued

Analyte	Method	LCS recovery	RPD-LCS duplicate	Matrix spike	RPD- Matrix spike	Method blank	RPD Sample duplicate
Nitrite + Nitrate	Std Method 4500-NO3-F	8	4	12	6	8	0
Ortho-phosphate	EPA 365.4	22	11	22	8	11	0
pH	pH - Std Method 2320 B	0	0	0	0	0	9
Phosphorous (total)	EPA 365.4	14	7	8	4	7	0
Potassium	EPA 200.7 (D)	14	7	20	10	8	0
Sodium	EPA 200.7 (D)	18	9	32	16	10	0
Solids (TDS)	Std Method 2540-C	0	0	0	0	5	7
Sulfate	EPA 375.2	20	10	27	13	10	0
Total Organic Carbon (TOC)	EPA 415_1 (T) Cmbst	34	17	0	0	17	26
Total Organic Carbon (TOC)	EPA 415.1 (T) Ox	138	68	0	0	68	81
Total Suspended Solids (TSS)	EPA 160.2	0	0	0	0	11	21
Turbidity	EPA 180.1	118	57	0	0	73	89
UV Absorbance @254nm	Std Method 5910B	55	26	0	0	36	51
TOTALS		684	332	415	171	411	403
TOTALS		1	0	2	1	17	2
1997		328	160	415	171	205	91
1998		196	94	0	0	126	138
1999		112	56	0	0	56	120
2000		48	22	0	0	24	54
Total		684	332	415	171	411	403

Table 23 Holding time exceedances

Analyte	Collection date	Sample number	Holding time	Limit
Ammonia, Nitrogen (Dissolved)	12/8/1997	CA1297A1672	30 days	28 days
Ammonia, Nitrogen (Dissolved)	12/8/1997	CA1297A1673	30 days	28 days
Kjeldahl Nitrogen	10/22/1997	CB1097A1339	49 days	28 days
Kjeldahl Nitrogen	10/22/1997	CB1097A1334	49 days	28 days
Kjeldahl Nitrogen	10/22/1997	CB1097A1338	49 days	28 days
Kjeldahl Nitrogen	10/22/1997	CB1097A1342	49 days	28 days
Kjeldahl Nitrogen	10/22/1997	CB1097A1343	49 days	28 days
Kjeldahl Nitrogen	11/17/1997	CB1197A1417	35 days	28 days
Kjeldahl Nitrogen	11/17/1997	CB1197A1423	25 days	28 days
Kjeldahl Nitrogen	11/17/1997	CB1197A1416	35 days	28 days
Kjeldahl Nitrogen	12/8/1997	CA1297A1669	32 days	28 days
Kjeldahl Nitrogen	12/17/1997	CA1097A1427	30 days	28 days
Phosphorus (Total)	10/22/1997	CB1097A1339	49 days	28 days
Phosphorus (Total)	10/22/1997	CB1097A1334	49 days	28 days
Phosphorus (Total)	10/22/1997	CB1097A1338	49 days	28 days
Phosphorus (Total)	10/22/1997	CB1097A1342	49 days	28 days
Phosphorus (Total)	10/22/1997	CB1097A1343	49 days	28 days
Phosphorus (Total)	11/17/1997	CB1197A1417	35 days	28 days
Phosphorus (Total)	11/17/1997	CB1197A1423	35 days	28 days
Phosphorus (Total)	11/17/1997	CB1197A1416	35 days	28 days
Turbidity	1/23/2000	CB1199A3080	70 hours	48 hours
Turbidity	1/23/2000	CB1199A3087	68 hours	48 hours
Turbidity	1/23/2000	CB1199A3081	66 hours	48 hours
Turbidity	1/23/2000	CB1199A3088	64 hours	48 hours
Turbidity	1/24/2000	CB1199A3082	62 hours	48 hours
Turbidity	1/24/2000	CB1199A3089	60 hours	48 hours
Turbidity	1/24/2000	CB1199A3083	58 hours	48 hours
Turbidity	1/24/2000	CB1199A3090	56 hours	48 hours
Turbidity	1/24/2000	CB1199A3084	54 hours	48 hours
Turbidity	1/24/2000	CB1199A3091	52 hours	48 hours

Table 23 continued

Analyte	Collection date	Sample number	Holding time	Limit
Turbidity	1/24/2000	CB1199A3085	50 hours	48 hours
Turbidity	2/11/2000	CC0100B0293	79 hours	48 hours
Turbidity	2/11/2000	CC0100B0300	77 hours	48 hours
Turbidity	2/11/2000	CC0100B0294	75 hours	48 hours
Turbidity	2/11/2000	CC0100B0301	73 hours	48 hours
Turbidity	2/11/2000	CC0100B0301	73 hours	48 hours
Turbidity	2/11/2000	CC0100B0295	71 hours	48 hours
Turbidity	2/11/2000	CC0100B0302	69 hours	48 hours
Turbidity	2/11/2000	CC0100B0296	67 hours	48 hours
Turbidity	2/11/2000	CC0100B0303	65 hours	48 hours
Turbidity	2/11/2000	CC0100B0297	63 hours	48 hours
Turbidity	2/11/2000	CC0100B0304	61 hours	48 hours
Turbidity	2/11/2000	CC0100B0298	59 hours	48 hours
Turbidity	2/12/2000	CC0100B0305	57 hours	48 hours
Turbidity	2/12/2000	CC0100B0305	57 hours	48 hours
Turbidity	3/4/2000	CD0100B0469	64 hours	48 hours
Turbidity	3/5/2000	CD0100B0470	60 hours	48 hours
Turbidity	3/5/2000	CD0100B0471	56 hours	48 hours
Turbidity	3/5/2000	CD0100B0483	56 hours	48 hours
Turbidity	3/5/2000	CD0100B0472	52 hours	48 hours
Turbidity	3/5/2000	CD0100B0472	52 hours	48 hours
Turbidity	3/5/2000	CD0100B0484	52 hours	48 hours
Turbidity	2/7/2001	DZ0201B6439	49 hours	48 hours
Turbidity	2/7/2001	DZ0201B6440	49 hours	48 hours
Turbidity	2/7/2001	DZ0201B6441	49 hours	48 hours
Turbidity	2/7/2001	DZ0201B6441	49 hours	48 hours

Table 24 Number of batches with method blank exceedances

Analyte	Total batches	Batches with method blanks out of limits	Frequency of samples out of limits (%)
Chloroform	2	2	100
Dissolved Organic Carbon	41	1	2.4
Total Organic Carbon (Ox)	68	1	1.5
Total Organic Carbon (Cm)	17	4	23.5

Ox = oxidation method
Cm = combustion method

from the combustion method with a maximum contamination level of 0.4 mg/L (Table 25). It is generally recognized that combustion instruments have higher "background" blank contamination than oxidation instruments. The exceedances were considered to be a method anomaly and the data are acceptable.

Laboratory Control Samples. Laboratory control sample (LCS) recoveries are used to assess the accuracy of the analytical method especially when matrix interference occurs in the analyses of the environmental samples. LCSs are prepared by adding a known concentration of analyte of interest into a clean medium. The LCS is then analyzed, and the results are compared to the laboratory's control limits. During the period of September 1997 to April 2001, 684 LCS analyses were performed (see Table 23), and none of the results exceeded the control limits. Therefore, the laboratory analyses for the project were of acceptable accuracy.

Matrix Spike Recovery. Matrix spike recoveries indicate the accuracy of recovering a known concentration of substance in a matrix of interest. The results of matrix spike recoveries indicate the accuracy of analysis given the interference peculiar to a given matrix. Matrix spikes are prepared by adding a known concentration of method analytes to an environmental sample with known background concentration. The percent recovery must fall within acceptable limits. During the study period, 415 matrix spike recoveries were performed (see Table 23). However, matrix spike recoveries were only performed between September 1997 and March 1998. Only 2 (0.48%) exceeded the control limits. The batches with matrix spike recoveries outside the control limits are shown in Table 26. The individual samples in these batches are shown in Table 27. The problem analytes were ammonia and bromide. The low frequency of recoveries outside the control limits for these analytes was considered insignificant to the overall data quality of the project. Therefore, the laboratory analyses were of acceptable accuracy, and matrix interference did not have significant effects on the analyses.

Matrix Spike Duplicates. Matrix spike duplicate results indicate the precision of the analytical method in a given matrix. The difference between the duplicate samples is reported as an RPD. This difference is compared to the laboratory's control limits as a conservative approach to determining precision. During the study period, 171 matrix spike duplicates were performed (see Table 22). None of the results exceeded the control limits, indicating that matrix interference had no significant effects in the precision of the laboratory analysis of the environmental samples.

Sample Duplicates. Sample duplicates are environmental samples that are divided into 2 aliquots in the laboratory and analyzed independently to determine the repeatability of the analytical method. The RPD for the duplicate results must fall within the established control limits. During the study period, there were 403 batches in which sample duplicate analyses were performed (see Table 22). Only 2

Table 25 Samples with method blank exceedances

Analyte	Method	Sample number	Collection date	Result	Reporting limit	Units
Chloroform	DWR THMFP (Buffered)	CA1097A1420	12/17/1997	4	1	µg/ L
Chloroform	DWR THMFP (Buffered)	CA1097A1419	12/17/1997	4	1	µg/ L
Chloroform	DWR THMFP (Buffered)	CA1097A1418	12/17/1997	4	1	µg/ L
Chloroform	DWR THMFP (Buffered)	CA1097A1423	12/17/1997	5	1	µg/ L
Chloroform	DWR THMFP (Buffered)	CA1097A1417	12/17/1997	5	1	µg/ L
Chloroform	DWR THMFP (Buffered)	CA1097A1422	12/17/1997	5	1	µg/ L
Chloroform	DWR THMFP (Buffered)	CB0198A0034	1/12/1998	4	1	µg/ L
Chloroform	DWR THMFP (Buffered)	CB0198A0035	1/12/1998	4	1	µg/ L
Chloroform	DWR THMFP (Buffered)	CB0198A0039	1/12/1998	4	1	µg/ L
Chloroform	DWR THMFP (Buffered)	CB0198A0036	1/12/1998	4	1	µg/ L
Chloroform	DWR THMFP (Buffered)	CB0198A0037	1/12/1998	4	1	µg/ L
Dissolved Organic Carbon	EPA 415.1 Ox	CB0199A0705	2/7/1999	0.2	0.1	mg/L as C
Dissolved Organic Carbon	EPA 415.1 Ox	DA0299A0034	2/17/1999	0.2	0.1	mg/L as C
Total Organic Carbon	EPA 415.1 Ox	CB0199A0702	2/7/1999	0.2	0.1	mg/L as C
Total Organic Carbon	EPA 415.1 Ox	CB0199A0703	2/7/1999	0.2	0.1	mg/L as C
Total Organic Carbon	EPA 415.1 Ox	CB0199A0706	2/7/1999	0.2	0.1	mg/L as C
Total Organic Carbon	EPA 415.1 Ox	CB0199A0704	2/7/1999	0.2	0.1	mg/L as C
Total Organic Carbon	EPA 415.1 Ox	DA0299A0034	2/17/1999	0.2	0.1	mg/L as C

Table 25 continued on next 2 pages

Table 25 continued

Analyte	Method	Sample number	Collection date	Result	Reporting limit	Units
Total Organic Carbon	EPA 415.1 Ox	DZ0101B4499	1/3/2001	0.3	0.1	mg/L as C
Total Organic Carbon	EPA 415_1 Cmbst	DZ1200B3382	12/6/2000	0.3	0.1	mg/L as C
Total Organic Carbon	EPA 415_1 Cmbst	DZ1200B3384	12/6/2000	0.3	0.1	mg/L as C
Total Organic Carbon	EPA 415_1 Cmbst	DZ1200B3605	12/13/2000	0.3	0.1	mg/L as C
Total Organic Carbon	EPA 415_1 Cmbst	DZ1200B3606	12/13/2000	0.3	0.1	mg/L as C
Total Organic Carbon	EPA 415_1 Cmbst	DZ0101B4501	1/3/2001	0.3	0.1	mg/L as C
Total Organic Carbon	EPA 415_1 Cmbst	DZ0101B4835	1/10/2001	0.2	0.1	mg/L as C
Total Organic Carbon	EPA 415_1 Cmbst	DZ0101B4838	1/10/2001	0.2	0.1	mg/L as C
Total Organic Carbon	EPA 415_1 Cmbst	DZ0101B4836	1/10/2001	0.2	0.1	mg/L as C
Total Organic Carbon	EPA 415_1 Cmbst	DZ0101B4839	1/10/2001	0.2	0.1	mg/L as C
Total Organic Carbon	EPA 415_1 Cmbst	DZ0101B4837	1/10/2001	0.2	0.1	mg/L as C
Total Organic Carbon	EPA 415_1 Cmbst	DZ0101B4840	1/10/2001	0.2	0.1	mg/L as C
Total Organic Carbon	EPA 415_1 Cmbst	DZ1200B3607	12/13/2000	0.3	0.1	mg/L as C
Total Organic Carbon	EPA 415_1 Cmbst	DZ1200B4215	12/27/2000	0.4	0.1	mg/L as C
Total Organic Carbon	EPA 415_1 Cmbst	DZ1200B3383	12/6/2000	0.3	0.1	mg/L as C
Total Organic Carbon	EPA 415_1 Cmbst	DZ0101B4500	1/3/2001	0.3	0.1	mg/L as C
Total Organic Carbon	EPA 415_1 Cmbst	DZ1200B3883	12/20/2000	0.4	0.1	mg/L as C
Total Organic Carbon	EPA 415_1 Cmbst	DZ1200B3915	12/20/2000	0.4	0.1	mg/L as C

Table 25 continued

Analyte	Method	Sample number	Collection date	Result	Reporting limit	Units
Total Organic Carbon	EPA 415_1 Cmbst	DZ1200B3916	12/20/2000	0.4	0.1	mg/L as C
Total Organic Carbon	EPA 415_1 Cmbst	DZ1200B3917	12/20/2000	0.4	0.1	mg/L as C
Total Organic Carbon	EPA 415_1 Cmbst	DZ1200B4214	12/27/2000	0.4	0.1	mg/L as C
Total Organic Carbon	EPA 415_1 Cmbst	DZ1200B4213	12/27/2000	0.4	0.1	mg/L as C

Table 26 Number of batches with matrix spike recovery exceedances

Analyte	Total batches	Batches with matrix spike recoveries out of limits	Frequency of samples out of limits (%)
Ammonia	16	1	6.3
Bromide	50	1	2

(0.49%) exceeded the control limits. The batches with sample duplicates outside of the control limits are shown in Table 28. The environmental samples in these batches and their results of the analyses are shown in Table 29. A total of 76 sample duplicate analyses were performed for DOC and only 1 (1.3%) was outside the control limits. Out of 26 TOC sample duplicates analyses performed with the combustion method, only 1 (3.8%) was outside the control limits. All the 81 TOC sample duplicate analyses performed with the oxidation method were within the control limits. These results indicate the laboratory had acceptable precision in its analysis of the project samples.

Table 27 Samples with matrix spike recovery exceedances

Analyte	Sample number	Collection date	Matrix spike recovery	Control limits
Ammonia	DA0198A0008	1/21/1998	120	85-118
Bromide	CB1197A1417	11/17/1997	120.4	82-118
Bromide	CB1197A1418	11/17/1997	120.4	82-118
Bromide	CB1197A1419	11/17/1997	120.4	82-118
Bromide	CB1197A1414	11/17/1997	120.4	82-118
Bromide	CB1197A1415	11/17/1997	120.4	82-118
Bromide	CB1197A1417	11/17/1997	120.4	82-118
Bromide	CB1197A1418	11/17/1997	120.4	82-118
Bromide	CB1197A1419	11/17/1997	120.4	82-118
Bromide	CB1197A1414	11/17/1997	120.4	82-118
Bromide	CB1197A1415	11/17/1997	120.4	82-118
Bromide	CB1197A1416	11/17/1997	120.4	82-118
Bromide	CB1197A1416	11/17/1997	120.4	82-118
Bromide	CB1197A1416	11/17/1997	120.4	82-118

Table 28 Number of batches with sample duplicate exceedances

Analyte	Method	Total batches	Batches with sample duplicates out of limits	Frequency of samples out of limits (%)
Dissolved Organic Carbon	EPA 415.1 Ox	76	1	1.3
Total Organic Carbon	EPA 415.1 Cmbst	26	1	3.8
Total Organic Carbon	EPA 415.1 Ox	81	0	0

Table 29 Samples with sample duplicate exceedances

Analyte	Sample number	Collection date	Result %	Limit %
Dissolved Organic Carbon	DA0298A0026	2/18/1998	42	0-30
Total Organic Carbon	DZ0101B4838	1/10/2001	35	0-30
Total Organic Carbon	DZ0101B4839	1/10/2001	35	0-30
Total Organic Carbon	DZ0101B4840	1/10/2001	35	0-30

Discussion and Conclusions

The goal of this and other NBA studies has been to determine the source of the elevated organic carbon and turbidity levels at the Barker Slough Pumping Plant. Studies conducted in 1996/1997 suggested that the water quality problems at the plant originated in the Barker Slough watershed. To date, the results from this study and others (for example, Singer and Eshel 2000 and Hydro Science 2001) indicate that there is no single area of the watershed that serves as the predominant source of organic carbon or turbidity. A study conducted by Hydro Science suggested that the physical characteristics of the watershed might be responsible for organic carbon and turbidity water quality results. The soils in the watershed tend to be high in sodium and fall within the silt /clay size fraction (Singer and Eshel 2000). These characteristics result in easily suspended particles that remain in the water column for extended periods of time. Hydro Science has hypothesized that turbidity may be due to in-channel erosion and that the observed organic carbon concentrations fall within rangeland boundaries.

In this study, limited autosampler results confirmed that in the farthest reaches examined, TOC concentrations did not decrease either temporally or spatially. Stage weighted TOC averages during storm events were similar between upstream and downstream sites. Because soil composition is similar across much of the watershed, these results support Hydro Science's conclusions that carbon concentrations in the watershed are a reflection of the soil composition. Stage weighted turbidity results, however, were inconclusive. Grab sample analysis of 1997/1998 data also indicated no statistical differences between upstream and downstream sites in the watershed. However, only a small data set was available for analysis. Mathematically, this lessens the resolution of the statistical test to discern differences between sites.

Autosampler results explained WTP observations of sharp increases in TOC and turbidity. Once the watershed is saturated, which occurs between approximately 4 to 8 inches of cumulative rainfall, storms of approximately an inch of rainfall or greater provide enough flow momentum for a turbidity and TOC pulse to move down the watershed and exit to the pumping plant's forebay. This results in an immediate and rapid rise in TOC and turbidity. It is unknown whether this same phenomenon could occur when the watershed is not saturated because a large storm under unsaturated conditions was never captured.

Both autosampler and grab sample results emphasized the importance of relative flows in the watershed and the impact of Campbell Lake on the water quality observed at the pumping plant. In the winter, Campbell Lake is essentially an unmanaged reservoir. As a result, discharge from the reservoir is based solely on natural, physical processes. Relative to Campbell Lake, the farther upstream, the shorter the duration of discharge. Given sufficient rainfall, and a saturated watershed, discharge from Campbell Lake occurs over a number of days or weeks, whereas upstream, discharge is measured in hours, or at most a few days.

Under low flows, Campbell Lake potentially serves as a shallow sink for the deposition of upstream loads of carbon and turbidity, but under high flows, unregulated flows result in extended periods of discharge from the lake. During storm events, as well as periods of extended discharge, discharge from the lake potentially consists of high carbon and turbidity water from upstream inputs, as well as resuspended loads deposited earlier in the lake and disturbed by the upstream pulse entering the lake. This hypothesis is supported by grab sample and particle size results. Singer found that particle sizes entering the lake were similar to the particle size exiting the lake (Singer and Eshel 2000). Our studies found that statistically

TOC and turbidity concentrations entering the lake were significantly lower than concentrations exiting the lake, suggesting the input of resuspended bed load.

The extended duration of flow from Campbell Lake also explained the extended occurrence of elevated carbon and turbidity at the pumping plant in the absence of significant rainfall. Loading calculations determined that, given the plant's pumping rate, carbon loads leaving the lake over a 4-week period in the 1999/2000 sampling season could have provided between 90% and 400% of the carbon load pumped into the NBA. During this time, little or no rainfall fell on the watershed. Of the storms that did occur, 90% of them produced less than a half inch of rainfall. Suspended sediment loads were not analyzed, but given that the seasonal pattern is the same as TOC, it is hypothesized that sediment loads from Campbell Lake could also explain elevated levels of turbidity at the pumping plant over an extended period.

Statistical analysis of 1999/2000 grab samples provided a stronger data set than 1997/1998 samples to gauge the relative roles of different sections of the watershed and provided further evidence that discharge from Campbell Lake was similar to that of the pumping plant and not sites upstream. Two-way analysis of variance resulted in significant interaction effects for both TOC and turbidity. A significant interaction effect precludes drawing simple conclusions about main effects (TOC, turbidity, or location). Analysis of interaction effects found that, after the last winter rains, TOC and turbidity remain elevated at Campbell Lake and the pumping plant but return to lower levels at sites upstream. The long duration of discharge from Campbell Lake compared to the relatively short period of discharge from sites upstream provides further evidence that flow from Campbell Lake, and not sites upstream, impact water quality at the pumping plant for extended periods.

To determine appropriate BMPs, resolution of the analytical method is critical. Consultants retained by the SCWA have hypothesized that BMPs controlling turbidity stand a stronger chance of success than BMPs controlling organic carbon (Hydro Science 2001). Results from the wet-oxidation method indicated that a decrease in turbidity might have little effect on TOC because the majority of TOC is not in particulate form. In contrast, results from the combustion method indicate a higher fraction of the TOC is particulate in nature. If this is the case, controlling turbidity might reduce TOC levels. Hydro Science also concluded that the natural TOC levels in the watershed may still remain well above the 6 mg/L desired by the NBA contractors; therefore, even with the reduction in particulates, TOC concentrations as measured by the combustion method may remain above desirable levels.

One aspect that has not been well studied is the potential impact of discharge from Calhoun Cut to water quality at the pumping plant. Results from the 1996/1997 study suggested that winter TOC or turbidity concentrations at the pumping plant fell between water quality observed at Cook Lane and Calhoun Cut. Statistically, the matter remains unsettled, but if true, water from Calhoun Cut may ultimately contribute to the reservoir of carbon created at the forebay. Potentially, an answer to this question would come from continuous flow studies.

It has been hypothesized that one mechanism to account for the poor flushing at the pumping plant and the potential intermingling of Calhoun Cut water at the forebay is the formation of a hydrologic plug created by winter flooding of the Yolo Bypass. This hypothesis has not been investigated, but in the 2000/2001 sampling year, the Yolo Bypass did not flood, yet elevated levels of carbon and TOC were observed for many weeks at the pumping plant. It is possible that a hydrologic plug formed by the bypass may serve to exaggerate the observed phenomenon but not to create it. Potentially, the higher winter levels of the Sacramento River may also serve as a hydrologic plug.

In conclusion, 2 phenomena occur in the winter in the Barker Slough watershed. Both are related to rainfall, one directly and the other indirectly. The direct effect initiates a TOC and turbidity pulse that with sufficient momentum travels down the watershed to create a fairly rapid increase in TOC and turbidity at the pumping plant. Indirectly, extended periods of discharge from Campbell Lake, and, potentially, water traveling toward the pumping plant from Calhoun Cut, create a reservoir of high carbon and turbidity water at the forebay. Because of low pumping rates by the plant in the winter, this reservoir clears slowly, resulting in an extended period of high carbon and turbidity water pumped to the NBA even in the absence of rainfall.

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Appendix A

Table A-1 Summary statistics for grab samples collected for metal analysis: Lindsey Slough at Bridge

	Analyte (mg/L)	Mean	Median	Low	High	Percentile 10-90%	# of detects/total sampled
1997/1998 (27 Sep 1997 to 12 Jan 1998)	Dissolved Aluminum - EPA 200_8	0.07	0.07	0.05	0.10	0.05 - 0.1	5/5
	Dissolved Arsenic - EPA 200_8	-					
	Dissolved Barium - EPA 200_8	-					
	Dissolved Cadmium - EPA 200_8	-					
	Dissolved Chromium - EPA 200_8	-					
	Dissolved Copper - EPA 200_8	-					
	Dissolved Iron - EPA 200_8	0.079	0.081	0.027	0.128	0.038 - 0.118	5/5
	Dissolved Lead - EPA 200_8	-					
	Dissolved Manganese - EPA 200_8	0.006	0.006	< 0.005	0.009	< 0.005 - 0.008	3/5
	Dissolved Mercury - EPA 245_1	-					
	Dissolved Selenium - EPA 200_8	-					
	Dissolved Silver - EPA 200_8	-					
	Dissolved Zinc - EPA 200_8	-					
	Total Aluminum - EPA 200_8	1.129	1.140	0.939	1.380	0.956 - 1.29	6/6
	Total Iron - EPA 200_8	1.463	1.430	1.260	1.690	1.27 - 1.69	6/6
	Total Manganese - EPA 200_8	0.039	0.040	0.034	0.042	0.036 - 0.041	6/6

1998/1999 No samples collected
1999/2000 No samples collected
2000/2001 No samples collected
For summary calculations, DL substituted for values < DL.

Table A-2 Summary statistics for grab samples collected for metal analysis: Calhoun Cut at Highway 113

	Analyte (mg/L)	Mean	Median	Low	High	Percentile 10-90%	# of detects/total sampled
1997/1998 (27 Sep 1997 to 12 Jan 1998)	Dissolved Aluminum - EPA 200_8	0.04	0.02	< 0.01	0.08	< 0.01 - 0.08	3/5
	Dissolved Arsenic - EPA 200_8	-					
	Dissolved Barium - EPA 200_8	-					
	Dissolved Cadmium - EPA 200_8	-					
	Dissolved Chromium - EPA 200_8	-					
	Dissolved Copper - EPA 200_8	-					
	Dissolved Iron - EPA 200_8	0.088	0.085	0.042	0.178	0.044 - 0.142	5/5
	Dissolved Lead - EPA 200_8	-					
	Dissolved Manganese - EPA 200_8	0.024	0.023	0.018	0.033	0.020 - 0.029	5/5
	Dissolved Mercury - EPA 245_1	-					
	Dissolved Selenium - EPA 200_8	-					
	Dissolved Silver - EPA 200_8	-					
	Dissolved Zinc - EPA 200_8	-					
	Total Aluminum - EPA 200_8	1.694	1.740	1.320	2.160	1.352 - 2.036	5/5
	Total Iron - EPA 200_8	2.180	2.160	1.680	2.770	1.768 - 2.618	5/5
	Total Manganese - EPA 200_8	0.063	0.061	0.048	0.089	0.049 - 0.079	5/5

1998/1999 No samples collected
1999/2000 No samples collected
2000/2001 No samples collected
For summary calculations, DL substituted for values < DL.

Table A-3 Summary statistics for grab samples collected for metal analysis: Barker Slough Pumping Plant

	Analyte (mg/L)	Mean	Median	Low	High	Percentile 10-90%	# of detects/total sampled
1997/1998 (7 Sep 1997 to 18 Mar 1998)	Dissolved Aluminum - EPA 200_8	< 0.01	< 0.01	< 0.01	< 0.01		0/8
	Dissolved Arsenic - EPA 200_8	0.002	0.002	0.001	0.003	0.002 - 0.003	7/7
	Dissolved Barium - EPA 200_8	0.053	< 0.05	< 0.05	0.065	< 0.05 - 0.06	2/6
	Dissolved Cadmium - EPA 200_8	< 0.001	< 0.001	< 0.001	< 0.001		0/7
	Dissolved Chromium - EPA 200_8	< 0.005	< 0.005	< 0.005	0.007	< 0.005 - 0.006	1/7
	Dissolved Copper - EPA 200_8	0.003	0.003	0.002	0.005	0.002 - 0.004	7/7
	Dissolved Iron - EPA 200_8	0.051	0.050	< 0.005	0.126	0.005 - 0.106	7/8
	Dissolved Lead - EPA 200_8	< 0.001	< 0.001	< 0.001	< 0.001		0/7
	Dissolved Manganese - EPA 200_8	0.020	0.015	0.008	0.061	0.010 - 0.032	8/8
	Dissolved Mercury - EPA 245_1	< 0.002	< 0.002	< 0.002	< 0.002		0/7
	Dissolved Selenium - EPA 200_8	< 0.001	< 0.001	< 0.001	< 0.001		0/7
	Dissolved Silver - EPA 200_8	< 0.001	< 0.001	< 0.001	< 0.001		0/7
	Dissolved Zinc - EPA 200_8	0.007	< 0.005	< 0.005	0.016	< 0.005 - 0.011	2/7
	Total Aluminum - EPA 200_8	4.370	4.230	1.450	7.570	1.981 - 6.871	4/4
	Total Iron - EPA 200_8	5.213	4.940	1.840	9.130	2.431 - 8.212	4/4
	Total Manganese - EPA 200_8	0.100	0.085	0.067	0.163	0.071 - 0.141	4/4

1998/1999 No samples collected
1999/2000 No samples collected
2000/2001 No samples collected
For summary calculations, DL substituted for values < DL.

Table A-4 Summary statistics for grab samples collected for metal analysis: Barker Slough at Cook Lane

	Analyte (mg/L)	Mean	Median	Low	High	Percentile 10-90%	# of detects/total sampled
1997/1998 (29 Sep 1997 to 12 Jan 1998)	Dissolved Aluminum - EPA 200_8	0.02	0.01	< 0.01	0.06	< 0.01 - 0.05	3/5
	Dissolved Arsenic - EPA 200_8	-					
	Dissolved Barium - EPA 200_8	-					
	Dissolved Cadmium - EPA 200_8	-					
	Dissolved Chromium - EPA 200_8	-					
	Dissolved Copper - EPA 200_8	-					
	Dissolved Iron - EPA 200_8	0.065	0.071	0.014	0.090	0.035 - 0.087	5/5
	Dissolved Lead - EPA 200_8	-					
	Dissolved Manganese - EPA 200_8	0.017	0.011	0.006	0.037	0.006 - 0.033	5/5
	Dissolved Mercury - EPA 245_1	-					
	Dissolved Selenium - EPA 200_8	-					
	Dissolved Silver - EPA 200_8	-					
	Dissolved Zinc - EPA 200_8	-					
	Total Aluminum - EPA 200_8	6.644	8.160	2.580	11.000	2.788 - 9.952	5/5
	Total Iron - EPA 200_8	7.914	9.540	3.600	12.100	3.732 - 11.42	5/5
	Total Manganese - EPA 200_8	-					

1998/1999 No samples collected
1999/2000 No samples collected
2000/2001 No samples collected
For summary calculations, DL substituted for values < DL.

Table A-5 Summary statistics for grab samples collected for metal analysis: Barker Slough at Dally Road

	Analyte (mg/L)	Mean	Median	Low	High	Percentile 10-90%	# of detects /total sampled
1997/1998 (22 Oct to 17 Dec 1997)	Dissolved Aluminum - EPA 200_8	0.09	0.04	0.01	0.22	0.02 - 0.18	2/3
	Dissolved Arsenic - EPA 200_8	-					
	Dissolved Barium - EPA 200_8	-					
	Dissolved Cadmium - EPA 200_8	-					
	Dissolved Chromium - EPA 200_8	-					
	Dissolved Copper - EPA 200_8	-					
	Dissolved Iron - EPA 200_8	0.105	0.038	0.037	0.240	0.0372 - 0.200	3/3
	Dissolved Lead - EPA 200_8	-					
	Dissolved Manganese - EPA 200_8	0.051	0.027	0.018	0.109	0.020 - 0.093	3/3
	Dissolved Mercury - EPA 245_1	-					
	Dissolved Selenium - EPA 200_8	-					
	Dissolved Silver - EPA 200_8	-					
	Dissolved Zinc - EPA 200_8	-					
	Total Aluminum - EPA 200_8	1.630	1.705	0.031	3.080	0.493 - 2.708	4/4
	Total Iron - EPA 200_8	1.786	1.965	0.055	3.160	0.606 - 2.824	4/4
	Total Manganese - EPA 200_8	0.095	0.096	0.048	0.141	0.055 - 0.135	4/4

1998/1999 No samples collected
1999/2000 No samples collected
2000/2001 No samples collected
For summary calculations, DL substituted for values < DL.

Table A-6 Summary statistics for grab samples collected for metal analysis: Barker Slough at Hay Road

	Analyte (mg/L)	Mean	Median	Low	High	Percentile 10-90%	# of detects/total sampled
1997/1998 (22 Oct 1997 to 12 Jan 1998)	Dissolved Aluminum - EPA 200_8	0.03	0.01	< 0.01	0.10	< 0.01 - 0.08	2/4
	Dissolved Arsenic - EPA 200_8	-					
	Dissolved Barium - EPA 200_8	-					
	Dissolved Cadmium - EPA 200_8	-					
	Dissolved Chromium - EPA 200_8	-					
	Dissolved Copper - EPA 200_8	-					
	Dissolved Iron - EPA 200_8	0.065	0.041	0.022	0.154	0.027 - 0.120	4/4
	Dissolved Lead - EPA 200_8	-					
	Dissolved Manganese - EPA 200_8	-					
	Dissolved Mercury - EPA 245_1	-					
	Dissolved Selenium - EPA 200_8	-					
	Dissolved Silver - EPA 200_8	-					
	Dissolved Zinc - EPA 200_8	-					
	Total Aluminum - EPA 200_8	0.458	0.534	0.010	0.917	0.012 - 0.875	5/5
	Total Iron - EPA 200_8	3.351	0.856	0.036	14.100	0.291 - 8.896	5/5
	Total Manganese - EPA 200_8	0.093	0.051	0.019	0.207	0.026 - 0.184	5/5

1998/1999 No samples collected
1999/2000 No samples collected
2000/2001 No samples collected
For summary calculations, DL substituted for values < DL

Appendix B

Table B-1 Summary statistics for grab samples for HAA analysis: Barker Slough Pumping Plant

	Analyte (µg/L)	Mean	Median	Low	High	# detects/ total sampled
1997/1998 (17 Sep 1997 to 18 Mar 1998)	Bromochloroacetic Acid (BCAA) - DWR HAAFP (Reactivity)	11.5	11.5	3	20	2/2
	Dibromoacetic Acid (DBAA) - DWR HAAFP (Reactivity)	2	2	< 1	3	1/2
	Dichloroacetic Acid (DCAA) - DWR HAAFP (Reactivity)	155	155	146	164	2/2
	Monobromoacetic Acid (MBAA) - DWR HAAFP (Reactivity)	2	2	< 1	3	1/2
	Monochloroacetic Acid (MCAA) - DWR HAAFP (Reactivity)	2	2	< 1	3	1/2
	Trichloroacetic Acid (TCAA) - DWR HAAFP (Reactivity)	231	231	223	238	2/2
	Bromochloroacetic Acid (BCAA) - DWR SDS HAA	< 0.01	< 0.01	< 0.01	< 0.01	0/3
	Dibromoacetic Acid (DBAA) - DWR SDS HAA	< 0.01	< 0.01	< 0.01	< 0.01	0/3
	Dichloroacetic Acid (DCAA) - DWR SDS HAA	< 0.01	< 0.01	< 0.01	< 0.01	0/3
	Monobromoacetic Acid (MBAA) - DWR SDS HAA	< 0.01	< 0.01	< 0.01	< 0.01	0/3
	Monochloroacetic Acid (MCAA) - DWR SDS HAA	< 0.01	< 0.01	< 0.01	< 0.01	0/3
	Trichloroacetic Acid (TCAA) - DWR SDS HAA	< 0.01	< 0.01	< 0.01	< 0.01	0/3

1998/1999 No samples collected
1999/2000 No samples collected
2000/2001 No samples collected
For summary calculations, DL substituted for values < DL.

Table B-2 Summary statistics for grab samples collected for organic analysis: Barker Slough Pumping Plant

	Analyte	Detection limit (µg/L)	# detects/ total sampled
1997/1998 (17 Sep 1997 to 18 Mar 1998)	1,1,1,2-Tetrachloroethane - EPA 502_2	< 0.5	0/4
	1,1,1-Trichloroethane - EPA 502_2	< 0.5	0/4
	1,1,2,2-Tetrachloroethane - EPA 502_2	< 0.5	0/4
	1,1,2-Trichloroethane - EPA 502_2	< 0.5	0/4
	1,1-Dichloroethane - EPA 502_2	< 0.5	0/4
	1,1-Dichloroethene - EPA 502_2	< 0.5	0/4
	1,1-Dichloropropene - EPA 502_2	< 0.5	0/4
	1,2,3-Trichlorobenzene - EPA 502_2	< 0.5	0/4
	1,2,3-Trichloropropane - EPA 502_2	< 0.5	0/4
	1,2,4-Trichlorobenzene - EPA 502_2	< 0.5	0/4
	1,2,4-Trimethylbenzene - EPA 502_2	< 0.5	0/4
	1,2-Dibromo-3-chloropropane (DBCP) - EPA 502_2	< 0.5	0/4
	1,2-Dibromoethane - EPA 502_2	< 0.5	0/4
	1,2-Dichlorobenzene - EPA 502_2	< 0.5	0/4
	1,2-Dichloroethane - EPA 502_2	< 0.5	0/4
	1,2-Dichloropropane - EPA 502_2	< 0.5	0/4
	1,3,5-Trimethylbenzene - EPA 502_2	< 0.5	0/4
	1,3-Dichlorobenzene - EPA 502_2	< 0.5	0/4
	1,3-Dichloropropane - EPA 502_2	< 0.5	0/4
	1,4-Dichlorobenzene - EPA 502_2	< 0.5	0/4
	2,2-Dichloropropane - EPA 502_2	< 0.5	0/4
	2,4,5-T - EPA 615	< 0.1	0/1
	2,4,5-TP (Silvex) - EPA 615	< 0.1	0/1
	2,4-D - EPA 615	< 0.1	0/1
	2,4-DB - EPA 615	< 0.1	0/1
	2-Chlorotoluene - EPA 502_2	< 0.5	0/4
	3-Hydroxycarbofuran - EPA 531_1	< 2	0/1
	4-Chlorotoluene - EPA 502_2	< 0.5	0/4

Table B-2 continued

	Analyte	Detection limit (µg/L)	# detects/ total sampled
1997/1998 (17 Sep 1997 to 18 Mar 1998)	4-Isopropyltoluene - EPA 502_2	< 0.5	0/4
	Alachlor - EPA 608	< 0.05	0/1
	Aldicarb - EPA 531_1	< 2	0/1
	Aldicarb sulfone - EPA 531_1	< 2	0/1
	Aldicarb sulfoxide - EPA 531_1	< 2	0/1
	Aldrin - EPA 608	< 0.01	0/1
	Aminomethylphosphonic Acid (AMPA) - EPA 547	< 100	0/1
	Atrazine - EPA 608	< 0.02	0/1
	Azinphos methyl (Guthion) - EPA 614	< 0.05	0/1
	Benfluralin - EPA 614	< 0.01	0/1
	Benzene - EPA 502_2	< 0.5	0/1
	BHC-alpha - EPA 608	< 0.01	0/1
	BHC-beta - EPA 608	< 0.01	0/1
	BHC-delta - EPA 608	< 0.01	0/1
	BHC-gamma (Lindane) - EPA 608	< 0.01	0/1
	Bromacil - EPA 614	< 1	0/1
	Bromobenzene - EPA 502_2	< 0.5	0/1
	Bromochloromethane - EPA 502_2	< 0.5	0/4
	Bromodichloromethane - EPA 502_2	< 0.5	0/4
	Bromoform - EPA 502_2	< 0.5	0/4
	Captan - EPA 608	< 0.02	0/1
	Carbaryl - EPA 531_1	< 2	0/1
	Carbofuran - EPA 531_1	< 2	0/1
	Carbon tetrachloride - EPA 502_2	< 0.5	0/4
	Carbophenothion (Trithion) - EPA 614	< 0.02	0/1
	Chlordane - EPA 608	< 0.05	0/1
	Chlorobenzene - EPA 502_2	< 0.5	0/4
	Chloroethane - EPA 502_2	< 0.5	0/4

Table continued on next page

Table B-2 continued

	Analyte	Detection limit (µg/L)	# detects /total sampled
1997/1998 (17 Sep 1997 to 18 Mar 1998)	Chloroform - EPA 502_2	< 0.5	0/4
	Chloromethane - EPA 502_2	< 0.5	0/4
	Chlorothalonil - EPA 608	< 0.01	0/1
	Chlorpropham - EPA 608	< 0.02	0/1
	Chlorpyrifos - EPA 608	< 0.01	0/1
	Chlorpyrifos - EPA 614	< 0.01	0/1
	cis-1,2-Dichloroethene - EPA 502_2	< 0.5	0/4
	cis-1,3-Dichloropropene - EPA 502_2	< 0.5	0/4
	Cyanazine - EPA 608	< 0.3	0/1
	Cyanazine - EPA 614	< 0.3	0/1
	Dacthal (DCPA) - EPA 608	< 0.01	0/1
	Dacthal (DCPA) - EPA 615	< 0.1	0/1
	Demeton (Demeton O + Demeton S) - EPA 614	< 0.02	0/1
	Diazinon - EPA 614	< 0.01	0/1
	Dibromochloromethane - EPA 502_2	< 0.5	0/4
	Dibromomethane - EPA 502_2	< 0.5	0/4
	Dicamba - EPA 615	< 0.1	0/1
	Dichloran - EPA 608	< 0.01	0/1
	Dichlorodifluoromethane - EPA 502_2	< 0.5	0/4
	Dichlorprop - EPA 615	< 0.1	0/1
	Dicofol - EPA 608	< 0.05	0/1
	Dieldrin - EPA 608	< 0.01	0/1
	Dimethoate - EPA 614	< 0.01	0/1
	Disulfoton - EPA 614	< 0.01	0/1
	Diuron - EPA 608	< 0.25	0/1
	Endosulfan sulfate - EPA 608	< 0.02	0/1
	Endosulfan-I - EPA 608	< 0.01	0/1
	Endosulfan-II - EPA 608	< 0.01	0/1

Table B-2 continued

	Analyte	Detection limit (µg/L)	# detects/ total sampled
1997/1998 (17 Sep 1997 to 18 Mar 1998)	Endrin - EPA 608	< 0.01	0/1
	Endrin aldehyde - EPA 608	< 0.01	0/1
	Ethion - EPA 614	< 0.01	0/1
	Ethyl benzene - EPA 502_2	< 0.5	0/4
	Formetanate hydrochloride - EPA 531_1	< 100	0/1
	Glyphosate - EPA 547	< 100	0/1
	Heptachlor - EPA 608	< 0.01	0/1
	Heptachlor epoxide - EPA 608	< 0.01	0/1
	Hexachlorobutadiene - EPA 502_2	< 0.5	0/4
	Isopropylbenzene - EPA 502_2	< 0.5	0/4
	m-Xylene - EPA 502_2	< 0.5	0/4
	Malathion - EPA 614	< 0.01	0/1
	MCPA - EPA 615	< 0.1	0/1
	MCPP - EPA 615	< 0.1	0/1
	Methidathion - EPA 614	< 0.02	0/1
	Methiocarb - EPA 531_1	< 4	0/1
	Methomyl - EPA 531_1	< 2	0/1
	Methoxychlor - EPA 608	< 0.05	0/1
	Methyl tert-butyl ether (MTBE) - EPA 502_2	< 1	0/4
	Methylene chloride - EPA 502_2	< 0.5	0/4
	Metolachlor - EPA 608	< 0.2	0/1
	Mevinphos - EPA 614	< 0.01	0/1
	n-Butylbenzene - EPA 502_2	< 0.5	0/4
	n-Propylbenzene - EPA 502_2	< 0.5	0/4
	Naled - EPA 614	< 0.02	0/1
	Naphthalene - EPA 502_2	< 0.5	0/4
	Napropamide - EPA 614	< 5	0/1
	Norflurazon - EPA 614	< 5	0/1

Table continued on next page

Table B-2 continued

	Analyte	Detection limit (µg/L)	# detects /total sampled
1997/1998 (17 Sep 1997 to 18 Mar 1998)	o-Xylene - EPA 502_2	< 0.5	0/4
	Oxamyl - EPA 531_1	< 2	0/1
	Oxyfluorfen - EPA 608	< 0.2	0/1
	p,p'-DDD - EPA 608	< 0.01	0/1
	p,p'-DDE - EPA 608	< 0.01	0/1
	p,p'-DDT - EPA 608	< 0.05	0/1
	p-Xylene - EPA 502_2	< 0.5	0/4
	Parathion (Ethyl) - EPA 614	< 0.01	0/1
	Parathion, Methyl - EPA 614	< 0.01	0/1
	PCB-1016 - EPA 608	< 0.1	0/1
	PCB-1221 - EPA 608	< 0.1	0/1
	PCB-1232 - EPA 608	< 0.1	0/1
	PCB-1242 - EPA 608	< 0.1	0/1
	PCB-1248 - EPA 608	< 0.1	0/1
	PCB-1254 - EPA 608	< 0.1	0/1
	PCB-1260 - EPA 608	< 0.1	0/1
	Pendimethalin - EPA 614	< 5	0/1
	Pentachloronitrobenzene (PCNB) - EPA 608	< 0.01	0/1
	Pentachlorophenol (PCP) - EPA 615	< 0.1	0/1
	Phorate - EPA 614	< 0.01	0/1
	Phosalone - EPA 614	< 0.02	0/1
	Phosmet - EPA 614	< 0.02	0/1
	Picloram - EPA 615	< 1	0/1
	Profenofos - EPA 614	< 0.01	0/1
	Prometryn - EPA 614	< 0.05	0/1
	Propargite - DWR Sulfur Pesticides	< 1	0/1
	Propetamphos - EPA 614	< 0.1	0/1
	s,s,s-Tributyl Phosphorotrithioate (DEF) - EPA 614	< 0.01	0/1

Table B-2 continued

	Analyte	Detection limit (µg/L)	# detects/ total sampled
1997/1998 (17 Sep 1997 to 18 Mar 1998)	sec-Butylbenzene - EPA 502_2	< 0.5	0/4
	Simazine - EPA 608	< 0.02	0/1
	Styrene - EPA 502_2	< 0.5	0/4
	tert-Butylbenzene - EPA 502_2	< 0.5	0/4
	Tetrachloroethene - EPA 502_2	< 0.5	0/4
	Thiobencarb - EPA 608	< 0.02	0/1
	Toluene - EPA 502_2	< 0.5	0/4
	Toxaphene - EPA 608	< 1	0/1
	trans-1,2-Dichloroethene - EPA 502_2	< 0.5	0/4
	trans-1,3-Dichloropropene - EPA 502_2	< 0.5	0/4
	Trichloroethene - EPA 502_2	< 0.5	0/4
	Trichlorofluoromethane - EPA 502_2	< 0.5	0/4
	Triclopyr - EPA 615	< 0.1	0/1
	Trifluralin - EPA 614	< 0.01	0/1
	Vinyl chloride - EPA 502_2	< 0.5	0/4

1998/1999 No samples collected
1999/2000 No samples collected
2000/2001 No samples collected

APPENDIX C

Table C-1 Summary statistics for grab samples collected for miscellaneous analysis: Lindsey Slough at Bridge

	Analyte	Mean	Median	Low	High	Percentile 10-90%	# detects/ total sampled
1997/1998 (29 Sep 1997 to 1 Mar 1998)	Dissolved Bromide - EPA 300_0 (mg/L)	0.04	0.03	0.03	0.06	0.03 - 0.06	7/7
	Dissolved Organic Carbon - EPA 415_1 Wet-Ox (mg/L)	4.2	4.8	2.0	5.5	2.2 - 5.5	7/7
	Fecal Coliform - Colilert (MPN)	-					
	Suspended Solids - Std Method 2540 D (mg/L)	-					
	Total Coliform - Colilert (MPN)	< 1	< 1	< 1	< 1		0/6
	Total Dissolved Solids - Std Method 2540-C (mg/L)	185.29	184.00	129.00	255.00	137.4 - 240	7/7
	Total Organic Carbon - EPA 415_1 Wet-Ox (mg/L)	4.8	5.5	2.7	6.2	3.0 - 6.1	7/7
	Total Suspended Solids - EPA 160_2 (mg/L)	41.14	28.40	23.20	109.20	24.88 - 69.84	7/7
	UV Absorbance @254nm - Std Method 5910B (absorbance/cm)	0.128	0.146	0.067	0.184	0.069 - 0.171	7/7
	Volatile Suspended Solids - EPA 160_4 (mg/L)	-					

1998/1999 No samples collected
1999/2000 No samples collected
2000/2001 No samples collected
For summary calculations, DL substituted for values < DL.

Table C-2 Summary statistics for grab samples collected for miscellaneous analysis: Calhoun Cut at Highway 113

	Analyte	Mean	Median	Low	High	Percentile 10-90%	# detects/ total sampled
1997/1998	Dissolved Bromide - EPA 300_0 (mg/L) 28d Hold	0.05	0.05	0.02	0.12	0.02 - 0.08	7/7
	Dissolved Organic Carbon - EPA 415_1 Wet-Ox (mg/L)	10.2	10.5	4.4	15.9	4.9 - 14.8	7/7
	Fecal Coliform - Colilert (MPN)	-					
	Suspended Solids - Std Method 2540 D (mg/L)	-					
	Total Coliform - Colilert (MPN)	< 1	< 1	< 1	< 1		0/6
	Total Dissolved Solids - Std Method 2540-C (mg/L)	203.14	194.00	130.00	269.00	144.4 - 255.8	7/7
	Total Organic Carbon - EPA 415_1 Wet-Ox (mg/L)	12.7	12.2	6.2	20.7	6.3 - 19.4	7/7
	Total Suspended Solids - EPA 160_2 (mg/L)	42.01	43.00	13.60	65.00	22.96 - 62.6	7/7
	UV Absorbance @254nm - Std Method 5910B (absorbance/cm)	0.383	0.391	0.164	0.595	0.185 - 0.563	7/7
	Volatile Suspended Solids - EPA 160_4 (mg/L)	-					
1999/2000 (1 Mar to 29 Mar 2000)	Dissolved Organic Carbon - EPA 415_1 Wet-Ox (mg/L)	-					
	Total Organic Carbon* - EPA 415_1 Wet-Ox (mg/L)	18.4	17.9	16.0	21.6	16.2 - 20.8	15/15

1998/1999 No samples collected
2000/2001 No samples collected
* Beginning Jan 1999 persulfate volumes and reaction times increased to increase compatibility to combustion results.
For summary calculations, DL substituted for values < DL.

Table C-3 Summary statistics for grab samples collected for miscellaneous analysis: Barker Slough Pumping Plant

	Analyte	Mean	Median	Low	High	Percentile 10-90%	# detects/ total sampled
1997/1998 (29 Sep 1997 to 1 Mar 1998)	Dissolved Bromide - EPA 300_0 (mg/L) 28d Hold	0.06	0.04	0.01	0.20	0.02 - 0.11	9/9
	Dissolved Organic Carbon - EPA 415_1 Wet-Ox (mg/L)	6.3	5.5	3.4	9.5	3.9 - 8.8	3/3
	Fecal Coliform - Colilert (MPN)	822	750	< 1	2419	< 1 - 1715	6/8
	Suspended Solids - Std Method 2540 D (mg/L)	60.86	49.00	34.00	106.00	37 - 103	7/7
	Total Coliform - Colilert (MPN)	< 1	< 1	< 1	< 1		0/8
	Total Dissolved Solids - Std Method 2540-C (mg/L)	99.83	109.00	< 1	207.00	< 1 - 189.5	4/6
	Total Organic Carbon - EPA 415_1 Wet-Ox (mg/L)	10.2	10.0	5.5	18.0	5.7 - 13.8	8/8
	Total Suspended Solids - EPA 160_2 (mg/L)	62.87	48.60	34.00	106.00	36.5 - 103.2	6/6
	UV Absorbance @254nm - Std Method 5910B (absorbance/cm)	0.307	0.311	0.069	0.473	0.087 - 0.471	8/8
	Volatile Suspended Solids - EPA 160_4 (mg/L)	7.0	7.2	< 10	10.0	3.84 - 8.88	3/4
1998/1999 (6 Nov 1998 to 30 Apr 1999)	Dissolved Organic Carbon - EPA 415_1 Wet-Ox (mg/L)	6.3	6.9	3.1	11.6	3.2 - 10.6	25/25
	Total Organic Carbon - EPA 415_1 Wet-Ox (mg/L)	7.2	6.2	3.2	14.5	3.7 - 13.0	26/26
1999/2000 (3 Nov 1999 to 29 Mar 2000)	Dissolved Organic Carbon - EPA 415_1 Wet-Ox (mg/L)	-					
	Total Organic Carbon* - EPA 415_1 Wet-Ox (mg/L)	7.5	3.3	2.1	17.9	2.4 - 16.0	66/66
2000/2001 (29 Nov 2000 to 25 Apr 2001)	Dissolved Organic Carbon - EPA 415_1 Wet-Ox (mg/L)	6.0	4.0	2.4	14.4	2.7 - 13.9	66/66
	Total Organic Carbon* - EPA 415_1 Wet-Ox (mg/L)	6.7	4.3	2.6	17.2	3.0 - 15.2	63/63
	Total Organic Carbon - EPA 415_1 Combustion (mg/L)	10	8.7	2.9	28.8	3.1 - 20.3	63/63

* Beginning Jan 1999 persulfate volumes and reaction times increased to increase compatibility to combustion results.
For summary calculations, DL substituted for values < DL.

Table C-4 Summary statistics for grab samples collected for miscellaneous analysis: Barker Slough above Campbell Lake

		Mean	Median	Low	High	Percentile 10-90%	# detects/ total sampled
1999/2000	Dissolved Organic Carbon - EPA 415_1 Wet-Ox (mg/L)	-					
(3 Nov 1999 to 29 Mar 2000)	Total Organic Carbon* - EPA 415_1 Wet-Ox (mg/L)	10.3	9.5	5.8	17.0	5.8 - 16.4	14/14

1997/1998 No samples collected
1998/1999 No samples collected
2000/2001 No samples collected
* Beginning Jan 1999 persulfate volumes and reaction times increased to increase compatibility to combustion results.

Table C-5 Summary statistics for grab samples collected for miscellaneous analysis: Barker Slough below Campbell Lake

		Mean	Median	Low	High	Percentile 10-90%	# detects/ total sampled
1999/2000	Dissolved Organic Carbon - EPA 415_1 Wet-Ox (mg/L)	-					
(3 Nov 1999 to 29 Mar 2000)	Total Organic Carbon* - EPA 415_1 Wet-Ox (mg/L)	11.5	10.2	6.4	23.4	6.9 - 16.9	65/65

1997/1998 No samples collected
1998/1999 No samples collected
2000/2001 No samples collected
* Beginning Jan 1999 persulfate volumes and reaction times increased to increase compatibility to combustion results.

Table C-6 Summary statistics for grab samples collected for miscellaneous analysis: Barker Slough at Junction

		Mean	Median	Low	High	Percentile 10-90%	# detects/ total sampled
1999/2000	Dissolved Organic Carbon - EPA 415_1 Wet-Ox (mg/L)	-					
(3 Nov 1999 to 29 Mar 2000)	Total Organic Carbon* - EPA 415_1 Wet-Ox (mg/L)	9.0	8.5	5.2	16.4	5.8 - 13.7	66/66

1997/1998 No samples collected
1998/1999 No samples collected
2000/2001 No samples collected
* Beginning Jan 1999 persulfate volumes and reaction times increased to increase compatibility to combustion results.

Table C-7 Summary statistics for grab samples collected for miscellaneous analysis: Barker Slough at Cook Lane

	Analyte	Mean	Median	Low	High	Percentile 10-90%	# detects/ total sampled
1997/1998 (29 Sep 1997 to 1 Mar 1998)	Dissolved Bromide - EPA 300_0 (mg/L) 28d Hold	0.03	0.02	0.01	0.09	0.01 - 0.07	7/7
	Dissolved Organic Carbon - EPA 415_1 Wet-Ox (mg/L)	10.1	10.2	6.0	12.8	6.2 - 12.7	7/7
	Fecal Coliform - Colilert (MPN)	-					
	Suspended Solids - Std Method 2540 D (mg/L)	-					
	Total Coliform - Colilert (MPN)	< 1	< 1	< 1	< 1		0/6
	Total Dissolved Solids - Std Method 2540-C (mg/L)	170.43	146.00	91.00	272.00	113.2 - 241.4	7/7
	Total Organic Carbon - EPA 415_1 Wet-Ox (mg/L)	15.3	15.6	8.8	20.5	9.5 - 19.8	7/7
	Total Suspended Solids - EPA 160_2 (mg/L)	183.14	198.00	76.00	274.00	88.6 - 253.6	7/7
	UV Absorbance @254nm - Std Method 5910B (absorbance/cm)	0.340	0.348	0.187	0.439	0.215 - 0.437	7/7
	Volatile Suspended Solids - EPA 160_4 (mg/L)	-					

1998/1999 No samples collected
1999/2000 No samples collected
2000/2001 No samples collected
For summary calculations, DL substituted for values < DL.

Table C-8 Summary statistics for grab samples collected for miscellaneous analysis: Barker Slough at Dally Road

	Analyte	Mean	Median	Low	High	Percentile 10-90%	# detects/ total sampled
1997/1998 (22 Oct 1997 to 1 Mar 1998)	Dissolved Bromide - EPA 300_0 (mg/L) 28d Hold	0.03	0.01	< 0.01	0.09	0.01 - 0.07	4/5
	Dissolved Organic Carbon - EPA 415_1 Wet-Ox (mg/L)	10.5	11.4	4.0	15.0	16.2 - 14.0	5/5
	Fecal Coliform - Colilert (MPN)	< 1	< 1	< 1	< 1		0/1
	Suspended Solids - Std Method 2540 D (mg/L)	-					
	Total Coliform - Colilert (MPN)	< 1	< 1	< 1	< 1		0/5
	Total Dissolved Solids - Std Method 2540-C (mg/L)	198.40	175.00	108.00	279.00	133.6 - 270.6	5/5
	Total Organic Carbon - EPA 415_1 Wet-Ox (mg/L)	13.2	12.8	4.8	20.0	7.4 - 18.8	5/5
	Total Suspended Solids - EPA 160_2 (mg/L)	87.70	42.70	33.00	276.00	36.12 - 184	5/5
	UV Absorbance @254nm - Std Method 5910B (absorbance/cm)	0.339	0.360	0.115	0.522	0.194 - 0.468	5/5
	Volatile Suspended Solids - EPA 160_4 (mg/L)	-					

1998/1999 No samples collected
1999/2000 No samples collected
2000/2001 No samples collected
For summary calculations, DL substituted for values < DL.

Table C-9 Summary statistics for grab samples collected for miscellaneous analysis: Barker Slough at Hay Road

	Analyte	Mean	Median	Low	High	Percentile 10-90%	# detects/ total sampled
1997/1998 (22 Oct 1997 to 1 Mar 1998)	Dissolved Bromide - EPA 300_0 (mg/L) 28d Hold	0.04	0.01	< 0.01	0.13	0.01 - 0.09	4/7
	Dissolved Organic Carbon - EPA 415_1 Wet-Ox (mg/L)	9.6	8.4	3.4	16.1	5.0 - 15.3	7/7
	Fecal Coliform - Colilert (MPN)	< 1	< 1	< 1	< 1		0/1
	Suspended Solids - Std Method 2540 D (mg/L)	-					
	Total Coliform - Colilert (MPN)	< 1	< 1	< 1	< 1		0/7
	Total Dissolved Solids - Std Method 2540-C (mg/L)	178.86	169.00	68.00	353.00	77.6 - 329.6	7/7
	Total Organic Carbon - EPA 415_1 Wet-Ox (mg/L)	12.3	12.9	3.7	17.4	8.0 - 16.0	7/7
	Total Suspended Solids - EPA 160_2 (mg/L)	172.44	30.00	8.80	402.00	13.6 - 400.8	7/7
	UV Absorbance @254nm - Std Method 5910B (absorbance/cm)	0.328	0.324	0.093	0.602	0.173 - 0.515	7/7
	Volatile Suspended Solids - EPA 160_4 (mg/L)	-					

1998/1999 No samples collected
1999/2000 No samples collected
2000/2001 No samples collected
For summary calculations, DL substituted for values < DL.

Table C-10 Summary statistics for grab samples collected for miscellaneous analysis: Barker Slough at Leisure Town Road

		Mean	Median	Low	High	Percentile 10-90%	# detects/ total sampled
1999/2000	Dissolved Organic Carbon - EPA 415_1 Wet-Ox (mg/L)	-					
(3 Nov 1999 to 29 Mar 2000)	Total Organic Carbon* - EPA 415_1 Wet-Ox (mg/L)	7.3	6.4	2.5	20.0	2.8 - 12.2	66/66

1997/1998 No samples collected
1998/1999 No samples collected
2000/2001 No samples collected
* Beginning Jan 1999 persulfate volumes and reaction times increased to increase compatibility to combustion results.

APPENDIX D

Table D-1 Summary statistics for grab samples collected for nutrient analysis: Lindsey Slough at Bridge

	Analyte* (mg/L)	Mean	Median	Low	High	Percentile 10-90%	# detects/ total sampled
1997/1998 (29 Sep 1997 to 2 Feb 1998)	Dissolved Ammonia - EPA 350_1	0.05	0.05	0.05	0.05	0.05 - 0.05	2/2
	Dissolved Nitrate - Std Method 4500-NO3-F	0.50	0.47	0.27	0.82	0.29 - 0.70	7/7
	Dissolved Nitrite + Nitrate - Std Method 4500-NO3-F	0.52	0.47	0.29	0.85	0.31 - 0.72	7/7
	Dissolved Ortho-phosphate - Std Method 4500-P	0.08	0.07	0.07	0.13	0.07 - 0.11	5/5
	Total Kjeldahl Nitrogen - EPA 351_2	0.63	0.60	0.40	0.90	0.46 - 0.84	7/7
	Total Phosphorus - EPA 365_4	0.20	0.16	0.12	0.41	0.13 - 0.33	7/7

1998/1999 No nutrient samples collected
2000/2001 No nutrient samples collected
*All nitrogen values are reported as N. All phosphate values are reported as P.
For summary calculations, DL substituted for values < DL.

Table D-2 Summary statistics for grab samples collected for nutrient analysis: Calhoun Cut at Highway 113

	Analyte* (mg/L)	Mean	Median	Low	High	Percentile 10-90%	# of detects/ total sampled
1997/1998 (29 Sep 1997 to 2 Feb 1998)	Dissolved Ammonia - EPA 350_1	0.03	0.03	0.03	0.03	0.03 - 0.03	2/2
	Dissolved Nitrate - Std Method 4500-NO3-F	0.09	0.07	0.01	0.18	0.01 - 0.18	5/7
	Dissolved Nitrite + Nitrate - Std Method 4500-NO3-F	0.11	0.13	0.02	0.20	0.04 - 0.18	7/7
	Dissolved Ortho-phosphate - Std Method 4500-P, F	0.14	0.14	0.12	0.17	0.12 - 0.16	5/5
	Total Kjeldahl Nitrogen - EPA 351_2	1.06	1.00	0.50	1.80	0.56 - 1.60	7/7
	Total Phosphorus - EPA 365_4	0.27	0.24	0.21	0.34	0.22 - 0.34	7/7

1998/1999 No nutrient samples collected
2000/2001 No nutrient samples collected
*All nitrogen values are reported as N. All phosphate values are reported as P.
For summary calculations, DL substituted for values < DL.

Table D-3 Summary statistics for grab samples collected for nutrient analysis: Barker Slough Pumping Plant

	Analyte* (mg/L)	Mean	Median	Low	High	Percentile 10-90%	# detects/ total sampled
1997/1998 (17 Sep 1997 to 18 Mar 1998)	Dissolved Ammonia - EPA 350_1	0.04	0.04	< 0.01	0.07	< 0.01 - 0.07	4/6
	Dissolved Nitrate - Std Method 4500-NO3-F	1.08	0.80	0.60	2.80	0.60 - 1.6	9/9
	Dissolved Nitrite + Nitrate - Std Method 4500-NO3-F	0.10	0.07	< 0.01	0.22	0.01 - 0.21	3/6
	Dissolved Ortho-phosphate - Std Method 4500-P, F	0.08	0.10	< 0.01	0.11	0.04 - 0.11	6/7
	Total Kjeldahl Nitrogen - EPA 351_2	1.08	1.00	0.40	1.70	0.56 - 1.62	5/5
	Total Phosphorus - EPA 365_4	0.28	0.30	0.15	0.40	0.17 - 0.39	6/6

1998/1999 No nutrient samples collected
2000/2001 No nutrient samples collected
*All nitrogen values are reported as N. All phosphate values are reported as P.
For summary calculations, DL substituted for values < DL.

Table D-4 Summary statistics for grab samples collected for nutrient analysis: Barker Slough at Cook Lane

	Analyte* (mg/L)	Mean	Median	Low	High	Percentile 10-90%	# detects/ total sampled
1997/1998 (29 Sep 1997 to 2 Feb 1998)	Dissolved Ammonia - EPA 350_1	0.11	0.11	0.04	0.17	0.05 - 0.16	2/2
	Dissolved Nitrate - Std Method 4500-NO3-F	0.36	0.27	0.02	0.98	0.06 - 0.70	7/7
	Dissolved Nitrite + Nitrate - Std Method 4500-NO3-F	0.36	0.28	0.03	1.00	0.07 - 0.68	7/7
	Dissolved Ortho-phosphate - Std Method 4500-P, F	0.07	0.06	0.01	0.14	0.02 - 0.12	5/5
	Total Kjeldahl Nitrogen - EPA 351_2	1.70	1.60	0.90	2.70	1.14 - 2.28	7/7
	Total Phosphorus - EPA 365_4	0.32	0.27	0.18	0.54	0.19 - 0.51	6/6

1998/1999 No nutrient samples collected
2000/2001 No nutrient samples collected
*All nitrogen values are reported as N. All phosphate values are reported as P.
For summary calculations, DL substituted for values < DL

Table D-5 Summary statistics for grab samples collected for nutrient analysis: Barker Slough at Dally Road

	Analyte* (mg/L)	Mean	Median	Low	High	Percentile 10-90%	# detects/ total sampled
1997/1998 (22 Oct 1997 to 29 Jan 1998)	Dissolved Ammonia - EPA 350_1	0.13	0.13	0.05	0.21	0.07 - 0.19	2/2
	Dissolved Nitrate - Std Method 4500-NO3-F	0.39	0.22	< 0.01	1.20	0.08 - 0.86	4/5
	Dissolved Nitrite + Nitrate - Std Method 4500-NO3-F	0.47	0.33	0.22	1.23	0.22 - 0.89	5/5
	Dissolved Ortho-phosphate - Std Method 4500-P, F	0.08	0.06	0.02	0.18	0.03 - 0.15	4/4
	Total Kjeldahl Nitrogen - EPA 351_2	1.70	1.60	0.50	2.50	0.86 - 2.50	5/5
	Total Phosphorus - EPA 365_4	0.23	0.20	0.10	0.41	0.13 - 0.35	5/5

1998/1999 No nutrient samples collected
2000/2001 No nutrient samples collected
*All nitrogen values are reported as N. All phosphate values are reported as P.
For summary calculations, DL substituted for values < DL

Table D-6 Summary statistics for grab samples collected for nutrient analysis: Barker Slough at Hay Road

	Analyte* (mg/L)	Mean	Median	Low	High	Percentile 10-90%	# detects/ total sampled
1997/1998 (22 Oct 1997 to 2 Feb 1998)	Dissolved Ammonia - EPA 350_1	0.04	0.04	0.02	0.05	0.02 - 0.05	3/3
	Dissolved Nitrate - Std Method 4500-NO3-F	0.40	0.13	< 0.01	1.60	0.01 - 1.07	5/7
	Dissolved Nitrite + Nitrate - Std Method 4500-NO3-F	0.46	0.24	< 0.01	1.68	0.08 - 1.11	6/7
	Dissolved Ortho-phosphate - Std Method 4500-P	0.09	0.08	< 0.01	0.20	0.03 - 0.16	5/6
	Total Kjeldahl Nitrogen - EPA 351_2	1.21	1.30	0.30	1.70	0.78 - 1.58	7/7
	Total Phosphorus - EPA 365_4	0.20	0.18	0.06	0.39	0.10 - 0.33	6/6

1998/1999 No nutrient samples collected
2000/2001 No nutrient samples collected
*All nitrogen values are reported as N. All phosphate values are reported as P.
For summary calculations, DL substituted for values < DL.

APPENDIX E

Table E-1 Summary statistics for grab samples collected for standard mineral analysis: Lindsey Slough at Bridge

		Mean	Median	Low	High	Percentile 10-90%	# detects/ total sampled
1997/1998 (lab results) approximately 29 Sep 1997 to 18 Mar 1998	Alkalinity (mg/L as CaCO3) - EPA 310.1	100	104	79	124	81-119	7/7
	Chloride mg/L - EPA 325_2	-	-	-	-	-	
	Conductance (EC) (µS/cm) - Std Method 2510-B	318	325	233	428	234.8 - 405.2	7/7
	Dissolved Boron (mg/L) - EPA 200_7 (D)	0.2	0.2	0.1	0.3	0.2 - 0.3	7/7
	Dissolved Calcium (mg/L) - EPA 200_7 (D)	18.4	18.8	14.8	22.5	14.9 - 22.3	7/7
	Dissolved Chloride (mg/L) - EPA 325_2	19.0	17.0	13.0	29.0	13.6 - 27.2	7/7
	Dissolved Fluoride (mg/L) - Std Method 4500-F-C	-	-	-	-	-	
	Dissolved Magnesium (mg/L) - EPA 200_7 (D)	13.7	14.0	9.9	19.0	10.0 - 17.6	7/7
	Dissolved Potassium (mg/L) - EPA 200_7 (D)	2.5	2.3	1.8	3.6	2.0 - 3.3	7/7
	Dissolved Sodium (mg/L) - EPA 200_7 (D)	26.3	26.8	17.6	37.9	17.8 - 35.9	7/7
	Dissolved Sulfate (mg/L) - EPA 375_2	27.0	30.0	11.0	44.0	12.8 - 39.2	7/7
	Hardness (mg/L as CaCO3)-Std Method 2340 B	102.3	105	78	133	78.0 - 128.2	7/7
	pH-Std Method 2320 B	8.0	8.0	8.0	8.0	8 - 8	1/1
	Suspended Solids (mg/L) - Std Method 2540 D						
	Total Dissolved Solids (mg/L) - Std Method 2540-C	185.3	184.0	129.0	255.0	137.4 - 240	7/7
	Total Suspended Solids (mg/L) - EPA 160_2	41.1	28.4	23.2	109.2	24.9 - 69.8	7/7
	Turbidity (NTU) - EPA 180_1	54.7	37.8	30.6	162.0	30.67 - 94.10	8/8
	Volatile Suspended Solids (mg/L) - EPA 160_4	-	-	-	-	-	

1998/1999 No Samples Collected
1999/2000 No Samples Collected
2000/2001 No Samples Collected
For summary calculations, DL substituted for values < DL.

Table E-2 Summary statistics for grab samples collected for standard mineral analysis: Calhoun Cut at Highway 113

		Mean	Median	Low	High	Percentile 10-90%	# detects/ total sampled
1997/1998 (lab results) approximately (29 Sep 1997 to 18 Mar 1998)	Alkalinity (mg/L as CaCO3) - EPA 310.1	99	108	55	127	63-120	7/77
	Chloride (mg/L) - EPA 325_2	-	-	-	-	-	
	Conductance (EC) (µS/cm) - Std Method 2510-B	336	352	174	439	209 - 429	7/7
	Dissolved Boron (mg/L) - EPA 200_7 (D)	0.2	0.2	0.1	0.3	0.1 - 0.2	7/7
	Dissolved Calcium (mg/L) - EPA 200_7 (D)	14.1	16.2	5.9	19.0	7.7 - 17.7	7/7
	Dissolved Chloride (mg/L) - EPA 325_2	29.0	24.0	13.0	43.0	16.6 - 48.8	7/7
	Dissolved Fluoride (mg/L) - Std Method 4500-F-C	-	-	-	-	-	
	Dissolved Magnesium (mg/L) - EPA 200_7 (D)	12.5	14.9	4.2	16.0	6.4 - 15.8	7/7
	Dissolved Potassium (mg/L) - EPA 200_7 (D)	2.7	2.7	2.0	3.4	2.2 - 3.3	7/7
	Dissolved Sodium (mg/L) - EPA 200_7 (D)	37.3	32.0	24.7	52.1	26.9 - 49.9	7/7
	Dissolved Sulfate (mg/L) - EPA 375_2	22.7	20.0	9.0	38.0	13.2 - 33.8	7/7
	Hardness (mg/L as CaCO3) - Std Method 2340 B	87.4	100.0	32.0	114.0	46.4 - 111	7/7
	pH - Std Method 2320 B	8.0	8.0	7.9	8.0	7.9 - 8.0	2/2
	Suspended Solids (mg/L) - Std Method 2540 D	-	-	-	-	-	
	Total Dissolved Solids (mg/L) - Std Method 2540-C	203.14	194.00	130.00	269.00	144.4 - 255.8	7/7
	Total Suspended Solids (mg/L) - EPA 160_2	42.01	43.00	13.60	65.00	22.96 - 62.6	7/7
	Turbidity (NTU) - EPA 180_1	63.86	53.15	36.80	112.00	40.86 - 107.80	8/8
	Volatile Suspended Solids (mg/L) - EPA 160_4	-	-	-	-	-	

Table E-2 continued

		Mean	Median	Low	High	Percentile 10-90%	# detects/ total sampled
1999/2000 (field results) 3 Nov 1999 to 29 Mar 2000)	Conductance (EC) µS/cm	246	238	103	352	147 - 341	5/5
	pH	7.3	7.3	7.2	7.6	7.2 - 7.5	5/5
	Turbidity (NTU)	74.7	71.7	60.9	101.0	61.3 - 98.9	15/15
	Temp °C	12.7	14.2	7.2	15.6	8.9 - 15.4	5/5

1998/1999 No samples collected
2000/2001 No samples collected
For summary calculations, DL substituted for values < DL.

Table E-3 Summary statistics for grab samples collected for standard mineral analysis: Barker Slough Pumping Plant

		Mean	Median	Low	High	Percentile 10-90%	# detects/ total sampled
1997/1998 (lab results) approximately (29 Sep 1997 to 18 Mar 1998)	Alkalinity (mg/L as CaCO3) - EPA 310.1	95	101	67	121	68 - 117	7/7
	Chloride (mg/L) - EPA 325_2	16.7	18.1	6.0	33.0	7.2 - 25.8	7/7
	Conductance (EC) - Std Method 2510-B	252	234	150	372	162 - 361	6/6
	Dissolved Boron (mg/L) - EPA 200_7 (D)	0.2	0.2	< 0.1	0.2	0.1 - 0.2	7/8
	Dissolved Calcium (mg/L) - EPA 200_7 (D)	13.8	13.5	8.7	19.0	9.6 - 19.0	9/9
	Dissolved Chloride (mg/L) - EPA 325_2	18.6	18.0	6.0	36.0	7.6 - 33.6	9/9
	Dissolved Fluoride (mg/L) - Std Method 4500-F-C	0.1	0.1	< 0.1	0.1	0.1 - 0.1	5/6
	Dissolved Magnesium (mg/L) - EPA 200_7 (D)	12.1	12.0	6.6	18.7	7.2 - 17.3	9/9
	Dissolved Potassium (mg/L) - EPA 200_7 (D)	2.4	2.4	2.2	2.6	2.3 - 2.6	2/2
	Dissolved Sodium (mg/L) - EPA 200_7 (D)	23.6	24.0	11.8	37.2	13.6 - 35.0	9/9
	Dissolved Sulfate (mg/L) - EPA 375_2	16.8	18.0	5.0	28.0	5.8 - 27.2	9/9
	Hardness (mg/L as CaCO3) - Std Method 2340 B	84.2	83.0	49.0	124.0	53.8 - 119.2	9/9
	pH - Std Method 2320 B	7.8	7.9	6.9	8.3	7.5 - 8.1	10/10
	Suspended Solids (mg/L) - Std Method 2540 D	60.9	49.0	34.0	106.0	37 - 103.0	7/7
	Total Dissolved Solids (mg/L) - Std Method 2540-C	149.3	150.0	90.0	207.0	101.4 - 196.5	4/4
	Total Suspended Solids (mg/L) - EPA 160_2	68.6	58.0	39.0	106.0	39.1 - 104.0	5/5
	Turbidity (NTU) - EPA 180_1	125.1	108.0	44.0	256.0	44.9 - 237.10	10/10
	Volatile Suspended Solids (mg/L) - EPA 160_4	11.4	10.0	< 10	16.0	6.6 - 15.6	5/5

Table E-3 continued

		Mean	Median	Low	High	Percentile 10-90%	# detects/ total sampled
1998/1999 (field results) 6 Nov 1998 to 24 Apr 1999	Conductance (EC) µS/cm	381	401	123	486	310 - 480	22/22
	pH	7.8	7.8	7	8.3	7.5 - 8.1	21/21
	Temperature (°C)	11.2	11.8	6.3	14.8	6.9 - 14.5	1.0
	Turbidity (NTU)	61.6	42.9	18.8	183.0	21.2 - 134.5	22/22
1999/2000 (field results) 3 Nov 1999 to 29 Mar 2000	Conductance (EC) µS/cm	269	267	111	434	190 - 364	21/21
	pH	7.4	7.5	6.7	7.9	7.1 - 7.7	22/22
	Temperature (°C)	11.8	11.7	7.6	16.8	8.7 - 15.0	22/22
	Turbidity (NTU)	56.8	40.1	20.2	187.0	22.5 - 102.4	22/22
2000/2001 (field results) 29 Nov 2000 to 25 Apr 2001	Conductance (EC) µS/cm	325	303	149	534	264 - 469	31/31
	pH	7.8	7.8	7.0	8.4	7.6 - 8.1	32/32
	Temperature (°C)	10.6	9.5	7.2	23.2	7.8 - 16.4	30/30
	Turbidity (NTU)	34.1	27.8	17.7	136.0	19.8 - 48.0	32/32

For summary calculations, DL substituted for values < DL.

Table E-4 Summary statistics for grab samples collected for standard mineral analysis: Barker Slough at Cook Lane

		Mean	Median	Low	High	Percentile 10-90%	# detects/ total sampled
1997/1998 approximately (29 Sep 1997 to 18 Mar 1998)	Alkalinity (mg/L as CaCO3) - EPA 310.1	102	79	56	176	61-153	7/7
	Chloride (mg/L) - EPA 325_2	-					
	Conductance (EC) (µS/cm) - Std Method 2510-B	280	231	147	464	167 - 426	7/7
	Dissolved Boron (mg/L) - EPA 200_7 (D)	0.1	0.1	< 0.1	0.2	0.1 - 0.2	5/7
	Dissolved Calcium (mg/L) - EPA 200_7 (D)	15.9	12.4	8.4	25.0	9.6 - 24.9	7/7
	Dissolved Chloride (mg/L) - EPA 325_2	12.9	9.0	5.0	35.0	7.4 - 21.8	7/7
	Dissolved Fluoride (mg/L) - Std Method 4500-F-C	-					
	Dissolved Magnesium (mg/L) - EPA 200_7 (D)	14.8	11.1	6.1	28.0	7.4 - 24.3	7/7
	Dissolved Potassium (mg/L) - EPA 200_7 (D)	3.3	3.0	2.1	4.8	2.5 - 4.5	7/7
	Dissolved Sodium (mg/L) - EPA 200_7 (D)	19.8	17.0	10.9	45.6	12.6 - 29.6	7/7
	Dissolved Sulfate (mg/L) - EPA 375_2	17.6	12.0	5.0	38.0	5.6 - 31.4	7/7
	Hardness (mg/L as CaCO3) - Std Method 2340 B	100	77	44	178	52.4 - 155.8	7/7
	pH - Std Method 2320 B	8.0	8.0	7.8	8.2	7.8 - 8.2	2/2
	Suspended Solids (mg/L) - Std Method 2540 D	-					
	Total Dissolved Solids (mg/L) - Std Method 2540-C	170.43	146.00	91.00	272.00	113.20 - 241.40	7/7
	Total Suspended Solids (mg/L) - EPA 160_2	183.14	198.00	76.00	274.00	88.60 - 253.60	7/7
	Turbidity (NTU) - EPA 180_1	266.99	313.50	82.20	469.00	90.95 - 413.00	8/8
	Volatile Suspended Solids (mg/L) - EPA 160_4	-					

1998/1999 No samples collected
1999/2000 No samples collected
2000/2001 No samples collected
For summary calculations, DL substituted for values < DL.

Table E-5 Summary statistics for grab samples collected for standard mineral analysis: Barker Slough above Campbell Lake

		Mean	Median	Low	High	Percentile 10-90%	# detects/ total sampled
1999/2000 (field results) (3 Nov 1999 to 29 Mar 2000)	Conductance (EC) µS/cm	544	550	190	927	212 - 879	5/5
	pH	7.9	7.9	7.6	8.0	7.7 - 8.0	5/5
	Turbidity (NTU)	31.6	31.9	18.0	40.4	20.8 - 40.0	14/14
	Temp °C	18.0	19.8	12.4	23.1	12.5 - 22.7	5/5

1997/1998 No samples collected
1998/1999 No samples collected
2000/2001 No samples collected
For summary calculations, DL substituted for values < DL.

Table E-6 Summary statistics for grab samples collected for standard mineral analysis: off-site pond near Campbell Lake

		Mean	Median	Low	High	Percentile 10-90%	# detects/ total sampled
1999/2000 (field results) (3 Nov 1999 to 29 Mar 2000)	Conductance (EC) µS/cm	260	261	208	308	218 - 300	4/4
	pH	7.8	7.8	7.5	7.9	7.6 - 7.9	4/4
	Turbidity (NTU)	625.8	586.0	445.0	900.0	446 - 869.9	12/12
	Temp °C	16.2	15.9	12.8	20.3	13.6 - 19.2	4/4

1997/1998 No samples collected
1998/1999 No samples collected
2000/2001 No samples collected
For summary calculations, DL substituted for values < DL.

Table E-7 Summary statistics for grab samples collected for standard mineral analysis: Barker Slough below Campbell Lake

		Mean	Median	Low	High	Percentile 10-90%	# detects/ total sampled
1999/2000 (field results) (3 Nov 1999 to 29 Mar 2000)	Conductance (EC) µS/cm	570	411	109	4920	190 - 489	21/21
	pH	8.1	8.1	7.4	9.2	7.7 - 8.4	21/21
	Turbidity (NTU)	143.4	116.5	42.8	409.0	58.6 - 224.6	62/62
	Temp °C	12.8	12.2	6.8	19.5	8.4 - 16.3	21/21

1997/1998 No samples collected
1998/1999 No samples collected
2000/2001 No samples collected
For summary calculations, DL substituted for values < DL.

Table E-8 Summary statistics for grab samples collected for standard mineral analysis: Barker Slough at Junction

		Mean	Median	Low	High	Percentile 10-90%	# detects/ total sampled
1999/2000 (field results) (3 Nov 1999 to 29 Mar 2000)	Conductance (EC) µS/cm	467	451	130	835	186 - 775	22/22
	pH	7.6	7.7	6.9	8.2	7.3 - 7.8	22/22
	Turbidity (NTU)	84.8	69.8	7.3	245.0	9.7 - 226.6	62/62
	Temp °C	10.8	11.0	7.7	14.1	8.8 - 13.0	21/21

1997/1998 No samples collected
1998/1999 No samples collected
2000/2001 No samples collected
For summary calculations, DL substituted for values <DL.

Table E-9 Summary statistics for grab samples collected for standard mineral analysis: Barker Slough at Dally Road

		Mean	Median	Low	High	Percentile 10-90%	# detects/ total sampled
1997/1998 (lab results) (22 Oct 1997 to 29 Jan 1998)	Alkalinity (mg/L as CaCO3) - EPA 310.1	123	123	68	167	82-162	5/5
	Chloride (mg/L) - EPA 325_2	-					
	Conductance (EC) (µS/cm) - Std Method 2510-B	299	275	167	480	193 - 425	4/4
	Dissolved Boron (mg/L) - EPA 200_7 (D)	0.1	0.1	< 0.1	0.2	0.1 - 0.2	4/5
	Dissolved Calcium (mg/L) - EPA 200_7 (D)	20.4	18.2	11.3	30.6	13.3 - 28.7	5/5
	Dissolved Chloride (mg/L) - EPA 325_2	14.0	7.5	6.0	35.0	6 - 27.2	4/4
	Dissolved Fluoride (mg/L) - Std Method 4500-F-C	-					
	Dissolved Magnesium (mg/L) - EPA 200_7 (D)	19.4	20.9	7.7	29.4	10.7 - 27.2	5/5
	Dissolved Potassium (mg/L) - EPA 200_7 (D)	3.6	3.8	2.2	4.8	2.4 - 4.6	5/5
	Dissolved Sodium (mg/L) - EPA 200_7 (D)	17.9	12.6	10.8	33.9	10.9 - 28.9	5/5
	Dissolved Sulfate (mg/L) - EPA 375_2	19.8	20.0	5.0	33.0	8.2 - 31.0	5/5
	Hardness (mg/L as CaCO3) - Std Method 2340 B	131.0	132.0	60.0	185.0	76.8 - 181.4	5/5
	pH - Std Method 2320 B	8.1	8.1	8.0	8.2	8.0 - 8.2	2/2
	Suspended Solids (mg/L) - Std Method 2540 D	-					
	Total Dissolved Solids (mg/L) - Std Method 2540-C	183.5	173.5	108.0	279.0	127.2 - 247.8	4/4
	Total Suspended Solids (mg/L) - EPA 160_2	87.7	42.7	33.0	276.0	36.1 - 184	5/5
	Turbidity (NTU) - EPA 180_1	139.64	69.90	49.10	436.00	49.46 - 298.88	5/5
	Volatile Suspended Solids (mg/L) - EPA 160_4	-					

1998/1999 No samples collected
1999/2000 No samples collected
2000/2001 No samples collected
For summary calculations, DL substituted for values < DL.

Table E-10 Summary statistics for grab samples collected for standard mineral analysis: Barker Slough at Hay Road

		Mean	Median	Low	High	Percentile 10-90%	# detects/ total sampled
1997/1998 (lab results) (22 Oct 1997 to 2 Feb 1998)	Alkalinity (mg/L as CaCO3) - EPA 310.1	102	109	45	172	46-172	7/7
	Chloride (mg/L) - EPA 325_2	-					
	Conductance (EC) (µS/cm) - Std Method 2510-B	251	199	97	608	108 - 447	6/6
	Dissolved Boron (mg/L) - EPA 200_7 (D)	0.2	0.1	< 0.1	0.3	< 0.1 - 0.24	4/7
	Dissolved Calcium (mg/L) - EPA 200_7 (D)	18.7	16.7	7.9	37.8	8.4 - 35.2	7/7
	Dissolved Chloride (mg/L) - EPA 325_2	16.6	6.0	2.0	51.0	2.6 - 43.8	7/7
	Dissolved Fluoride (mg/L) - Std Method 4500-F-C	-					
	Dissolved Magnesium (mg/L) - EPA 200_7 (D)	15.7	16.6	4.3	33.5	4.6 - 27.9	7/7
	Dissolved Potassium (mg/L) - EPA 200_7 (D)	2.6	1.9	1.3	5.1	1.4 - 4.2	7/7
	Dissolved Sodium (mg/L) - EPA 200_7 (D)	18.1	10.7	5.9	54.6	6.6 - 37.1	7/7
	Dissolved Sulfate (mg/L) - EPA 375_2	17.6	15.0	2.0	47.0	2.6 - 37.4	7/7
	Hardness (mg/L as CaCO3) - Std Method 2340 B	113	113	38	225	41 - 206	7/7
	pH - Std Method 2320 B	8.4	8.4	8.0	8.7	8.1 - 8.6	2/2
	Suspended Solids (mg/L) - Std Method 2540 D	-					
	Total Dissolved Solids (mg/L) - Std Method 2540-C	149.8	127.5	68.0	314.0	76 - 246	6/6
	Total Suspended Solids (mg/L) - EPA 160_2	172.4	30.0	8.8	402.0	13.6 - 400.8	7/7
	Turbidity (NTU) - EPA 180_1	262.23	47.40	18.00	608.00	21.12 - 590.00	7/7
	Volatile Suspended Solids (mg/L) - EPA 160_4	-					

1998/1999 No samples collected
1999/2000 No samples collected
2000/2001 No samples collected
For summary calculations, DL substituted for values < DL.

Table E-11 Summary statistics for grab samples collected for standard mineral analysis: Barker Slough at Leisure Town Road

		Mean	Median	Low	High	Percentile 10-90%	# detects/ total sampled
1999/2000 (field results) (3 Nov 1999 to 29 Mar 2000)	Conductance (EC) µS/cm	687	580	160	2800	308 - 912	23/23
	pH	8.0	8.0	7.2	8.7	7.5 - 8.4	21/21
	Turbidity (NTU)	24.6	12.7	3.6	102.0	5.1 - 67.4	63/63
	Temp °C	11.6	11.8	5.6	18.2	7.1 - 14.7	21/21

1997/1998 No samples collected
1998/1999 No samples collected
2000/2001 No samples collected
For summary calculations, DL substituted for values < DL.

Appendix F

Table F-1 Summary statistics for grab samples collected for THMFP analysis: Lindsey Slough at Bridge

		Mean	Median	Low	High	Percentile 10-90%	# detect/ total sampled
1997/ 1998 (29 Feb 1997 to 13 May 1998)	Bromodichloromethane (µg/L) - DWR THMFP (Buffered)	34	35	21	46	22 - 44	14/14
	Bromoform (µg/L) - DWR THMFP (Buffered)	< 10					0/14
	Chloroform (µg/L) - DWR THMFP (Buffered)	384	330	260	610	270 - 576	14/14
	Dibromochloromethane (µg/L) - DWR THMFP (Buffered)	< 10					0/14
	Dissolved Bromide (mg/L) - EPA 300_0 28d Hold	0.05	0.04	0.03	0.07	0.03 - 0.07	14/14
	Dissolved Organic Carbon (mg/L) - EPA 415_1 (D) Ox	3.7	3.4	2.4	5.9	2.7 - 5.4	14/14
	Total Alkalinity mg/L as CaCO3 - Std Method 2320 B	121	122	79	160	86 - 154	14/14
	Total Organic Carbon (mg/L) - EPA 415_1 (T) Ox	4.2	3.8	3.1	6.2	3.2 - 6.0	11/11
	UV Absorbance @254nm (absorbance/cm) - Std Method 5910B	0.107	0.086	0.067	0.184	0.071 - 0.160	13/13

1998/1999 No THMFP samples analyzed
1999/2000 No THMFP samples analyzed
2000/2001 No THMFP samples analyzed
For summary calculations, DL substituted for values < DL.

Table F-2 Summary statistics for grab samples collected for THMFP analysis: Calhoun Cut at Highway 113

		Mean	Median	Low	High	Percentile 10-90%	# detects/ total sampled
1997/ 1998 (29 Sep 1997 to 29 Apr 1998)	Bromodichloromethane (µg/L) - DWR THMFP (Buffered)	68	62	34	110	36 - 108	13/13
	Bromoform (µg/L) - DWR THMFP (Buffered)	<10	<10	<10	<10		0/13
	Chloroform (µg/L) - DWR THMFP (Buffered)	1069	1000	570	1800	746 - 1620	13/13
	Dibromochloromethane (µg/L) - DWR THMFP (Buffered)	< 10	<10	<10	<10		0/13
	Dissolved Bromide (mg/L) - EPA 300_0 28d Hold	0.08	0.07	0.02	0.12	0.03 - 0.12	13/13
	Dissolved Organic Carbon (mg/L) - EPA 415_1 (D) Ox	9.7	8.9	6.2	15.9	6.2 - 13.8	13/13
	Total Alkalinity mg/L as CaCO3 - Std Method 2320 B	115	113	55	155	75 - 155	13/13
	Total Organic Carbon (mg/L) - EPA 415_1 (T) Ox	12.0	10.3	7.7	20.7	8.7 - 18.8	10/10
	UV Absorbance @254nm (absorbance/cm) - Std Method 5910B	0.342	0.321	0.164	0.595	0.201 - 0.529	12/12

1998/1999 No THMFP samples analyzed
1999/2000 No THMFP samples analyzed
2000/2001 No THMFP samples analyzed
For summary calculations, DL substituted for values < DL.

Table F-3 Summary statistics for grab samples collected for THMFP analysis: Barker Slough Pumping Plant

		Mean	Median	Low	High	Percentile 10-90%	# detects/ total sampled
1997/ 1998 (17 Sep 1997 to 29 Apr 1998)	Bromodichloromethane (µg/L) - DWR THMFP (Buffered)	55	50	17	130	28 - 82	16/16
	Bromoform (µg/L) - DWR THMFP (Buffered)	10	10	< 1	10	< 1 - < 10	10/16
	Chloroform (µg/L) - DWR THMFP (Buffered)	884	845	560	1500	600 - 1240	16
	Dibromochloromethane (µg/L) - DWR THMFP (Buffered)	11	10	< 10	26	10 - 13	11/16
	Dissolved Bromide (mg/L) - EPA 300_0 28d Hold	0.07	0.07	0.01	0.20	0.02 - 0.09	16/16
	Dissolved Organic Carbon (mg/L) - EPA 415_1 (D) Ox	8.5	8.3	3.4	14.6	4.9 - 13.7	17/17
	Total Alkalinity mg/L as CaCO3 - Std Method 2320 B	102	101	57	140	72 - 133	17/17
	Total Organic Carbon (mg/L) - EPA 415_1 (T) Ox	10.4	9.5	5.5	20.3	5.9 - 17	17/17
	UV Absorbance @254nm (absorbance/cm) - Std Method 5910B	0.279	0.271	0.069	0.473	0.110 - 0.467	13/13

1998/1999 No THMFP samples analyzed
1999/2000 No THMFP samples analyzed
2000/2001 No THMFP samples analyzed
For summary calculations, DL substituted for values < DL.

Table F-4 Summary statistics for grab samples collected for THMFP analysis: Barker Slough at Cook Lane

		Mean	Median	Low	High	Percentile 10-90%	# detects/ total sampled
1997/1998 (29 Sep 1997 to 29 Apr 1998)	Bromodichloromethane (µg/L) - DWR THMFP (Buffered)	99	130	< 10	250	24 - 148	12/13
	Bromoform (µg/L) - DWR THMFP (Buffered)	< 10	< 10	< 10	< 10		0/13
	Chloroform (µg/L) - DWR THMFP (Buffered)	917	890	580	1400	598 - 1300	13/13
	Dibromochloromethane (µg/L) - DWR THMFP (Buffered)	21	12	< 10	39	< 10 - 36	6/13
	Dissolved Bromide (mg/L) - EPA 300_0 28d Hold	0.12	0.09	0.01	0.27	0.01 - 0.24	13/13
	Dissolved Organic Carbon (mg/L) - EPA 415_1 (D) Ox	9.6	8.8	6.4	19.3	6.4 - 12.8	13/13
	Total Alkalinity mg/L as CaCO3 - Std Method 2320 B	156	176	56	244	66 - 227	13/13
	Total Organic Carbon (mg/L) - EPA 415_1 (T) Ox	12.5	10.6	7.6	20.5	8.0 - 19.4	10/10
	UV Absorbance @254nm (absorbance/cm) - Std Method 5910B	0.274	0.216	0.170	0.439	0.178 - 0.434	12/12

1998/1999 No THMFP samples analyzed
1999/2000 No THMFP samples analyzed
2000/2001 No THMFP samples analyzed
For summary calculations, DL substituted for values < DL.

Table F-5 Summary statistics for grab samples collected for THMFP analysis: Barker Slough at Dally Road

		Mean	Median	Low	High	Percentile 10-90%	# detects/ total sampled
1997/1998 (22 Oct 1997 to 29 Jan 1998)	Bromodichloromethane (µg/L) - DWR THMFP (Buffered)	31	20	< 20	68	15.8 - 55	4/5
	Bromoform (µg/L) - DWR THMFP (Buffered)	< 10	< 10	< 10	< 10		0/5
	Chloroform (µg/L) - DWR THMFP (Buffered)	1098	1200	490	1500	694 - 1420	5/5
	Dibromochloromethane (µg/L) - DWR THMFP (Buffered)	< 10	< 10	< 10	< 10		0/5
	Dissolved Bromide (mg/L) - EPA 300_0 28d Hold	0.03	0.01	< 0.01	0.09	0.01 - 0.07	4/5
	Dissolved Organic Carbon (mg/L) - EPA 415_1 (D) Ox	11.3	12.5	4.8	15.0	7.4 - 14.1	5/5
	Total Alkalinity mg/L as CaCO3 - Std Method 2320 B	123	123	68	167	82 - 161	5/5
	Total Organic Carbon (mg/L) - EPA 415_1 (T) Ox	18.5	18.5	17.0	20.0	17.3 - 19.7	2/2
	UV Absorbance @254nm (absorbance/cm) - Std Method 5910B	0.339	0.360	0.115	0.522	0.194 - 0.468	5/5

1998/1999 No THMFP samples analyzed
1999/2000 No THMFP samples analyzed
2000/2001 No THMFP samples analyzed
For summary calculations, DL substituted for values < DL.

Table F-6 Summary statistics for grab samples collected for THMFP analysis: Barker Slough at Hay Road

		Mean	Median	Low	High	Percentile 10-90%	# detects /total sampled
1997/1998 (22 Oct 1997 to 2 Feb 1998)	Bromodichloromethane (µg/L) - DWR THMFP (Buffered)	34	16	< 10	94	10 - 84	6/7
	Bromoform (µg/L) - DWR THMFP (Buffered)	< 10	< 10	< 10	< 10		0/7
	Chloroform (µg/L) - DWR THMFP (Buffered)	1059	1000	410	1700	584 - 1640	7/7
	Dibromochloromethane (µg/L) - DWR THMFP (Buffered)	< 10	< 10	< 10	< 10		0/7
	Dissolved Bromide (mg/L) - EPA 300_0 28d Hold	0.04	0.01	< 0.01	0.13	0.01 - 0.09	4/7
	Dissolved Organic Carbon (mg/L) - EPA 415_1 (D) Ox	9.8	8.4	3.7	16.1	5.1 - 15.5	7/7
	Total Alkalinity mg/L as CaCO3 - Std Method 2320 B	111	115	45	172	47 - 172	7/7
	Total Organic Carbon (mg/L) - EPA 415_1 (T) Ox	14.1	14.1	10.8	17.4	11.4 - 16.7	4/4
	UV Absorbance @254nm (absorbance/cm) - Std Method 5910B	-					

1998/1999 No THMFP samples analyzed
1999/2000 No THMFP samples analyzed
2000/2001 No THMFP samples analyzed
For summary calculations, DL substituted for values < DL

Appendix G

Table G-1 Autosampler results for 5 Dec to 6 Dec 1998: Leisure Town Road

TOC			DOC			Turbidity and Conductivity		
Time Sequence	NBR TOC (mg/L)	DWR TOC (mg/L)	Time Sequence	NBR DOC (mg/L)	DWR DOC (mg/L)	Time Sequence	Turbidity (NTU)	EC (µS/cm)
1	9.7	19	1	8.5	11.5	1	689	580
2	8.1		2			2	1240	121
3	7.6		3			3	1708	106
4	7.7	25.1	4	6.4	8.2	4	2640	138
5	9.2		5			5	2836	165
6	9.7		6			6	2636	191
7	9.9		7			7	2152	212
8	10.3	29.9	8			8	1872	233
9	11.1		9			9	1544	245
10	12.6		10			10	1300	260
11	11.4		11			11	1028	266
12	12.2	24	12			12	584	281
13	13		13			13	312	293
14	13.6		14			14	185	310
15	14.5		15			15	131	327
16	14.5	20.4	16			16	98.8	342
17	14.9		17			17	85.1	360
18	14.3		18			18	77.5	378
19	14.9		19			19	61.6	386
20	14.6	19.3	20			20	60.1	383
21	14.2		21			21	63.3	377
22	14.6		22			22	63.2	381
23	13.4		23			23	67.3	396
24	13.2	18.3	24	13.2	15.4	24	54.2	407

Table G-2 Autosampler results for 5 Dec to 6 Dec 1998: below Campbell Lake

TOC			DOC			Turbidity and Conductivity		
	NBR	DWR		NBR	DWR			
Time Sequence	TOC (mg/L)	TOC (mg/L)	Time Sequence	DOC (mg/L)	DOC (mg/L)	Time Sequence	Turbidity (NTU)	EC (µS/cm)
1	9.9	20	1	9.1	11.1	1	456	290
2	9.1		2			2	345	287
3	9.5		3			3	348	289
4	8.7	17.5	4	8.3	9.8	4	331	290
5	9.4		5			5	320	288
6	8.7		6			6	326	289
7	8.9		7			7	309	288
8	8.6	16.9	8	8.3	9.4	8	305	287
9	10.3		9			9	304	291
10	9.7		10			10	292	290
11	9.5		11			11	306	289
12	9.4	16.2	12			12	287	288
13	8.8		13			13	285	288
14	8.7		14			14	283	287
15	8.6		15			15	294	292
16	8.8	17.4	16			16	307	291
17	8.8		17			17	287	290
18	8.8		18			18	295	290
19	8.9		19			19	306	290
20	10.1	17.4	20			20	322	292
21	8.6		21			21	318	291
22	8.8		22			22	307	290
23	9.2		23			23	296	289
24	12.1	17.4	24	9.1	9.2	24	324	290

Table G-3 Autosampler results for 5 Dec to 6 Dec 1998: Barker Slough Pumping Plant

TOC			DOC			Turbidity and Conductivity		
	NBR	DWR		NBR	DWR			
Time Sequence	TOC (mg/L)	TOC (mg/L)	Time Sequence	DOC (mg/L)	DOC (mg/L)	Time Sequence	Turbidity (NTU)	EC (µS/cm)
1	8.1	9.1	1	9.1	11.1	1	39.8	381
2	8.2		2			2	40.5	383
3	7.6		3			3	43.7	381
4	6.5	8	4	8.3	9.8	4	47.9	381
5	7.2		5			5	46.4	383
6	6.8		6			6	45.2	385
7	6.7		7			7	47.9	384
8	6.6	7.4	8	8.3	9.4	8	47.1	384
9	6.7		9			9	47.5	388
10	6.7		10			10	48.2	388
11	6.5		11			11	47.4	389
12	6.4	7.4	12			12	46.1	388
13	6.7		13			13	47.4	387
14	6.7		14			14	41.2	388
15	6.6		15			15	38.4	390
16	6.4	6.9	16			16	36.6	384
17	6.9		17			17	34.9	391
18	7		18			18	37.8	389
19	6.8		19			19	48.1	388
20	6.4	7.4	20			20	45.5	389
21	7		21			21	41.9	390
22	6.9		22			22	37.1	391
23	6.6		23			23	35.1	391
24	6.4	6.9	24	9.1	9.2	24	33.5	394

Table G-4 Autosampler results for 6 Feb to 7 Feb 1999: Junction

Time Sequence	TOC (mg/L)	DOC (mg/L)	Turbidity (NTU)	EC(µS/cm)
1	29	10.2	1712	277
2	30.6		1488	204
3	27		1140	156
4	23.6	8.8	740	169
5	19.4		1120	225
6	19.8		880	274
7	21.95		1016	234
8	24.3	8.9	1088	115
9	24.4		840	104
10	23.2		644	116
11	22.1		651	127
12	21.5	9.7	551	129
13	21		523	128
14	20.5		502	132
15	20.5		525	129
16	19	NA	510	118
17	18.2		472	113
18	17.1		418	95
19	16		394	87
20	15.2	NA	428	77
21	14.8		415	71
22	14.5		395	75
23	14.2		351	77
24	14.2	7.2	325	80

Table G-5 Autosampler results for 6 Feb to 7 Feb 1999: below Campell Lake

Time Sequence	TOC (mg/L)	DOC (mg/L)	Turbidity (NTU)	EC(µS/cm)
1	15	9.5	199	414
2	14.6		144	412
3	14.2		152	407
4	14	8.9	158	408
5	13.6		152	404
6	13.6		122	407
7	13.2		147	407
8	13.3	8.4	145	407
9	13.5		106	403
10	13.4		141	404
11	13.6		153	400
12	14.2	8.8	155	396
13	17.9		299	376
14	20		522	338
15	21.1		575	320
16	23.1	10.5	849	249
17	23.4		787	218
18	22.4		677	182
19	21.9		631	165
20	21	10	599	140
21	20.3		584	127
22	20		573	112
23	19.5		583	98
24	21.3	9.4	562	94

Table G-6 Autosampler results for 6 Feb to 7 Feb 1999: Barker Slough Pumping Plant

Time Sequence	TOC (mg/L)	DOC (mg/L)	Turbidity (NTU)	EC(µS/cm)
1	7.7	6.9	48.4	417
2	7.5		51.2	415
3	7.1		52.2	413
4	6.9	6	50.2	414
5	6.9		49.1	416
6	6.8		46.8	415
7	6.6		47.2	416
8	6.1	5.5	44.6	415
9	6.2		43.9	417
10	6		41.5	419
11	6.1		42.9	420
12	6.2	5.4	46.7	418
13	6.5		49.6	416
14	6.3		44.5	414
15	6.6		55	409
16	6.6	5.4	52.5	410
17	6.5		52.4	408
18	6.9		51	407
19	7.6		53.7	401
20	7.7	6.3	57.6	400
21	10.6		102	392
22	13.1		223	355
23	15.4		317	316
24	16.3	8.8	395	273

Table G-7 Autosampler results for 23 Jan to 24 Jan 2000 sampling event: Leisure Town and Junction*

Time Tripped	Relative Time	TOC[a] (mg/L)	TOC[b] (mg/L)	Turbidity (NTU)	EC (µS/cm)
Leisure Town					
4:30 PM	0-4 hours	13.6	26	504	NA
	4-8 hours	12.3	12.3	314	NA
	8-12 hours	10.6	26	401	NA
	12-16 hours	11.1	22	254	NA
	16-20 hours	12.3	21	192	NA
	20-24 hours	14.8	20	137	NA
Junction					
6:30 PM	0-4 hours	16.6	17	194	NA
	4-8 hours	13.6	13.6	380	NA
	8-12 hours	17.3	22.8	562	NA
	12-16 hours	14.5	25.4	415	NA
	16-20 hours	16.7	22.2	300	NA
	20-24 hours	16.8	17.7	217	NA

*Leisure Town tripped at time 0, Junction tripped 2 hours later.
[a] Standard wet-oxidation analysis
[b] Persulfate volume and reaction time increased to achieve results similar to combustion TOC method.
NA = not analyzed or data not available

Table G-8 Autosampler results for 11 Feb to 12 Feb 2000 sampling event: Leisure Town, Junction and Barker Slough Pumping Plant*

Time Tripped	Relative Time	TOC[a] (mg/L)	TOC[b] (mg/L)	Turbidity (NTU)	EC (µS/cm)
Leisure Town					
3:45 PM	0-4 hours	17.6	17.6	540	132
	4-8 hours	27.6	27.6	1510	130
	8-12 hours	26.8	26.8	1040	135
	12-16 hours	18.5	18.5	154	154
	16-20 hours	16.9	21.4	84	180
	20-24 hours	16.2	16.2	112	259
Junction					
5:45 PM	0-4 hours	12.2	19.6	260	186
	4-8 hours	14.9	14.9	246	188
	8-12 hours	12.6	16.4	242	141
	12-16 hours	12.4	16.7	184	100
	16-20 hours	13.0	16.3	140	100
	20-24 hours	13.3	17.3	110	124
Barker Slough Pumping Plant					
12 Feb 2000 7:45 AM	0-4 hours	7.9	no change in value	53	352
	4-8 hours	10.0	no change in value	84	339
	8-12 hours	14.4	no change in value	142	298
	12-16 hours	15.2	no change in value	152	248
	16-20 hours	13.3	no change in value	154	225
	20-24 hours	-	-	-	-

* Leisure Town tripped at time 0, Junction tripped 2 hours later, Barker Slough PP tripped 16 hours after Leisure Town.

[a] Standard wet-oxidation analysis

[b] Persulfate volume and reaction time increased to achieve results similar to combustion TOC method.

Table G-9 Autosampler results for 4 Mar to 6 Mar 2000 sampling event: Leisure Town below Campbell Lake and Barker Slough Pumping Plant*

Time Tripped	Relative Time	TOC[a] (mg/L)	Turbidity (NTU)	EC (µS/cm)
Leisure Town				
10:00 PM	0-4 hours	12.9	252	119
	4-8 hours	19.0	170	150
	8-12 hours	17.9	74	187
	12-16 hours	17.0	44	224
	16-20 hours	16.8	54	226
	20-24 hours	19.9	73	222
Below Campbell Lake				
6:00 AM	0-4 hours	25.7	130	237
	4-8 hours	24.1	112	199
	8-12 hours	20.8	105	199
	12-16 hours	20.5	100	173
	16-20 hours	20.7	110.5	176
	20-24 hours	19.5	96	156
Barker Slough Pumping Plant				
4:00 PM	0-4 hours	22.9	69	218
	4-8 hours	22.0	81	225
	8-12 hours	21.7	87	219
	12-16 hours	22.0	89	206
	16-20 hours	21.0	96	193
	20-24 hours	21.1	84	187

*Leisure Town tripped at time 0, below Campbell Lake tripped 8 hours later, Barker Slough PP tripped 18 hours after Leisure Town.

[a] Persulfate volume and reaction time increased to achive results similar to combustion TOC method.

Appendix H

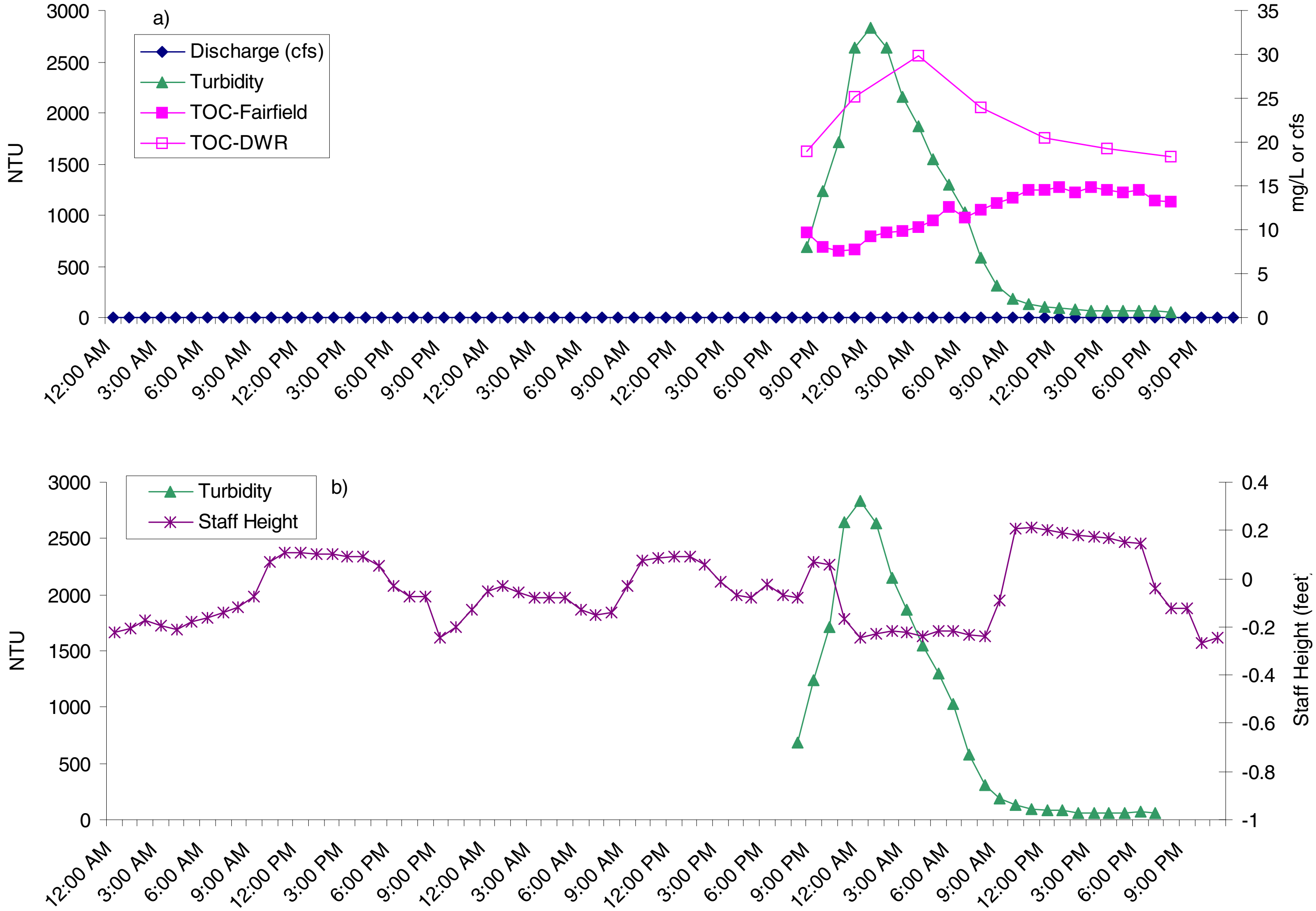
Table H-1 Summary statistics for grab samples collected for bacterial analysis

	Site	Organism (MPN/100 mL)	Median	Low	High	Percentile 10-90%	# detects/ total sampled
1997/1998 (Nov 1997 to Feb 1998)	Lindsey Slough at Bridge	*E. coli*	50	38	488	39 - 317	5/5
	Calhoun Cut at Hwy 113	*E. coli*	770	411	2419	537 - 2246	5/5
	Barker Slough Pumping Plant[1]	*E. coli*	300	230	3000	244 - 2460	5/5
	Barker Sl at Cook Lane	*E. coli*	2282	1046	3148	1422 - 2929	5/5
	Barker Sl at Dally Road[2]	*E. coli*	517	326	7701	364 - 6264	5/5
	Barker Sl at Hay Road	*E. coli*	1203	192	6131	197 - 5321	5/5
2000/2001	Barker Slough Pumping Plant	Total coliform	170	11	9000	35 - 1250	66/66
		Fecal coliform	40	0	1600	12 - 240	65/66
		E. coli	30	0	1600	9.5 - 220	64/66

1998/1999 No samples collected
1999/2000 No samples collected
For summary calculations, DL substituted for values < DL.
[1] Samples not directly comparable to other sites. Samples collected on different days.
[2] Samples not directly comparable to other sites. Some samples not collected due to flooding.

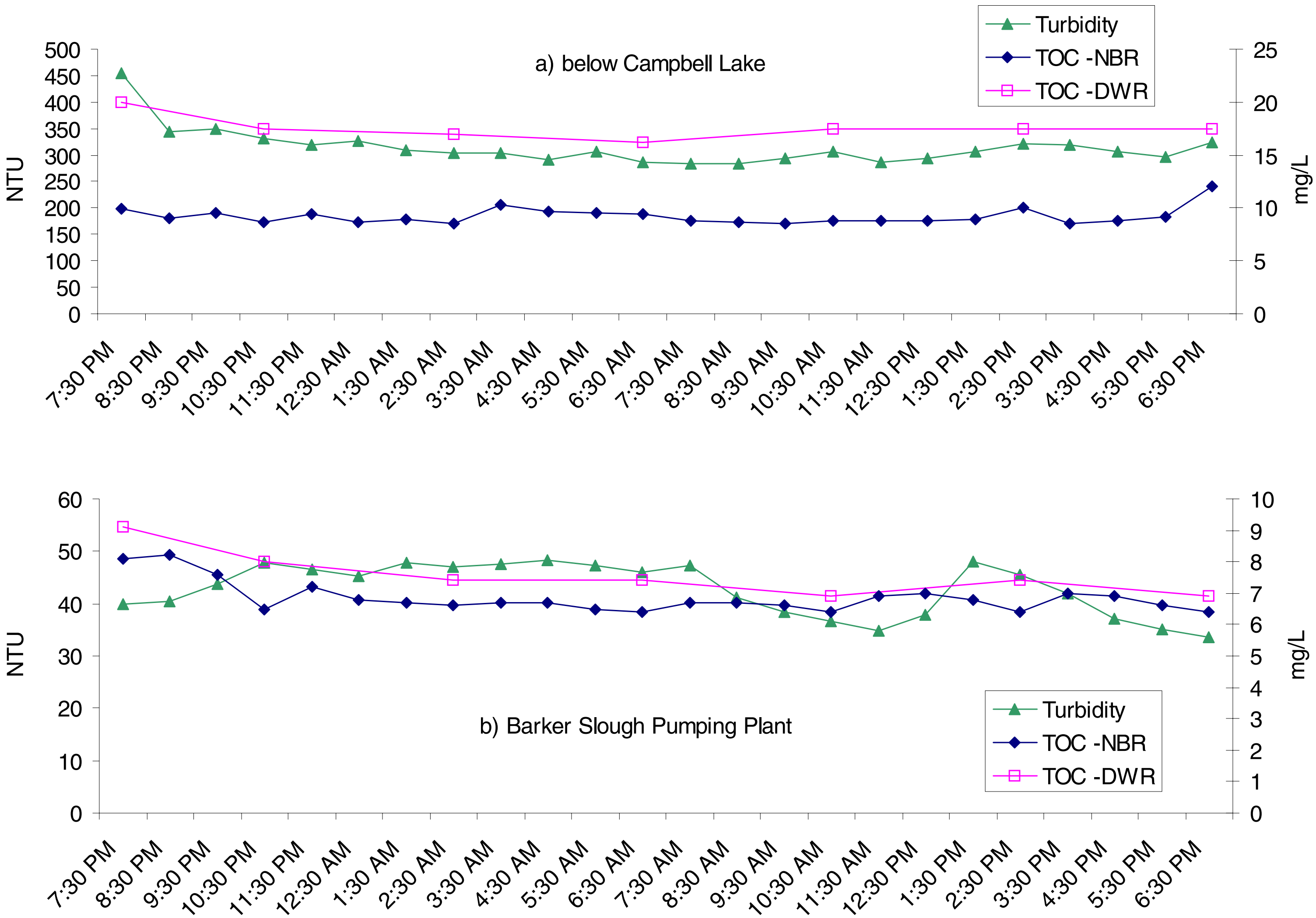
Appendix I

Figure I-1 Leisure Town autosampler, 5 Dec 1998: (a) flow vs. TOC and turbidity and (b) staff height vs. turbidity



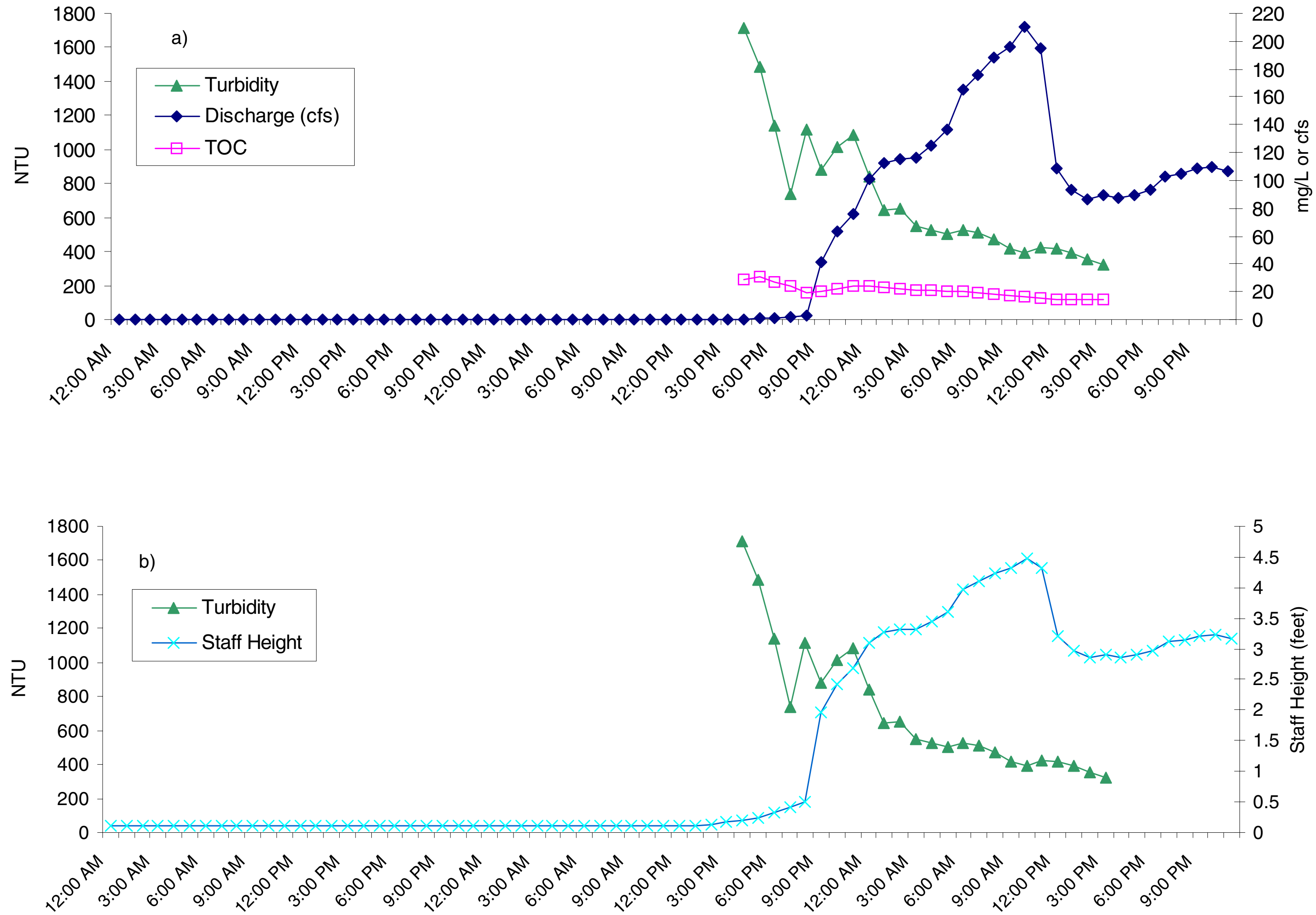
Note that autosampler malfunctioned at Junction, and no flow data were collected for Campbell Lake.

Figure I-2 TOC vs. turbidity, 5 Dec 1998: (a) below Campbell Lake and (b) Barker Slough Pumping Plant



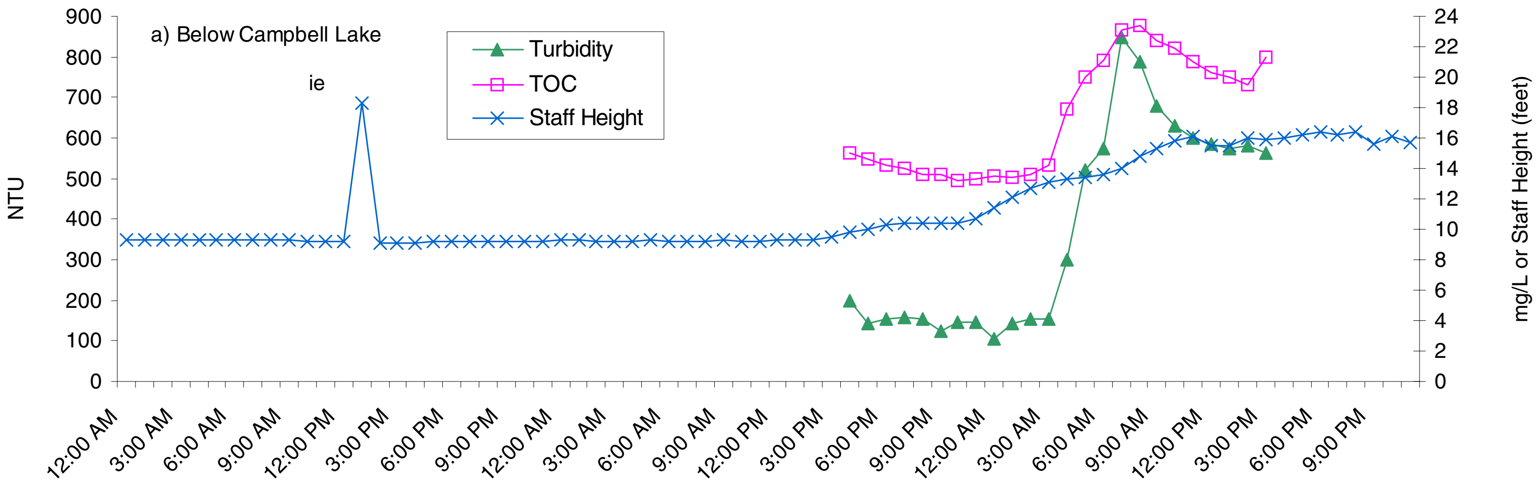
No staff height available for either site.

Figure I-3 Junction autosampler, 6 Feb 1999: (a) flow vs. TOC and turbidity and (b) staff height vs. turbidity



Note that autosampler malfunctioned at Leisure Town.

Figure I-4 Staff height vs. TOC and turbidity, 6 Feb 1999: (a) below Campbell Lake and (b) Barker Slough Pumping Plant



ie = instrument error

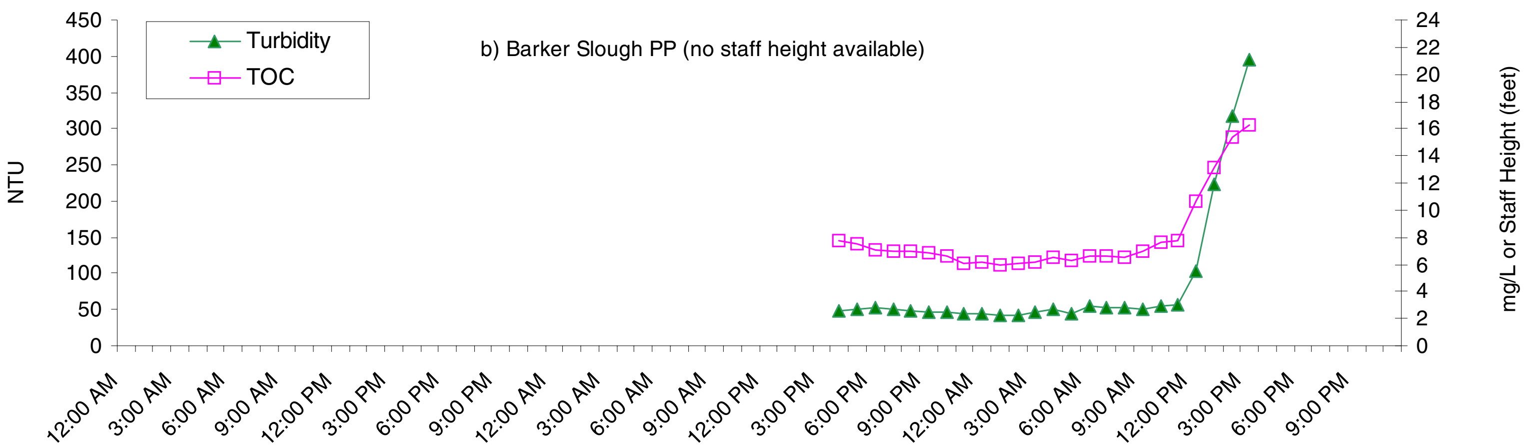
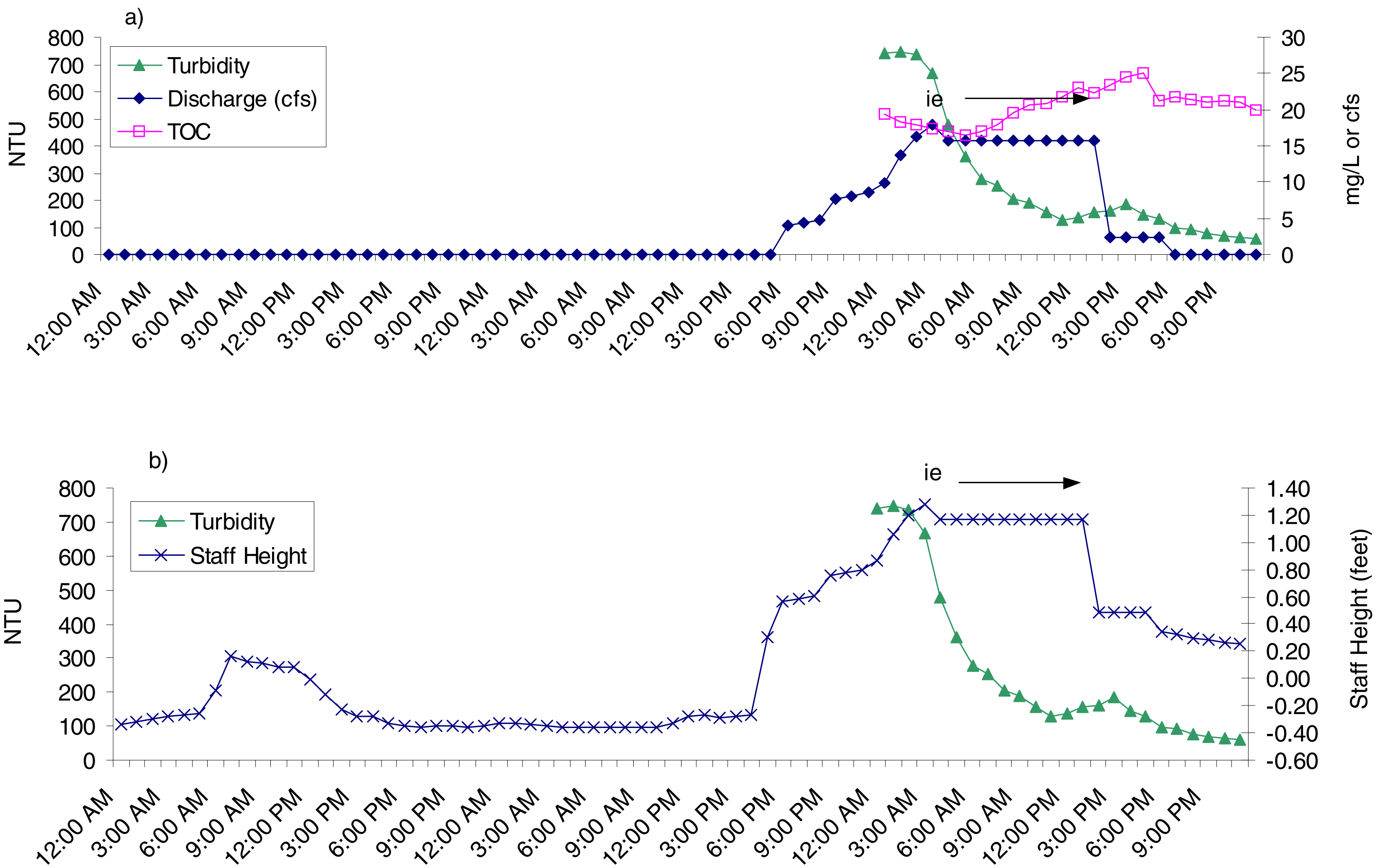
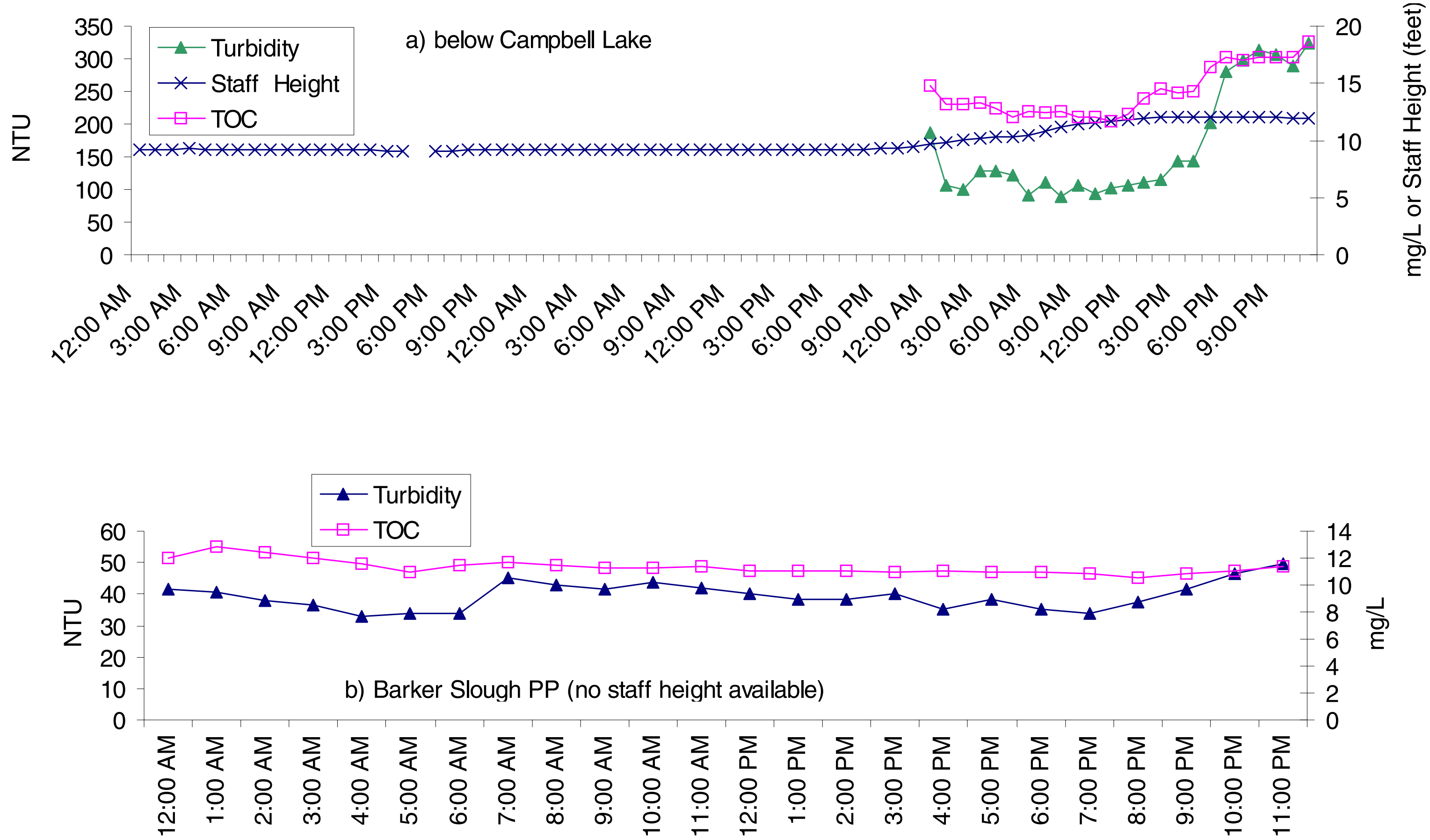


Figure I-5 Leisure Town autosampler, 24 Mar to 25 Mar 1999: (a) flow vs. TOC and turbidity and (b) staff height vs. turbidity



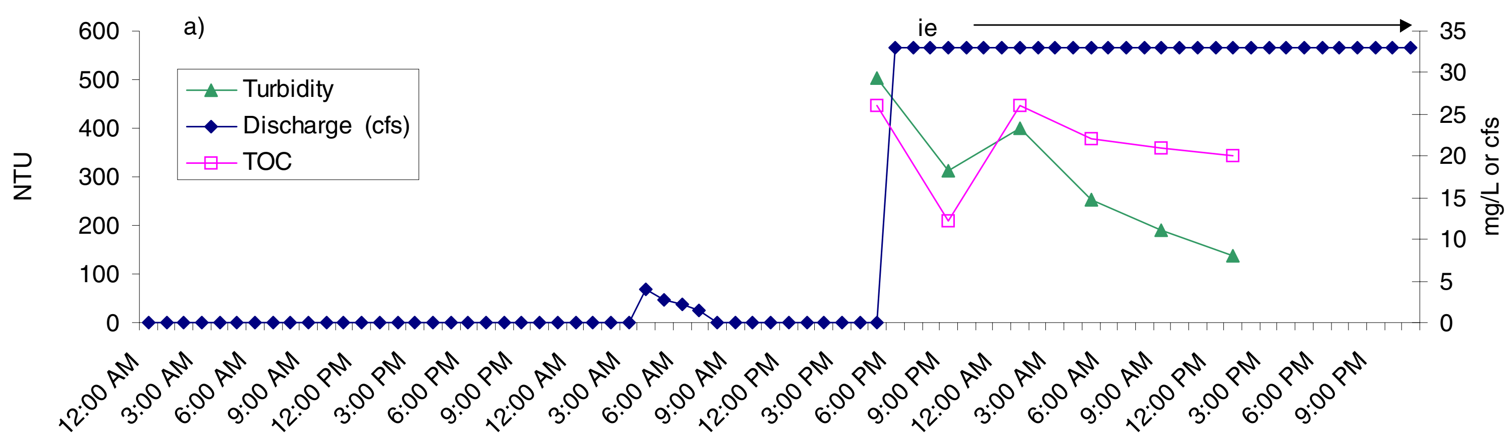
ie = instrument error
Autosampler trigger times moved forward 0.5 hour to correspond to flow measurements.

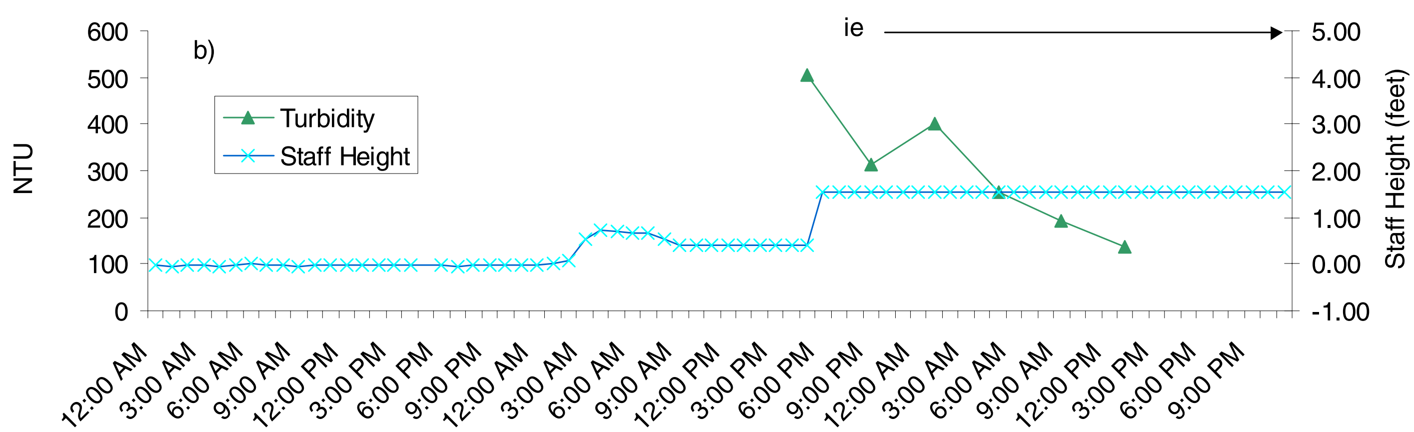
Figure I-6 Staff height vs. TOC and turbidity, 24 Mar 1999: (a) below Campbell Lake and (b) Barker Slough Pumping Plant



Autosampler trigger times move forward 0.5 hour to correspond to flow measurements.

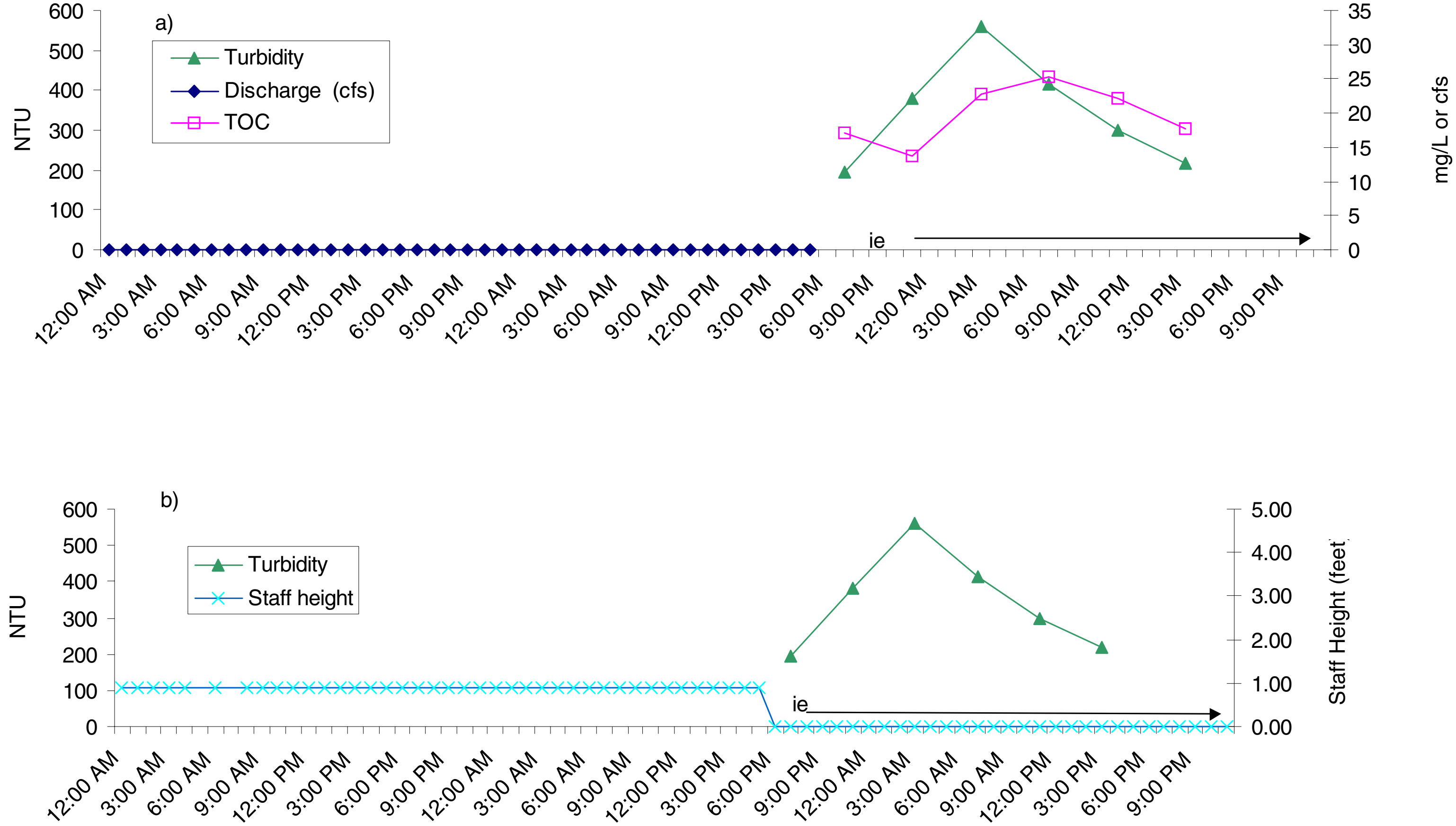
Figure I-7 Leisure Town autosampler, 23 Jan 2000, (a) flow vs. TOC and turbidity and (b) staff height vs. turbidity





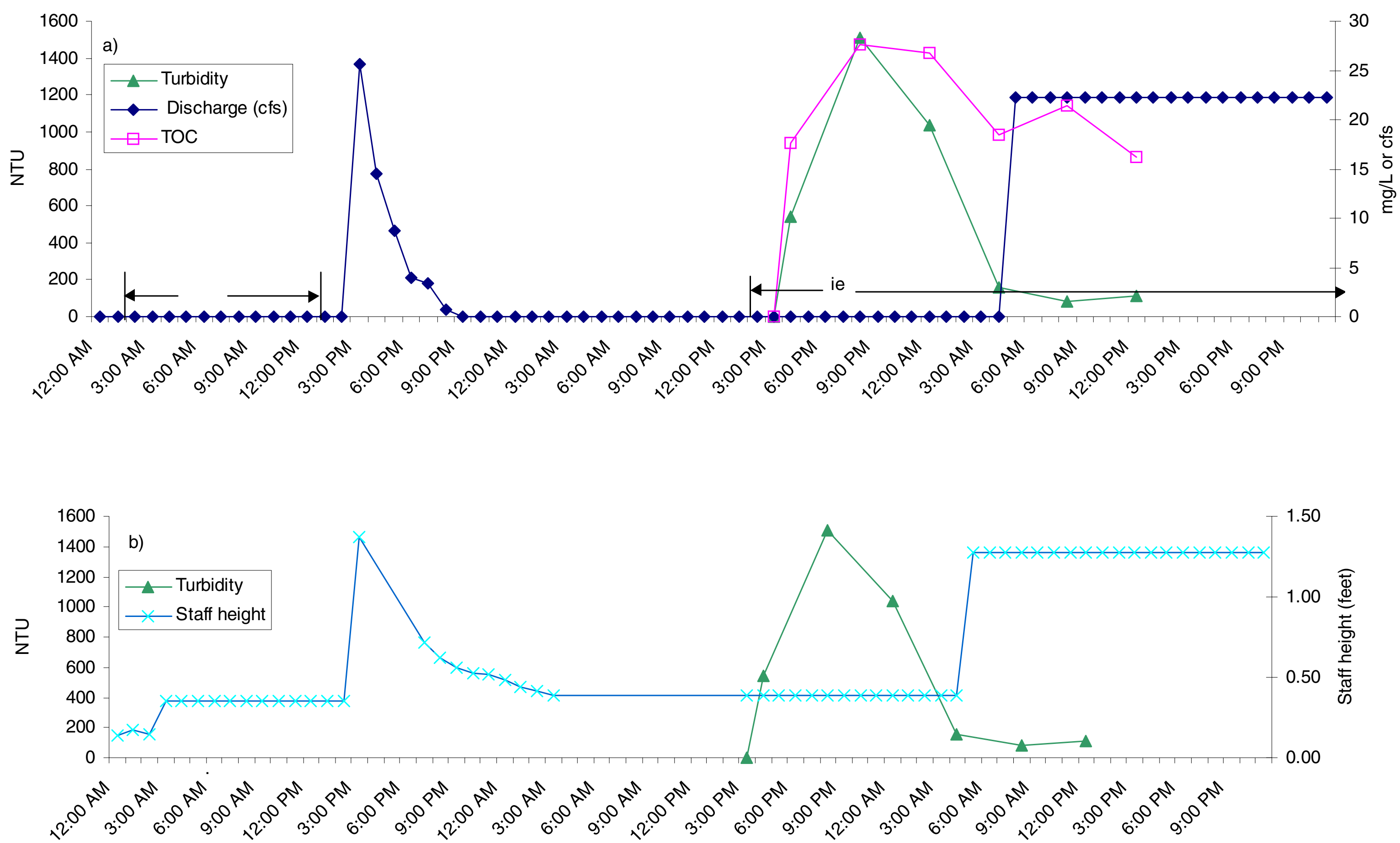
ie = flow instrument error
Autosamplers tripped on the quarter or half hour moved forward to the next upcoming hour.

Figure I-8 Junction autosampler, 23 Jan 2000: (a) flow vs. TOC and turbidity and (b) staff height vs. turbidity



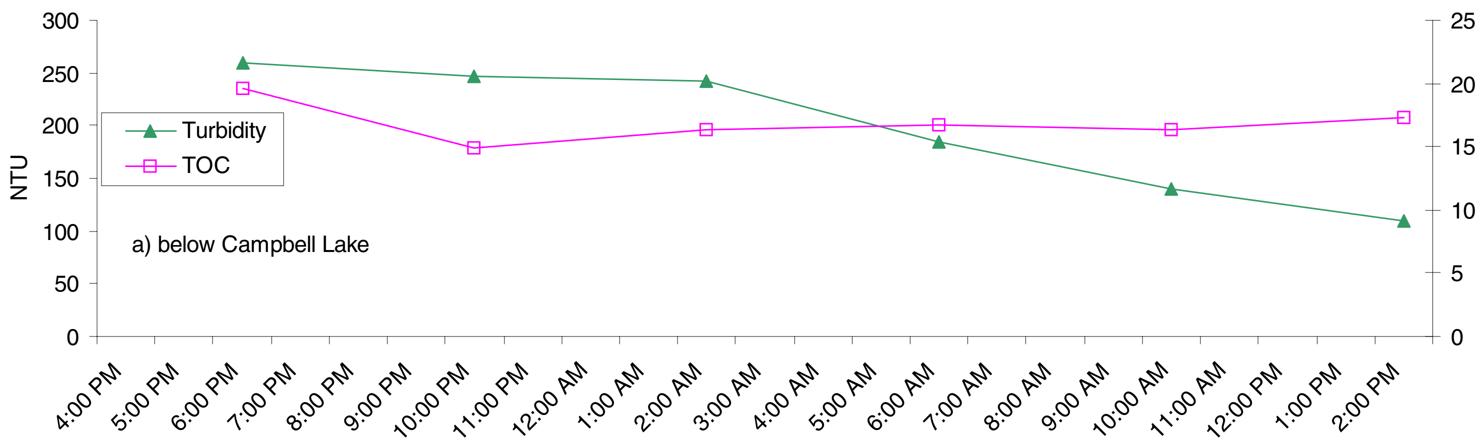
ie = flow instrument error
Autosamplers tripped on the quarter or half hour moved forward to the next upcoming hour.

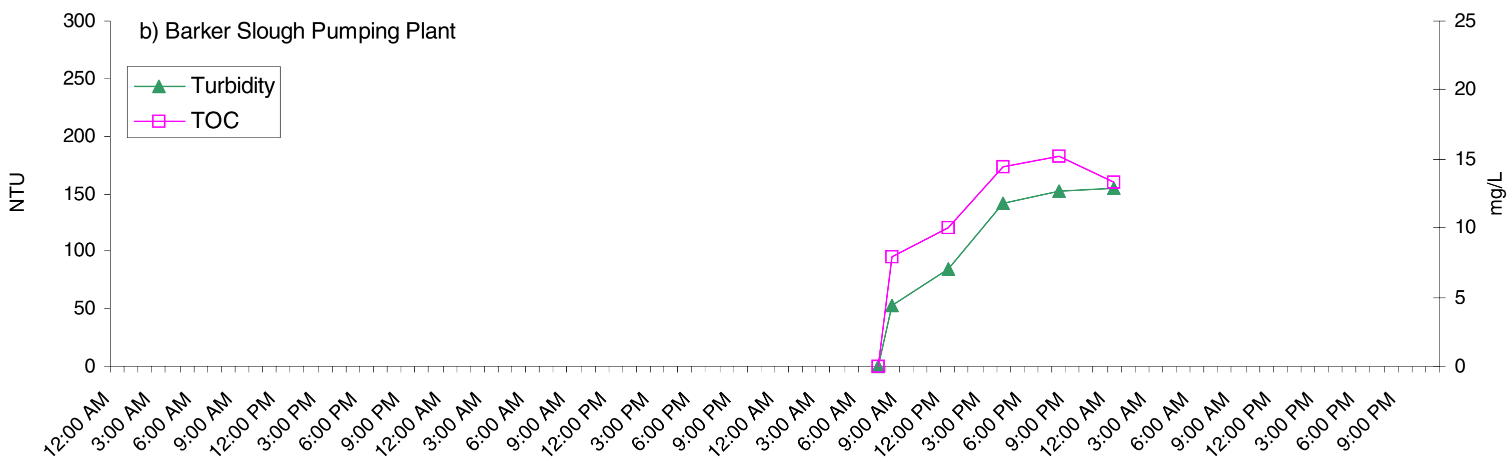
Figure I-9 Leisure Town autosampler, 11 Feb 2000: (a) flow vs. TOC and turbidity and (b) staff height vs. turbidity



ie = flow instrument error

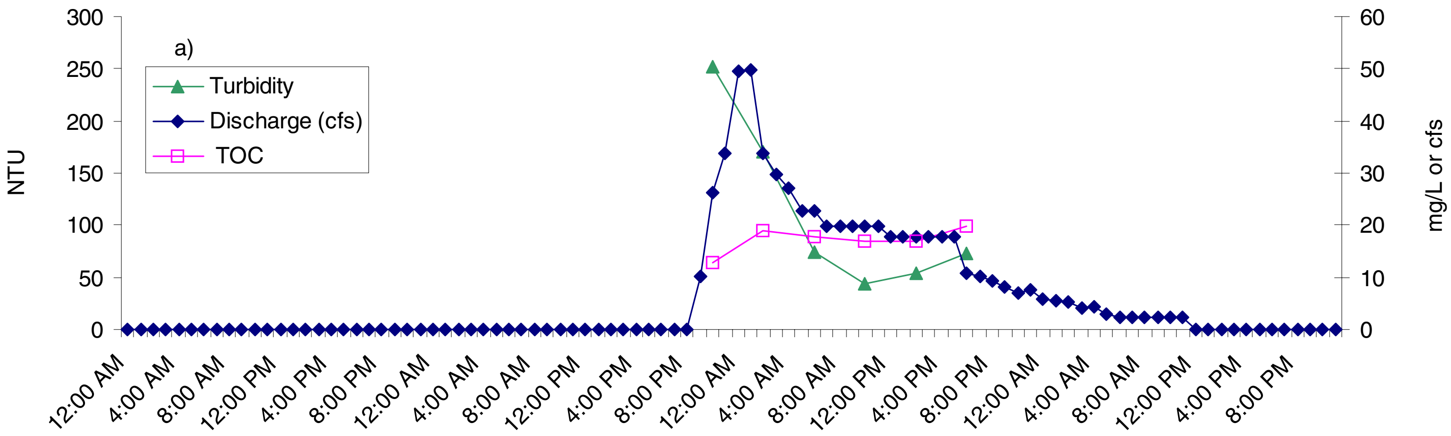
Figure I-10 TOC vs. turbidity, 11 Feb 2000: (a) below Campbell Lake and (b) Barker Slough Pumping Plant

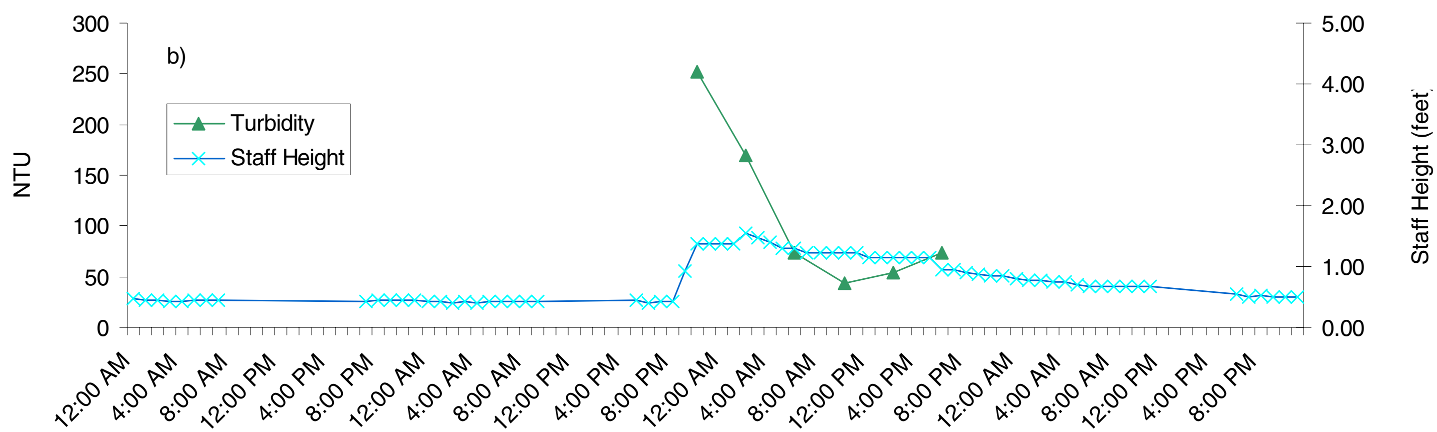




No staff height available for either site.

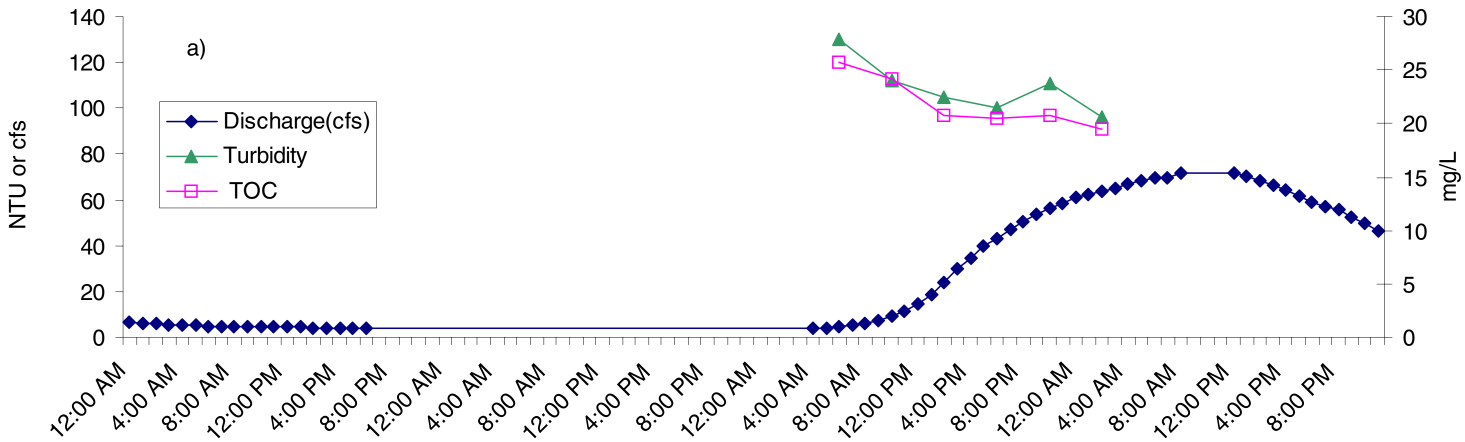
Figure I-11 Leisure Town autosampler, 4 Mar 2000: (a) flow vs. TOC and turbidity and (b) staff height vs. turbidity





Note that autosampler malfunctioned at Junction.

Figure I-12 Below Campbell Lake autosampler, 5 Mar 2000: (a) flow vs. TOC and turbidity and (b) staff height vs. turbidity



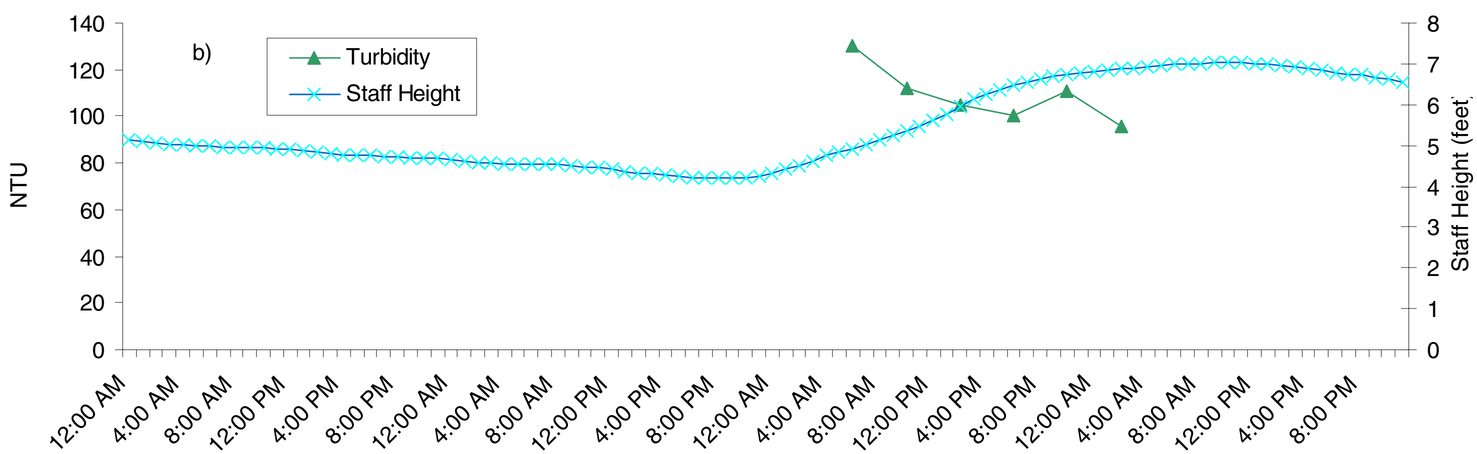
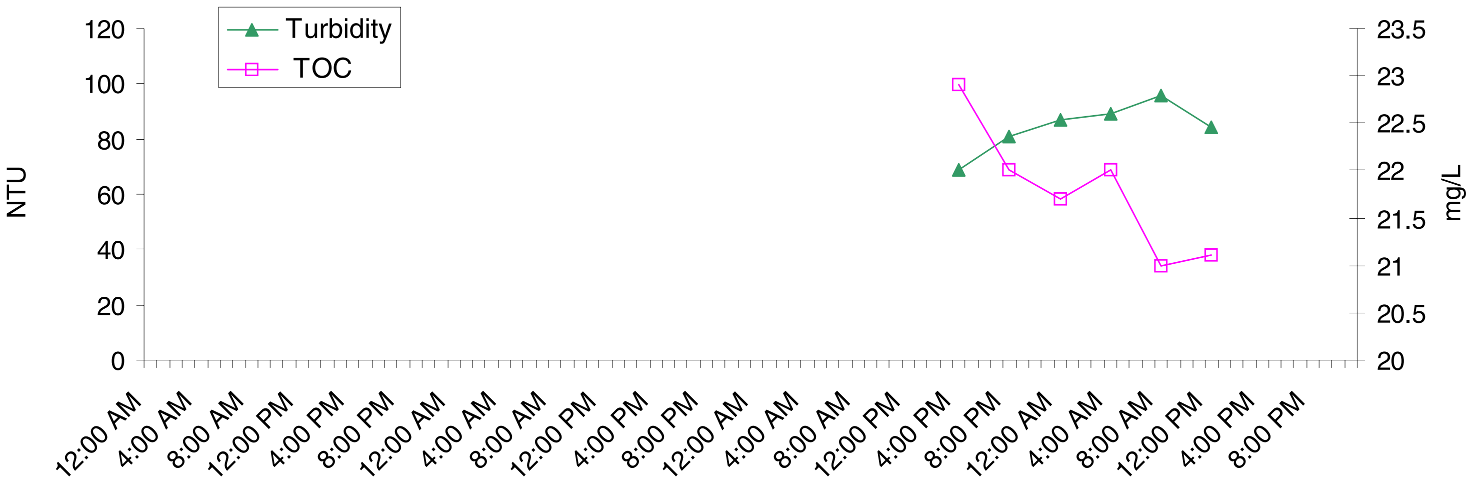


Figure I-13 Barker Slough Pumping Plant autosampler, 5 Mar 2000



No flow or staff height available.

Glossary

A

af
acre-foot/acre-feet

B

BMP(s)
Best Management Practice(s)

BTEX
benzene, toluene, ethyl benzene, xylene

C

cfs
cubic feet per second

D

DOC
dissolved organic carbon

DWR
California Department of Water Resources

E

EC
electrical conductivity

EPA
US Environmental Protection Agency

F

FLIMS
Field and Laboratory Information Management System

H

HAA(s)
haloacetic acid(s)

L

L
Liters

LCS
laboratory control sample

M

maf
million acre-feet

mg/L
milligrams per liter

MPN
most probable number

MWQI
DWR Municipal Water Quality Investigations

N

n
number

NBA
North Bay Aqueduct

NBR
North Bay Regional Water Treatment Plant

NCFCWCD
Napa County Flood Control and Water Conservation District

NM
nautical miles

NTU(s)
nephelometric turbidity unit(s)

O

O&M
DWR Division of Operations and Maintenance

P

PP
pumping plant

Q

QA/QC
quality assurance/quality control

R

RPD
relative percent difference

S

SCWA
Solano County Water Agency

SID
Solano Irrigation District

SUVA
specific ultra violet absorbance

SWP
State Water Project

T

TDS
total dissolved solids

TOC
total organic carbon

TTHMFP
total trihalomethane formation potential

U

USGS
US Geological Survey

UVA-254
ultraviolet absorbance measured at a wavelength
of 254 nanometers

W

WTP(s)
water treatment plant(s)

µ

µg/L
micrograms per liter

µS/cm
microseimens per centimeter

CONVERSION FACTORS

Quantity	To convert from customary unit	To metric unit	Multiply customary unit by	To convert to customary unit, multiply metric unit by
Length	inches (in)	millimeters (mm)●	25.4	0.03937
	inches (in)	centimeters (cm)	2.54	0.3937
	feet (ft)	meters (m)	0.3048	3.2808
	miles (mi)	kilometers (km)	1.6093	0.62139
Area	square inches (in^2)	square millimeters (mm^2)	645.16	0.00155
	square feet (ft^2)	square meters (m^2)	0.092903	10.764
	acres (ac)	hectares (ha)	0.40469	2.4710
	square miles (mi^2)	square kilometers (km^2)	2.590	0.3861
Volume	gallons (gal)	liters (L)	3.7854	0.26417
	million gallons (10^6 gal)	megaliters (ML)	3.7854	0.26417
	cubic feet (ft^3)	cubic meters (m^3)	0.028317	35.315
	cubic yards (yd^3)	cubic meters (m^3)	0.76455	1.308
	acre-feet (ac-ft)	thousand cubic meters (m^3 x 10^3)	1.2335	0.8107
	acre-feet (ac-ft)	hectare-meters (ha - m)■	0.1234	8.107
	thousand acre-feet (taf)	million cubic meters (m^3 x 10^6)	1.2335	0.8107
	thousand acre-feet (taf)	hectare-meters (ha - m)■	123.35	0.008107
	million acre-feet (maf)	billion cubic meters (m^3 x 10^9)◆	1.2335	0.8107
	million acre-feet (maf)	cubic kilometers (km^3)	1.2335	0.8107
Flow	cubic feet per second (ft^3/s)	cubic meters per second (m^3/s)	0.028317	35.315
	gallons per minute (gal/min)	liters per minute (L/min)	3.7854	0.26417
	gallons per day (gal/day)	liters per day (L/day)	3.7854	0.26417
	million gallons per day (mgd)	megaliters per day (ML/day)	3.7854	0.26417
	acre-feet per day (ac-ft/day)	thousand cubic meters per day (m^3 x 10^3/day)	1.2335	0.8107
Mass	pounds (lb)	kilograms (kg)	0.45359	2.2046
	tons (short, 2,000 lb)	megagrams (Mg)	0.90718	1.1023
Velocity	feet per second (ft/s)	meters per second (m/s)	0.3048	3.2808
Power	horsepower (hp)	kilowatts (kW)	0.746	1.3405
Pressure	pounds per square inch (psi)	kilopascals (kPa)	6.8948	0.14505
	head of water in feet	kilopascals (kPa)	2.989	0.33456
Specific capacity	gallons per minute per foot of drawdown	liters per minute per meter of drawdown	12.419	0.08052
Concentration	parts per million (ppm)	milligrams per liter (mg/L)	1.0	1.0
Electrical conductivity	micromhos per centimeter	microsiemens per centimeter (mS/cm)	1.0	1.0
Temperature	degrees Fahrenheit (°F)	degrees Celsius (°C)	(°F - 32)/1.8	(1.8 x °C) + 32

● When using "dual units," inches are normally converted to millimeters (rather than centimeters).

■ Not used often in metric countries, but is offered as a conceptual equivalent of customary western U.S. practice (a standard depth of water over a given area of land).

◆ ASTM Manual E380 discourages the use of billion cubic meters since that magnitude is represented by giga (a thousand million) in other countries. It is shown here for potential use for quantifying large reservoir volumes (similar to million acre-feet).

OTHER COMMON CONVERSION FACTORS

1 cubic foot=7.48 gallons=62.4 pounds of water

1 cubic foot per second (cfs)=450 gallons per minute (gpm)

1 cfs=646,320 gallons a day=1.98 ac-ft a day

1 acre-foot=325,900 gallons=43,560 cubic feet

1 million gallons=3.07 acre-feet

1 million gallons a day (mgd)=1,120 ac-ft a year