MUNICIPAL
WATER QUALITY
INVESTIGATIONS
PROGRAM

JONES TRACT FLOOD WATER QUALITY INVESTIGATIONS

Division of Environmental Services
California Department of Water Resources
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Executive Summary

Purpose

The report documents all the water quality data collected by the Department of Water Resources (DWR) at Upper Jones Tract and Lower Jones Tract and the Middle River after the levee breached at Upper Jones Tract. Sampling was conducted while Middle River was filling the Upper Jones Tract and Lower Jones Tract and continued through the levee repair and the dewatering. Analyses were done with the monitoring data required by the Regional Water Quality Control Board (Regional Water Board) and the independent data collected by DWR staff. Because the delta provides drinking water to many Californians, a comprehensive monitoring program was implemented to collect and analyze the water quality constituents. The methods used by the field staff as well as the Bryte Laboratory have been summarized in the report, and the analyses done by laboratories under contract to DWR also are described. The results and the discussion of the data analysis are in Chapter 3.

Within the overall DWR goal of recovering Jones Tract from the levee breech and flood, the Municipal Water Quality Investigations Branch of the Division of Environmental Services of DWR undertook the water quality monitoring with 3 project purposes:

1 Evaluate the water quality of pump discharge as required by the Regional Water Quality Control Board to meet water quality objectives;
2 Evaluate water quality at the pump-out site to determine possible water quality effects to delta waters used for municipal purposes; and
3 Gather and analyze data that might help assess potential water quality effects of future island water storage projects.

Background

On the morning of June 3, 2004, a levee on the southwest side of Upper Jones Tract breached. Within about 48 hours both Upper and Lower Jones tracts were flooded, forming a new 12,000-acre lake in the central-south delta. The exact cause and time of the breach are not known. The 300-foot breach allowed the Middle River water to stream into the Upper Jones Tract. Water flowed under the east-west-running railroad embankment via an underpass, filling Lower Jones Tract to the north. Just before noon on June 4, 2004, staff from the DWR Office of Water Quality, Municipal Water Quality Investigations Program (MWQI) arrived at the Upper Jones Tract.

The breach was 10 stream miles northeast of the State Water Project's Clifton Court Forebay gates and 11 stream miles northeast of the federal Central Valley Project's Delta-Mendota Canal intake. Water from the Middle River filled Jones Tract, and once filled, a tidal reverse flow of water from Jones Tract carried dissolved and suspended material into the Middle River.

The volume of water pulled into the Upper and Lower Jones tracts in just three days was about 150,000 to 200,000 acre-feet on an area of 12,000 acres and filled to an average depth between 12 and 16 feet. This represents about 35% of the entire volume of the Delta, not including Suisun Bay, and almost 10 times the volume of water in the south delta. The Jones Tract flood pulled primarily on the San Joaquin River, from the south and east. This temporarily reduced the water level at nearby water stage monitoring stations. As the river water was pulled in, increased seawater intrusions became a concern. To reduce the seawater intrusions, pumping was reduced at the export facilities, the Delta Cross Channel was opened, and more water was released from the upstream reservoirs on the Sacramento River. Within a few days after the breach, rocks were brought in to fill the levee starting from the south side. Once the levee was filled in July, dewatering (or pump-out) activity began.

Scope of the Report

The report documents all the water quality data collected by DWR related to the Jones Tract flood, along with preliminary analysis and discussion. The Municipal Water Quality Investigations Branch of the Division of Environmental Services of DWR undertook the water quality monitoring with 3 project purposes:

- Evaluate the water quality of pump discharge as required by the Regional Water Quality Control Board to meet water quality objectives;
- Evaluate water quality at the pumps to determine water quality effects of pump-out on drinking water source water; and
- Gather and analyze data that might help assess potential water quality effects of future island water storage projects.

From the day after the levee breach, samples were collected from the breach site, Lower Jones Tract, and the Middle River, by MWQI staff. After the breach was filled in July, samples were collected from temporary sampling stations at Upper Jones Tract and Lower Jones Tract. In addition, to comply with the Regional Water Quality Control Board requirements, grab samples were collected at three Middle River Sampling sites after the dewatering started in July 2004. Automated water quality sondes were placed in the floodwater at several locations to collect continuous water quality data. A weather station to measure wind speed, air temperature, and other meteorological variables, was installed by the California Irrigation Management Information System (CIMIS) and was maintained until December 2004. Analysis included comparison between observed organic carbon concentrations at Jones Tract and those observed or predicted in other studies.

The monthly monitoring reports delivered to the Regional Board kept the Board apprised of changes in water quality. With the exception of a positive fish toxicity test which, when repeated, came up negative, Regional Board staff did not express concerns with the levels or concentrations of the monitored water quality parameters. That said, this study quantified a wide range of water quality parameter effects that provided information on the effects on source water quality for drinking water, and on the likely water quality effects of reservoir-island systems.

Summary of Findings

The Jones Tract flood was a serious and disruptive event in the Delta. In the short term, it necessitated a large flood-fighting mobilization to prevent further levee bank erosion, and the loss of crops, farm equipment, and buildings. The levee breach had to be repaired, and large pumps installed on the west side of Jones Tract, to drain the island. Pumping continued for approximately five months, during which discharge water affected water quality at State Water Project and Central Valley Water Project pumps to the south.

Physical conditions and weather were strong drivers of water quality conditions. On windy days floodwater was stirred up and turbidity increased. Turbidity and total suspended solids (TSS) were strongly correlated with wind ($r^2 = 0.91$); total suspended solids and total settleable solids increased when wind speed increased. Precipitation on and near Jones Tract was very low between June and October during the time when most of the floodwater was pumped out. Thus, precipitation did not play a significant role in the hydrology of the flood recovery.

Before the levee was repaired, the southwest side of Upper Jones Tract was open to the Middle River. At this time the water temperature at Upper Jones Tract was lower than Lower Jones Tract, to the north.

Presumably, water in Upper Jones Tract was exchanging with relatively cooler Middle River water. After the levee was repaired and water was contained within Upper and Lower Jones Tracts, the temperatures in both tracts were very similar.

Water temperature affects the water's ability to hold dissolved oxygen (DO). All else being equal, cold water holds more DO than does warm water. Comparisons between the temperature variations from June through November at both Upper and Lower Jones indicated that the DO variations were affected by other processes in addition to water temperature. Often the concentration of DO was higher in the surface water than at the bottom due to oxygen demands in the organic sediments, oxygen diffusion from the air, and, during daylight hours, oxygen production by algal photosynthesis. DO concentrations were frequently below 6 mg/L required for the proposed In-Delta water storage project discharges. High dissolved iron and manganese concentrations were observed in Jones Tract waters, a condition that occurs when flooded soils become anoxic. After the floodwaters had been removed and the soil itself could be examined, mottle formations were observed, which further suggests that low DO conditions existed in the flooded island.

On hourly to daily time scales, the data suggests that there is a strong relationship between DO, pH and algal phytoplankton photosynthetic activity. Diurnal (daily) variation in DO appears to be similar to the changes in pH. This is most likely due to photosynthesis during daylight hours. Photosynthesis removes carbon dioxide (CO_2, or carbonic acid, H_2CO_3) and produces oxygen, driving both pH and DO up. At night, respiration consumes oxygen and produces CO_2, reducing both DO and pH.

The Jones Tract flood provided an opportunity to perform a natural experiment on the dissolved organic carbon (DOC) production that might be produced from flooding of a delta peat-soil island. An areal DOC yield rate of about 0.5 $gC/m^2/d$ (0.47 $gC/m^2/d$) described reasonably well the increase in DOC concentrations observed on Jones Tract. There appeared to be a decrease in this areal yield rate in October and November as water temperatures declined. The Jones Tract summer data are also consistent with the growing season (March through October) rate of 0.47 g/m2/d developed from mesocosm studies and used in earlier modeling of the proposed In-Delta Storage Project.

These calculated rates may be lower after a few years of continuous flooding and might be expected to decline from 0.5 $gC/m^2/d$. Nevertheless, in complex, dynamic, and productive aquatic ecosystems like flooded islands in the delta, many factors such as re-exposure, oxidation of soils, wind mixing, biological productivity, and re-suspension of sediments and soil, will tend to keep the DOC yield rates higher than the minimum rate.

Once pumped off of Jones Tract, a portion of the high-DOC waters were drawn southward to the export facilities. DOC concentrations at the Banks Pumping Plant are affected by interannual variability and hydrology. However, field/grab sample data agree with Delta Simulation Model (DSM2) computer model numerical results suggesting that Jones Tract caused a sustained increase in DOC at Banks on the order of 0.5 to 1 mg/L due to the Jones Tract pump-out relative to the historical mean.

Naturally-occurring algal populations are known to produce complex organic molecules that result in objectionable tastes and/or odors in drinking water. One of these, methylisoborneol (MIB), rose to relatively high concentrations and created taste and odor problems at Banks in July during dewatering. At the same time field staff reported that the Jones Tract water had "a bad smell." These problems have not received much attention in recent discussions of potential impacts from In-Delta Storage Projects. Taste and odor compounds from In-Delta Storage Project islands could cause operational problems at the urban intakes.

The concentrations of organic nitrogen and organic phosphorus compounds increased in the Jones Tract floodwater relative to those in the surrounding river channels. Dewatering that moved the floodwater to Clifton Court Forebay may have increased the algal population at the forebay and resulted in higher than normal MIB at Banks.

Trihalomethanes are carcinogens that are formed by DOC reacting with chlorine during chlorination of drinking water, or in a laboratory test. The results showed that the trihalomethane concentrations steadily went up in chlorinated laboratory water samples as the dewatering activities continued at Jones Tract, in parallel with increased DOC concentration. Many samples contained higher than 1,500 μg/L of chloroform after September. These levels were compared to levels that were found in Upper Jones Tract agricultural drain grab-samples between 1988 and 1991; the agricultural drainage samples seldom had trihalomethane concentrations higher than 1,500 μg/L.

Bromodichloromethane is another disinfection by-product (DBP) of concern in delta waters. Bromodichloromethane concentrations were high in water samples that contained higher concentrations of bromide. The bromodichloromethane concentrations increased with the increase in bromide in the floodwater. Usually in delta water, bromide concentration is closely related to the chloride concentration and the bromide to chloride ratio is similar to the seawater ratio of 0.0034. The ratio observed at Lower Jones was 0.006. The ratio at Jones Tract was higher than the ratio observed in the Delta, and there was a possibility of another source of bromine in the floodwater other than the seawater.

Ultraviolet (UV) absorption data were collected through September. The chloroform and bromodichloromethane concentrations correlated with UV light absorption at 254 nm (UVA-254). At the same time DOC concentrations were highly correlated at lower values of chloroform concentrations. At chloroform levels higher than 2000 μg/L, DOC did not correlate well with chloroform concentration.

Electrical conductivity (EC) is a surrogate measurement of salinity and dissolved solids concentration. EC was measured by field instruments, standard laboratory methods, and automated *in-situ* sondes placed in the water. All these methods gave similar readings. The EC at Jones Tract did not rise above 512 μS/cm, a level often found in Delta channels. The change in EC, total dissolved solids (TDS), sodium, calcium, magnesium, chloride, and hardness were very similar. In all cases the amounts were higher at Lower Jones relative to Upper Jones just after the levee break, suggesting that these were coming into solution from the flooded soil. After the levee breach was closed, the concentrations were very similar in both Lower Jones and Upper Jones. The correlation of EC to TDS was lower than what is usually expected in delta water. Unusually high concentration of carbon compounds in the floodwater may have affected the TDS readings. Potassium levels were higher in the floodwater than in the Middle River. Boron was always present in floodwater samples collected after the levee was repaired and its concentration varied from 0.1 to 0.2 mg/L. But levels of boron could not be detected in most samples collected from the Middle River.

Iron and manganese concentrations above the maximum contaminant level (MCL) were recorded in Jones Tract floodwaters. (The maximum contaminant level is the highest permissible level of contaminant in drinking water for it to be deemed suitable for human consumption). This was caused by the anaerobic conditions on the bottom during the pump-out. In organic soils, anaerobic conditions and temperatures higher than 5 °C, as observed at Jones Tract, transform insoluble ferric and manganic compounds to soluble ferrous and manganous compounds, respectively. These soluble chemicals then mix upwards into the water column. Average concentrations of iron and manganese at Lower Jones were about seven times those found in the Middle River. The average concentration of iron and manganese at Upper Jones was about three to four times the concentration at Middle River. When the water receded during the pump-out, red and orange mottling was seen on the exposed soil. This is characteristic of re-oxidation of iron and manganese compounds that were left behind on the soil.

The concentrations of many common pesticides were below the limits of detection. Pesticides that were detectable were metolachlor, diazinon, molinate, atrazine, diuron, simazine, and trifluralin. None of their concentrations were above the MCLs for drinking water.

Because farm equipment containing petroleum products were submerged, tests were carried out for organic carbon compounds. Diesel range organics were detected in the floodwater while benzene, toluene, ethyl benzene, xylene, gasoline range organics, oil and grease, volatile organic compounds, semi volatile organic compounds were below reporting limits.

In the beginning of June, the concentrations of total coliforms, fecal coliforms, and *E. coli* were high in the floodwater compared to the Middle River. By the end of June the total bacterial count in the floodwater dropped to very low values and the fecal coliforms and *E.coli* became so low that sometimes these were undetectable. The total bacterial count at these sites varied from 8 to >1600 MPN/100ml between June and end of August. At the same time the fecal coliforms varied from 2 to 30 MPN/100 ml and *E. coli* count was 20 MPN/100 ml and sometimes undetectable. The bacterial monitoring stopped after August.

Large variability in average chlorophyll concentration was seen at Lower and Upper Jones tracts and at Upper Jones Tract. The chlorophyll concentrations in the samples collected at the bottom were lower than the samples collected at upper levels of the water column. Acute toxicity tests conducted in the floodwater showed that the water was not toxic.

The monthly monitoring reports delivered to the Regional Board kept the Board apprised of changes in water quality. With the exception of a positive fish toxicity test which, when repeated, came up negative, Regional Board staff did not express concerns with the water quality findings.

While the changes in water quality directly outside of Jones Tract due to the pump-out did not rise to the level of concern that would have threatened the environment or the continued pump-out operations, the study did find many potential effects of interest or concern regarding delta water as a drinking water source. These included increases in dissolved organic carbon concentration, algae concentration and type, potential for the formation of disinfection byproducts, nutrient loading, production of unpleasant taste and odor compounds, and anoxia in the bottom waters leading to elevated dissolved manganese and iron concentrations. Of these, DOC loading from the island peat soils is probably among the top concerns for drinking water use, due to the production of DBPs during treatment.

It is very likely that the intentional flooding of a delta island similar to Jones Tract for the purposes of water storage would exhibit most or all of the effects discussed above. How these and other effects evolve over time would likely vary according to how the island water storage project were operated, but the fundamental controlling mechanisms would be approximately the same.

The CALFED Record of Decision states that the goal of the Water Quality Program is to provide “safe, reliable, and affordable drinking water in a cost-effective way,” with a target to “achieve either: (a) average concentrations at Clifton Court Forebay and other southern and central Delta drinking water intakes of 50 µg/L bromide and 3.0 mg/L total organic carbon, or (b) an equivalent level of public health protection using a cost effective combination of alternative source waters, source control, and treatment technologies.” At present, TOC, of which approximately 80 to 90 percent is DOC, at the Banks Pumping Plant (immediately downstream from Clifton Court Forebay) exceeds 3.0 mg/L approximately 80% of the time on an annual basis. TOC tends to be highest in winter due to inputs from the tributary rivers and in-delta island drainage, and lowest in the summer and fall, from approximately July to the onset of winter rains in October and November.

The potential water quality effects of an island water storage project would depend substantially on the seasonal timing of water movement into and out of the storage island. One likely scenario is that the island would be filled in the winter when river stages are high and water is relatively plentiful, and drained during the summer when water is relatively scarce. A likely water quality implication of this scenario is that the island would be filled with water containing seasonally elevated TOC/DOC concentrations. The stored water would receive additional DOC through the spring and summer. The resultant high-TOC/DOC water would be released into the delta during the months in which TOC/DOC is generally lowest and closest to reaching the CALFED water quality goal. From a drinking water standpoint, the net effect would be to move delta waters even further from the CALFED water quality TOC goal.

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Abbreviations and Acronyms

ANH	city of Antioch
BAC	Bacon Island
CDEC	California Data Exchange Center
cfs	cubic feet per second
CFU	colony forming unit
CIMIS	The California Irrigation Management Information System
CLC*	Clifton Court Forebay
DBPs	disinfection byproducts
DO	dissolved oxygen
DOC	dissolved organic carbon
DOE	DWR Division of Engineering
DRO	diesel range organics
EC	electrical conductivity
ELAP	Environmental Laboratory Accreditation Program
EPA	US Environmental Protection Agency
FID	flame ionization detector
FLIMS	Field and Laboratory Information Management System
GRO	gasoline range organics
IDL	Instrument Detection Limit
ISI	Integrated Storage Investigations
LCS	laboratory control samples
LIDAR	Light Detection and Ranging
LJD	Lower Jones Discharge
LJI	Lower Jones Intake
LJM	Lower Jones Middle
LJMB	Lower Jones Middle-bottom
LJMT	Lower Jones Intake-top
LTB	lauryl tryptose broth
MB	method blanks
MDL	Method Detection Limit
MF	Membrane Filter
MIB	Methylisoborneol
MPN	most probable number
MS	matrix spikes
MS	matrix spikes
MWI	Moving Water Industries
MWQI	Municipal Water Quality Investigations Unit
NDIR	nondispersive infrared detector
NTU	nephelometric turbidity unit
RL	Reporting Limit
RL	Reporting Limit
RPDS	relative pearcent differences
RRI*	Rough and Ready Island
SMARTS	Special Multipurpose Applied Research Technology Station
SOPs	Standard Operating Procedures
SS	settleable solids

TAF	thousand acre-feet
TC	total carbon
TDS	total dissolved solids
THMFP	trihalomethane formation potential
TIC	total inorganic carbon
TOC	total organic carbon
TSS	total suspended solids
TTHMFP	total trihalomethane formation potential
UJD	Upper Jones Discharge
UJI	Upper Jones Intake
UJM	Upper Jones Middle
UJMB	Upper Jones Middle – bottom
UJMT	Upper Jones Middle - top
USBR	US Bureau of Reclamation
UVA	Ultraviolet Absorption
VIC*	Victoria Island at Middle River and Victoria Canal

* CDEC station name

Metric Conversion Table

Quantity	*To Convert from Metric Unit*	*To Customary Unit*	*Multiply Metric Unit By*	*To Convert to Metric Unit Multiply Customary Unit By*
Length	millimeters (mm)	inches (in)	0.03937	25.4
	centimeters (cm) for snow depth	inches (in)	0.3937	2.54
	meters (m)	feet (ft)	3.2808	0.3048
	kilometers (km)	miles (mi)	0.62139	1.6093
Area	square millimeters (mm^2)	square inches (in^2)	0.00155	645.16
	square meters (m^2)	square feet (ft^2)	10.764	0.092903
	hectares (ha)	acres (ac)	2.4710	0.40469
	square kilometers (km^2)	square miles (mi^2)	0.3861	2.590
Volume	liters (L)	gallons (gal)	0.26417	3.7854
	megaliters (ML)	million gallons (10*)	0.26417	3.7854
	cubic meters (m^3)	cubic feet (ft^3)	35.315	0.028317
	cubic meters (m^3)	cubic yards (yd^3)	1.308	0.76455
	cubic dekameters (dam^3)	acre-feet (ac-ft)	0.8107	1.2335
Flow	cubic meters per second (m^3/s)	cubic feet per second (ft^3/s)	35.315	0.028317
	liters per minute (L/mn)	gallons per minute (gal/mn)	0.26417	3.7854
	liters per day (L/day)	gallons per day (gal/day)	0.26417	3.7854
	megaliters per day (ML/day)	million gallons per day (mgd)	0.26417	3.7854
	cubic dekameters per day (dam^3/day)	acre-feet per day (ac-ft/day)	0.8107	1.2335
Mass	kilograms (kg)	pounds (lbs)	2.2046	0.45359
	megagrams (Mg)	tons (short, 2,000 lb.)	1.1023	0.90718
Velocity	meters per second (m/s)	feet per second (ft/s)	3.2808	0.3048
Power	kilowatts (kW)	horsepower (hp)	1.3405	0.746
Pressure	kilopascals (kPa)	pounds per square inch (psi)	0.14505	6.8948
	kilopascals (kPa)	feet head of water	0.32456	2.989
Specific capacity	liters per minute per meter drawdown	gallons per minute per foot drawdown	0.08052	12.419
Concentration	milligrams per liter (mg/L)	parts per million (ppm)	1.0	1.0
Electrical conductivity	microsiemens per centimeter (µS/cm)	micromhos per centimeter (µmhos/cm)	1.0	1.0
Temperature	degrees Celsius (°C)	degrees Fahrenheit (°F)	(1.8X°C)+32	0.56(°F-32)

Chapter 1 Introduction

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Chapter 1 Introduction

1.1 The Jones Tract Flood: An Overview

On the morning of June 3, 2004, a 300-foot section of levee on the west side of Upper Jones Tract, adjacent to Middle River, breached. As a result, both Upper and Lower Jones tracts flooded, creating a new 12,000-acre lake in the central-southern region of the Sacramento-San Joaquin River Delta (Delta; Figure 1.1). Depths ranged from 12 to 16 feet. All of the floodwater was pumped out of both halves of the island and back into the Middle River over the course of approximately six months.

Figure 1.1 Delta region with transportation corridors and waterways illustrated

This report presents the results of an investigation of the effects of drainage from the flooded Jones Tract Island on water quality in the Middle River and eventually at the Harvey O. Banks Pumping Plant. Monitoring was conducted from June 4, 2004, through November 22, 2004, by the Municipal Water Quality Investigations Unit (MWQI) within the Department of Water Resources' Office of Water Quality (Division of Environmental Services). In addition to MWQI staff, other Department of Water Resources (DWR) units assisted with this investigation. These included the Environmental Real-Time Monitoring and Support Section (Division of Environmental Services), the State Water Project Water Quality Program Branch (Division of Operations and Maintenance), and staff from Central District (Division of Planning and Local Assistance).

MWQI = Municipal Water Quality Investigations Unit

DWR = California Department of Water Resources

Numerous parameters were measured at several locations within the Jones Tract flood site, including physical parameters (i.e., pH, dissolved oxygen, biochemical oxygen demand, temperature, turbidity), total and dissolved organic carbon, trihalomethane formation potential, bromide, electrical conductivity, nutrients (i.e., nitrogen and phosphorus compounds), chlorophyll a, trace elements, pesticides, organic compounds, and bacteria.

An evaluation of the effects on Delta water quality from events such as the 2004 Jones Tract flood is especially important in the context of diversions from the Delta and the potential impacts on drinking water quality associated with intentional or accidental flooding of peat islands in the Delta.

Figure 1.2 Water flowing into Upper Jones Tract from the Middle River after the levee break (photo)

1.2 Detailed Description of the Jones Tract Levee Breach

Figure 1.3 Jones Tract region with pumps and levee break locations marked

cfs = cubic feet per second

Figure 1.4 Water flowing northward under a railroad embankment from Upper Jones Tract to the Lower Jones Tract (photo)

Figure 1.5 Upper Jones Tract levee breach at noon on June 4, 2004 (photo)

The 300-foot breach allowed Middle River water to stream into the western side of Upper Jones Tract (Figures 1.2 and 1.3). The breach was about 10 stream miles northeast of the Clifton Court Forebay gates and 11 stream miles northeast of the Delta-Mendota Canal intake. The exact cause and time of the breach are not known. But reports on when the breach occurred range from 7 to 9 a.m. on June 3. Water flowed from Middle River through the breach into Upper Jones Tract and then through a large railroad trestle culvert into Lower Jones Tract (Figure 1.4). Peak flow rates through the breach have been estimated at around 100,000 cubic feet per second (cfs). A part of the railroad trestle was damaged by the waterflow through the culvert. When MWQI staff arrived at the Middle River breach about noon on June 4, the tide appeared to be just starting to ebb (flow out) of the Upper Jones Tract breach (Figure 1.5). This may have been the first significant flow out of the completely flooded Upper Jones Tract. A mud or tide/current line between turbid island water and relatively clear Middle River water was observed moving south from the Upper Jones Tract breach down Middle River (Figure 1.6). MWQI staff observed the tide line moving about 1,000 feet south from the breach toward the Woodward Island Ferry from about noon to 2 p.m. It appeared that water flowing out of Upper Jones Tract spread to the north and south (downstream and upstream) at the same time in Middle River.

Figure 1.6 Mud/tide line at Woodward Island Ferry 2 p.m. on June 4, 2004, flowing south down Middle River (photo)

1.3 Jones Tract's Location in the Sacramento – San Joaquin River Delta

Jones Tract is in the south-central region of the Delta (Figure 1.1). It is bordered by the Middle River to the west, Trapper Slough to the south, Whiskey Slough to the east, and Empire Cut to the north (Figure 1.3). Other Delta islands surrounding Jones Tract include Victoria, Woodward, and Bacon islands on the west side; Union Island to the south; Roberts Island is on the east side; and McDonald and Mildred islands on the north side (Figure 1.3).

1.4 Jones Tract: Island Size, Soil Description, and Elevation

Upper and Lower Jones tracts together make up a single Delta island called Jones Tract. The two tracts are separated by a railroad embankment running east to west (Figure 1.4). Upper Jones Tract is 6,200 acres, and Lower Jones Tract is 5,800 acres. The names denote the tracts' relative elevation rather than their north-to-south orientation: Upper Jones is to the south.

Both portions of Jones Tract are used primarily for agriculture. Soils of both Upper and Lower Jones tracts are primarily muck (up to 75%) with the remaining portion mostly loam. Loams are productive agricultural soils containing sand, silt, and organic material. By definition, muck soils are composed of peat that has substantially decomposed over time so that the original organic materials are unidentifiable. The depth of muck soils is about 5 to 10 feet in Upper Jones Tract and 10 to 12.5 feet in Lower Jones Tract. The muck soils are so fine that when dry, they become powdery and subject to wind erosion.

Surface elevation on the island ranges from 10 feet below sea level (Upper Jones Tract) to 15 feet below sea level (areas of Lower Jones Tract). Land surfaces have dropped below sea level due to subsidence, primarily the result of soil loss. This loss occurs when the previously saturated soils are drained and exposed to air, at which point they are subject to wind erosion or oxidation of the organic matter to carbon dioxide. Peat soil is also lost when water used for irrigation is drained from the island and returned to adjacent channels. This subsidence, which is typical of many islands in the Delta, has led to the land surfaces in Jones Tract being 10 to 15 feet lower than the water level of Middle River.

1.5 Delta Hydrology, Electrical Conductivity, and Stage Affected by the Jones Tract Flood

The effects of the Jones Tract levee breach was almost immediately felt throughout much of the Delta. The “suction” of water being pulled through the breach and into Jones Tract is illustrated by changes in stage and electrical conductivity (EC) data at several key monitoring stations in this region of the Delta. The California Data Exchange Center (CDEC) provides a clearinghouse of EC and water stage measurements at various stations near Jones Tract (Figure 1.7), from instruments maintained by several cooperating agencies. Figure 1.8 shows CDEC EC data for the station on the east side of Victoria Island at Middle River and Victoria Canal (CDEC name VIC) about 3 miles south of the Jones Tract breach. These data suggest that saltier San Joaquin River water reached this station about 12 hours after the breach, about 8 p.m. on June 3, as the Upper and Lower Jones tracts were filling and pulling water from surrounding Delta channels, especially from the south Delta and the San Joaquin River. Data in Figure 1.8 also suggest that at about 9 a.m. on June 5, after Upper Jones Tract was full and ebb flows were coming off the island, the tide line or the first of the water from Upper Jones reached the VIC station and brought EC levels down to about 280 microsiemens per centimeter (µS/cm), the same EC as in Upper Jones Tract. The drop in EC between June 2 and June 5 at the VIC station represents a shift in water source and quality. After the breach, much of the water at the VIC station was probably replaced by fresher Upper Jones Tract water, which was a mixture of San Joaquin River and much fresher Sacramento River that came through the recently opened Delta Cross Channel. It appears that late on June 6 water from Upper Jones Tract reached the Clifton Court Forebay gates (CLC) effectively homogenizing water all over the south Delta to an EC of about 280 µS/cm (Figure 1.9).

EC = electrical conductivity

CDEC = California Data Exchange Center

VIC = station at Victoria Island at Middle River and Victoria Canal

Figure 1.7 CDEC stations with EC and stage recorders affected by the Jones Tract flood

Figure 1.8 EC at VIC station (Victoria Island), June 2 through June 6, 2004

µS/cm = microsiemens per centimeter

CLC = station at Clifton Court Forebay

Peak tidal flows in and out of the breach were on the order of 30,000 cfs, which would have mixed water throughout the nearby channels of the south Delta. The volume of water pulled into Upper and Lower Jones tracts in just three days was about 150 to 200 thousand acre-feet (taf), based on an area of 12,000 acres and an average depth between 12 and 16 feet. This represents about 35% of the entire volume of the Delta, not including Suisun Bay, and almost 10 times the volume of water in the south Delta. Although these flows only occurred for a few hours with each tide, they were probably sufficient to flush out or replace a large percentage of the volume of the south Delta (about 23 taf) each day. Staff observed about a 1-foot tidal change in stage on Jones Tract, which is about a 12-taf change and would require peak tidal flows of about 36,000 cfs to remove and replace this volume of water each tidal cycle.

Figure 1.9 EC at CLC station (Clifton Court), June 1 through June 9, 2004

taf = thousand acre-feet

ANH = station at city Antioch

Effects from the Jones Tract flood can be seen in stage data from as far away as Antioch, about 20 miles northwest of the breach (Figure 1.10). Figure 1.10 shows stage at the CDEC station at the city of Antioch (ANH). The higher low tides were predicted to increase by about 0.5 feet per day from June 2 through June 5, an increase from about 2 to 3 feet. The observed higher low tide did show an increasing trend during this period, but the higher low tide

Figure 1.10 Stage at ANH station (Antioch), June 1 through June 5, 2004

on June 4 was about a half a foot lower than predicted, probably due to the flood.

A similar drop in stage was also observed at the Bacon Island (BAC) sensor about 3 miles west of Jones Tract (Figure 1.11). Tidal effects of the breach appear to have been stronger on the south Delta and San Joaquin River than on the central and western Delta. Figure 1.12 shows that the breach created a negative tidal wave that hit the stage sensor (RRI) at Rough and Ready Island about 15 or 20 miles east of the breach between 12:15 and 12:30 p.m. on June 3. The flood appears to have suddenly and dramatically lowered the stage of the San Joaquin River at Rough and Ready Island by more than a foot.

BAC = station at Bacon Island

Figure 1.11 Stage at BAC station (Bacon Island), June 1 through June 5, 2004

Figure 1.12 Stage at RRI station (Rough and Ready Island), June 1 through June 5, 2004

RRI = station at Rough and Ready Island

It appears that the Jones Tract flood pulled more water from, or had a larger effect on, the San Joaquin River and channels far to the east than it did on channels in the central and western Delta even though central Delta channels were closer to the breach. Figure 1.13 illustrates the Jones Tract fingerprint, showing that salinity, measured as EC, came from the San Joaquin River, which is consistent with the stage and EC data shown in Figures 1.8 through 1.12.

Figure 1.13 Fingerprint of EC sources in Jones Tract

It is difficult to say why the Jones Tract flood appeared to affect stage in the San Joaquin River more than the channels in the central Delta that were relatively closer to the breach. One possibility is that the south Delta and San Joaquin River have a smaller volume of water and smaller or slower inflow rates which would not replace the drop in stage as rapidly. Also, in the first few hours following the breach, tidal (ebb) flows were already pulling San Joaquin water toward the breach, and pushing central and western Delta waters away from the breach.

1.6 Agency Actions to Protect Water Quality in the South Delta after the Levee Break

From the beginning of the flood, there was concern that salinity intrusion from San Francisco Bay to the west would contaminate water at the State Water Project and Central Valley Project export pumps in the southwest Delta. Several agencies coordinated efforts to control salinity increases in the Delta. By June 4 the measures listed below were taken to protect water quality by controlling salinity and repelling salt water intrusion:

1 The US Bureau of Reclamation (USBR) increased the release of fresh water from Shasta Dam.
2 USBR opened gates at the Delta Cross Channel to move Sacramento River water into the central Delta.
3 DWR and USBR reduced pumping at the South Delta export pumps.
4 DWR monitored water quality at many sites to detect changes in EC levels.
5 DWR monitored channel velocity changes in the Jones Tract area of the Delta.

USBR = US Bureau of Reclamation

The Central Valley Regional Water Quality Control Board, after some consideration, decided that DWR needed to closely monitor the water quality of flood water being pumped off the island. DWR was required to monitor and report the discharge water quality characteristics monthly. The water quality parameters listed in the Monitoring and Recording Program became the set of parameters reported in subsequent chapters of this report.

While the primary DWR goal was to recover Jones Tract from the levee breech and flood, the Municipal Water Quality Investigations Branch of the Division of Environmental Services of DWR undertook the water quality monitoring with 3 project purposes:

1. Evaluate the water quality of pump discharge as required by the Regional Water Quality Control Board to meet water quality objectives;
2. Evaluate water quality at the pumps to determine water quality effects of pump-out on drinking water source water; and
3. Gather and analyze data that might help assess potential water quality of future island storage projects.

The monthly monitoring reports delivered to the Regional Board kept the Board apprised of changes in water quality. With the exception of a positive fish toxicity test which, when repeated, came up negative, Regional Board staff did not express concerns with the levels or concentrations of the monitored water quality parameters.

Most of the data presented in this report pertains to purposes 2 and 3, especially dissolved organic carbon and, to a lesser extent, naturally-occurring metals that came into solution as a result of low oxygen concentrations at the sediment-water interface.

1.7 Upper Jones Tract Levee Repair and Erosion Protection

Within a few days after the breach, rocks were brought in to fill the levee breach, starting from the south side. Later, a 50-foot deep scour hole in the middle of the breach was filled, and the foundation to repair the breached levee was laid. The California Conservation Corps and the California Department of Forestry undertook the initial flood fight to protect the interiors of the levees. Fire protection inmate crews from the California Department of Corrections helped in erosion protection by placing plastic sheeting and sand bags on 13 miles of interior Jones Tract levees.

Repairs to the Middle River levee breach at Jones Tract continued around the clock. By June 22, 61% of the job was completed and about 110,000 tons of rocks had been placed in a 300-foot-wide gap. Fill material placement was completed by the end of June, and pumps to remove floodwater were installed the following month. Although the rock fill was able to keep the water from the Middle River from entering Jones Tract, some seepage through the rocks continued until the end of November. Shaping fill material and filling the seepage area with dirt and rocks continued until December 2004.

The Trapper Slough levee, which forms the southeast side of Upper Jones Tract, was raised and strengthened at the same time the Upper Jones Tract breach was filled. It was feared that the large volume of water coming through the breach during high tides could destroy nearby State Highway 4 and cause significant damage to Roberts Island, to the southeast. The US Army Corps of Engineers, California Department of Transportation, and Ford Construction Company of Stockton together raised the Trapper Slough levee to a 6-foot elevation using 56,000 yards of fill dirt and armored the levee sides with 40,000 tons of rock.

The Trapper Slough levee was initially raised with material purchased from the Port of Stockton. Tests were conducted in response to concerns that this material was strongly acidic and contained elevated levels of barium, copper, lead, and zinc. There was a concern that under acidic conditions these materials could dissolve and leach into Delta waterways. DWR worked with the Central Valley Regional Water Quality Control Board and the Port of Stockton to determine the effect of these materials on water quality in the Delta. In December 2004, DWR declined to purchase additional fill material from the Port of Stockton. The levee road was reshaped so that runoff from precipitation would flow toward the inward side of the levee, and fill material was pulled back from contact with the slough. Lime was applied and incorporated to raise the pH level of the fill material.

1.8 The Pump Out of Floodwaters from Jones Tract

Once the Upper Jones Tract levee breach was filled, preparations were made to pump out water from both Upper and Lower Jones tracts into Middle River. DWR awarded the contract for this pump out work to the Ford Construction Company of Lodi on June 28.

On July 12, four 42-inch diameter pumps began to remove water from Upper Jones Tract. Each pump removed 50,000 gallons of water per minute. On July 23, four 42-inch and two 30-inch pumps were placed in Lower Jones Tract. By July 26, all 10 pumps were in full operation (Figure 1.14). The specialized pumps were installed by Moving Water Industries of Deerfield Beach, Florida. All pumps were operated around the clock.

Figure 1.14 Pump out of Upper and Lower Jones tracts (photo)

Initial pump out was under way by July 12 (about a month after the flood), and the floodwater was lowered by 3.2 feet (about 1 meter) by August 6. By September 8 (about 2 months after the flood), the water level was lowered by more than 6 feet (1.8 m) and by September 28 the level was reduced by 9.4 feet (2.8 m). In mid-November, depth of the remaining water was about 3.4 feet (about 1 m), and the pump out rate became slower as the pumps were required to lift the water up to the river level that was now above the water level on the island. Also, pumps were increasingly clogged by suspended material and had to be stopped often for maintenance. By late November, the water level in Upper Jones Tract was almost at field elevation, though Lower Jones Tract was still 3 to 5 feet (0.9 m – 1.5 m) deep at the pumps. The pump out continued until December 20. At that point, Reclamation Districts 2038 and 2039 took over the responsibility to remove the relatively small amount of remaining water.

m = meter (equals 3.28 feet)

Chapter 1 Introduction

Figures

Figure 1.1 Delta region with transportation corridors and waterways illustrated

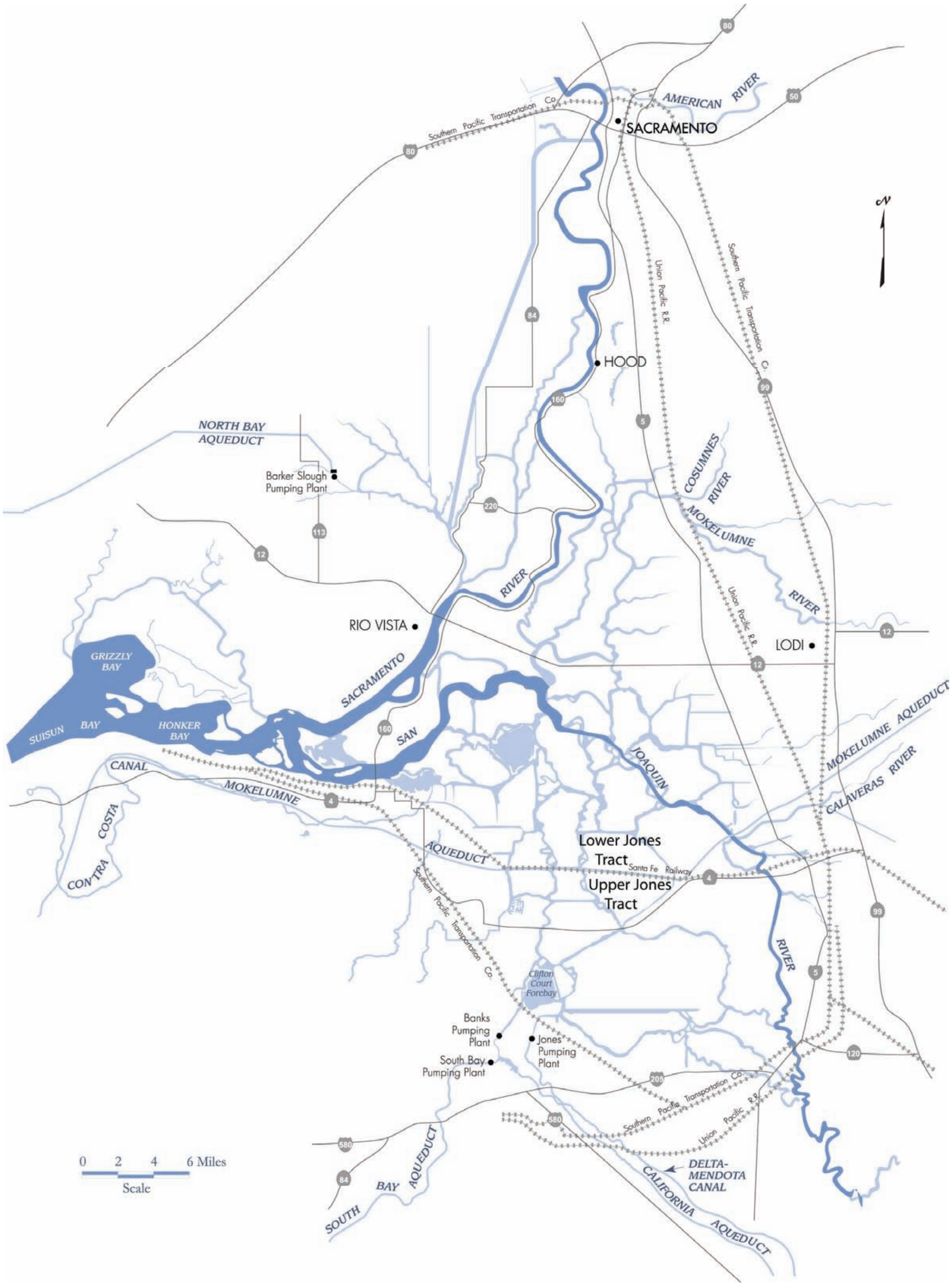


Figure 1.2 Water flowing into Upper Jones Tract from the Middle River after the levee break (photo)

Figure 1.3 Jones Tract region with pumps and levee break locations marked

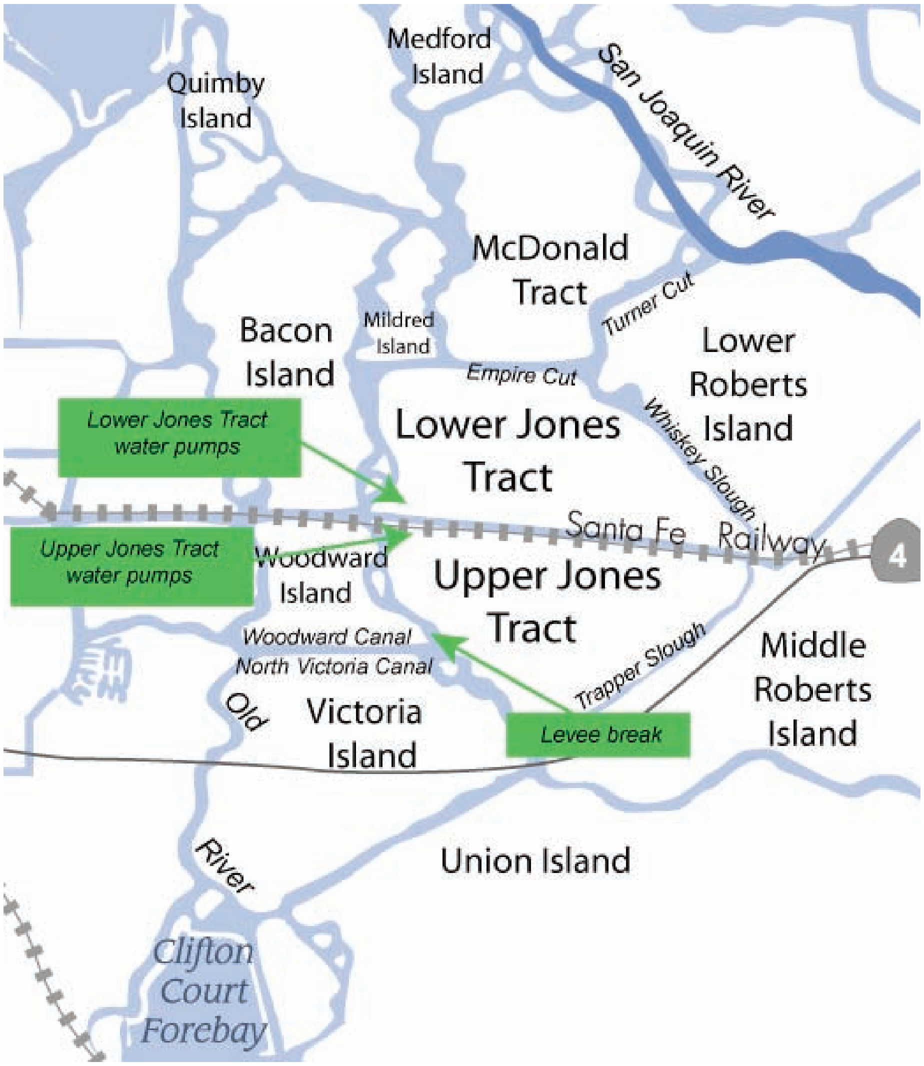


Figure 1.4 Water flowing northward under a railroad embankment from Upper Jones Tract to the Lower Jones Tract (photo)

Figure 1.5 Upper Jones Tract levee breach at noon on June 4, 2004 (photo)

* Figures 1.5 and 1.6 show the flow of the Middle River at the breach after the arrival of DWR MWQI staff.

Figure 1.6 Mud/tide line at Woodward Island Ferry 2 p.m. on June 4, 2004, flowing south down Middle River (photo)

* Figures 1.5 and 1.6 show the flow of the Middle River at the breach after the arrival of DWR MWQI staff.

Figure 1.7 CDEC stations with EC and stage recorders affected by the Jones Tract flood

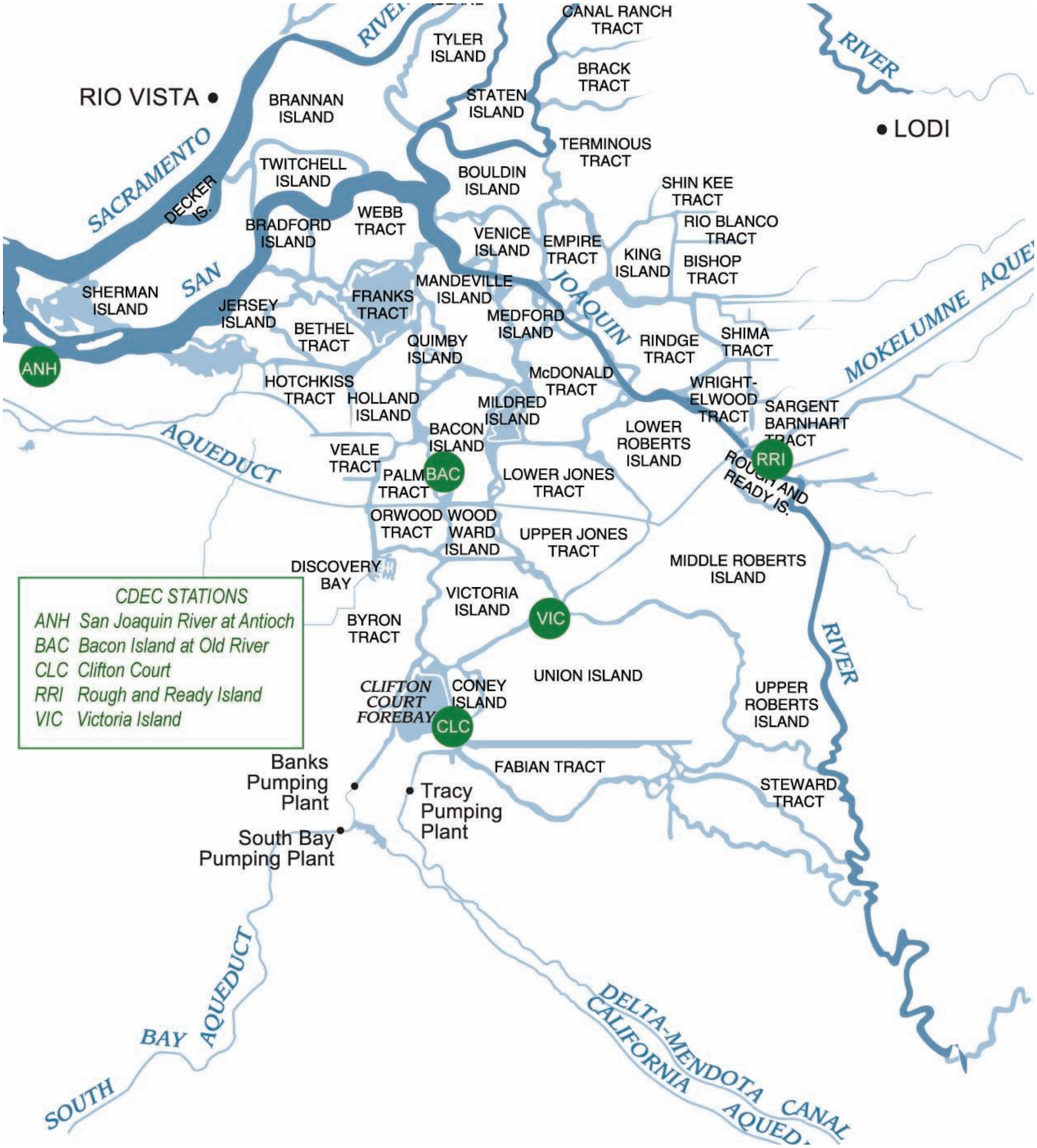


Figure 1.8 EC at VIC station (Victoria Island), June 2 through June 6, 2004

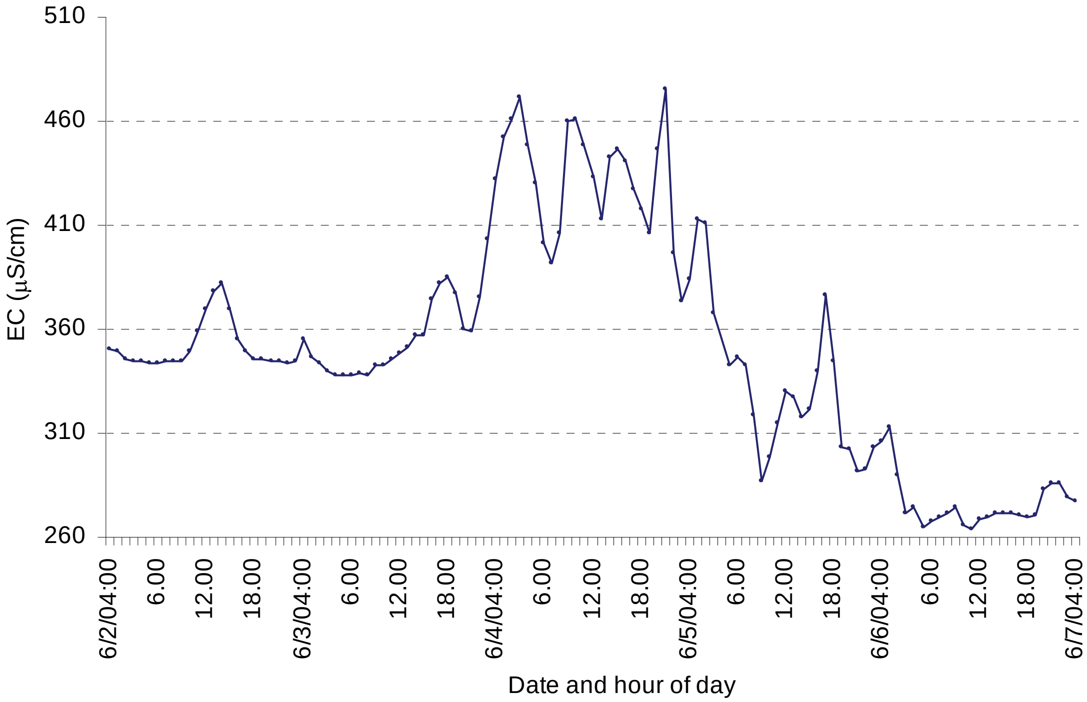


Figure 1.9 EC at CLC station (Clifton Court), June 1 through June 9, 2004

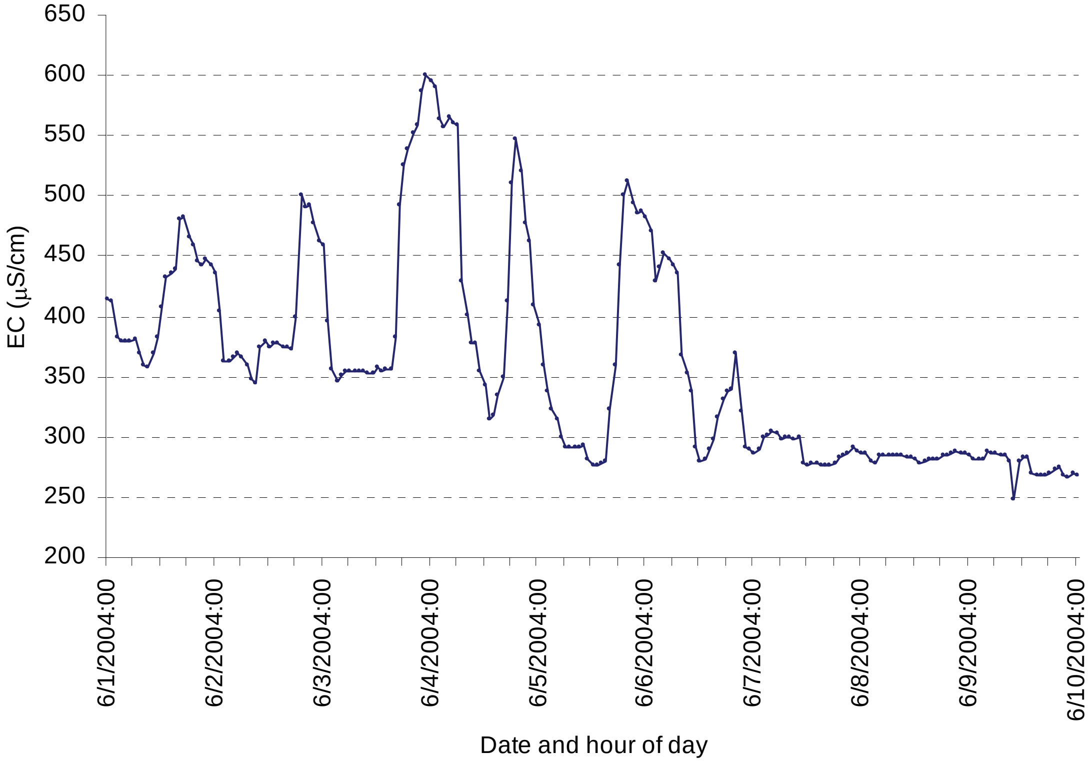


Figure 1.10 Stage at ANH station (Antioch), June 1 through June 5, 2004

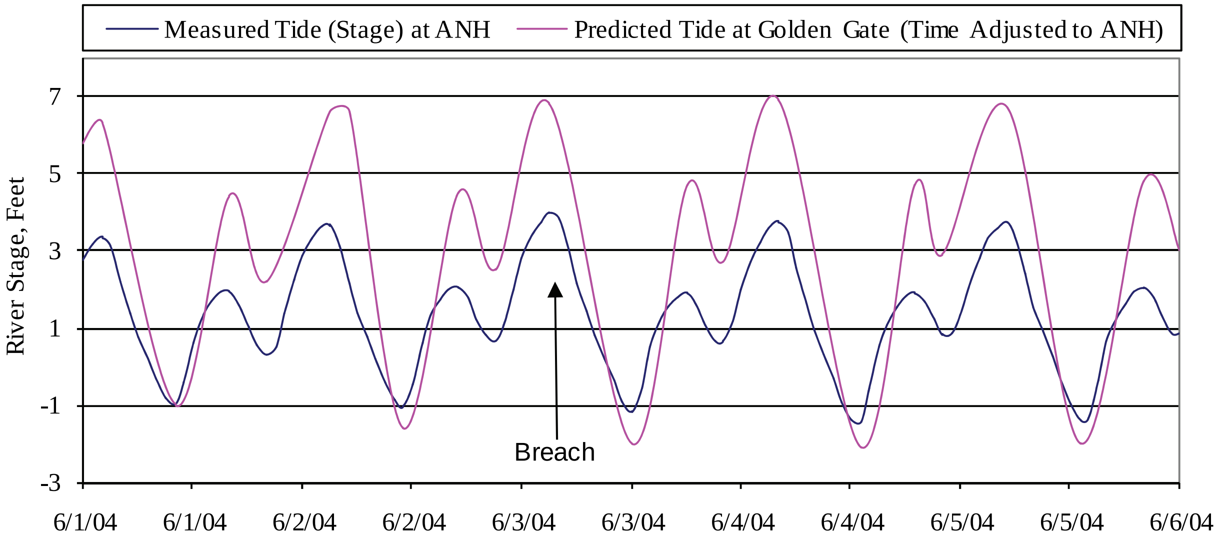


Figure 1.11 Stage at BAC station (Bacon Island), June 1 through June 5, 2004

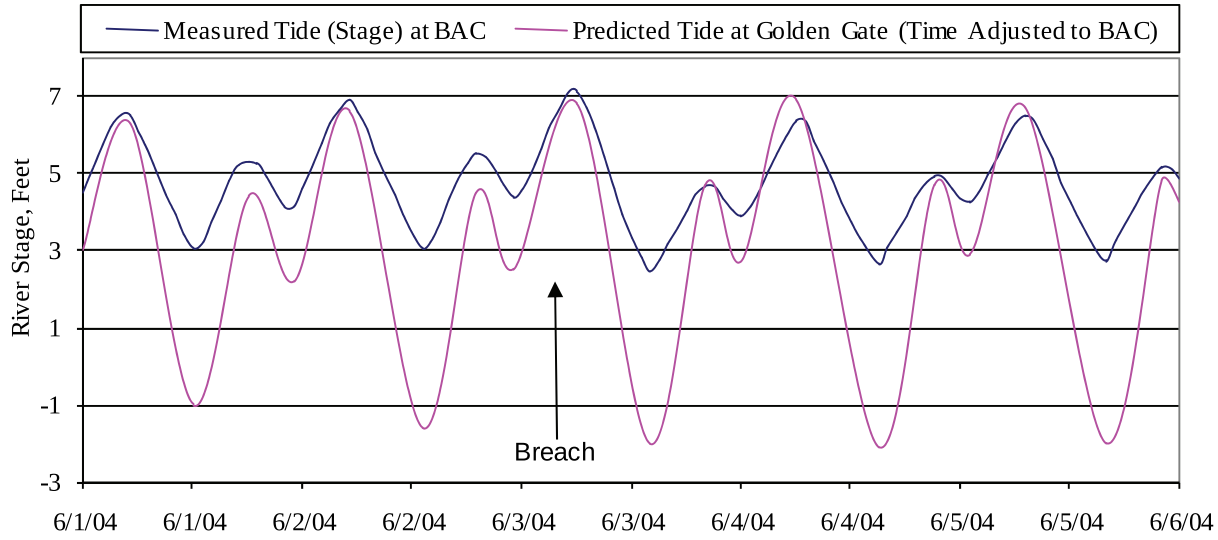
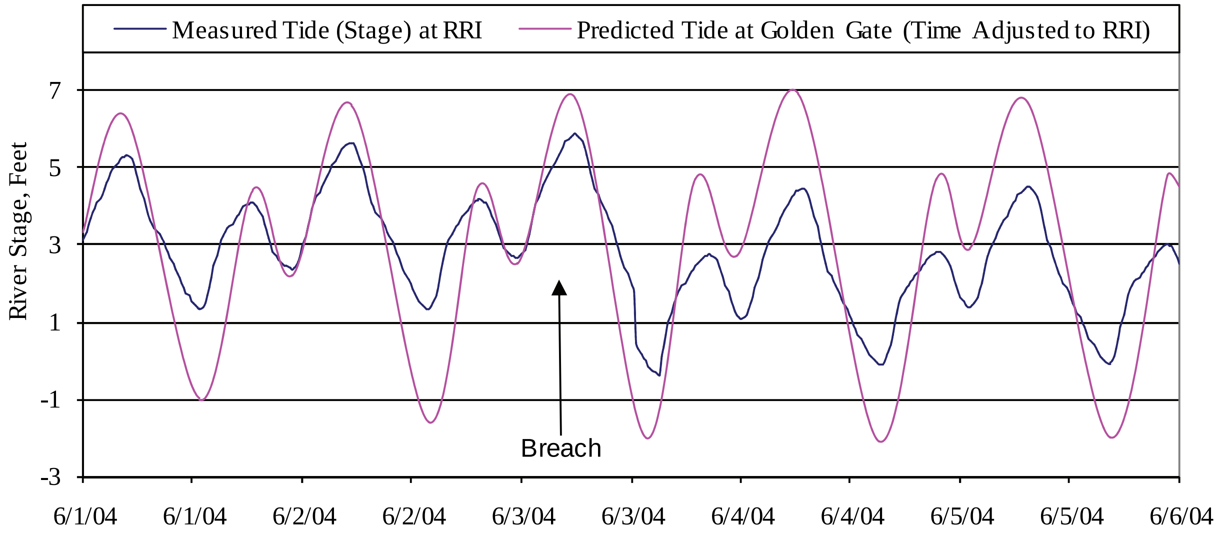


Figure 1.12 Stage at RRI station (Rough and Ready Island), June 1 through June 5, 2004



Data for Figure 1.8. through 1.12 are from CDEC stations and NOAA publications

Figure 1.13 Fingerprint of EC sources in Jones Tract

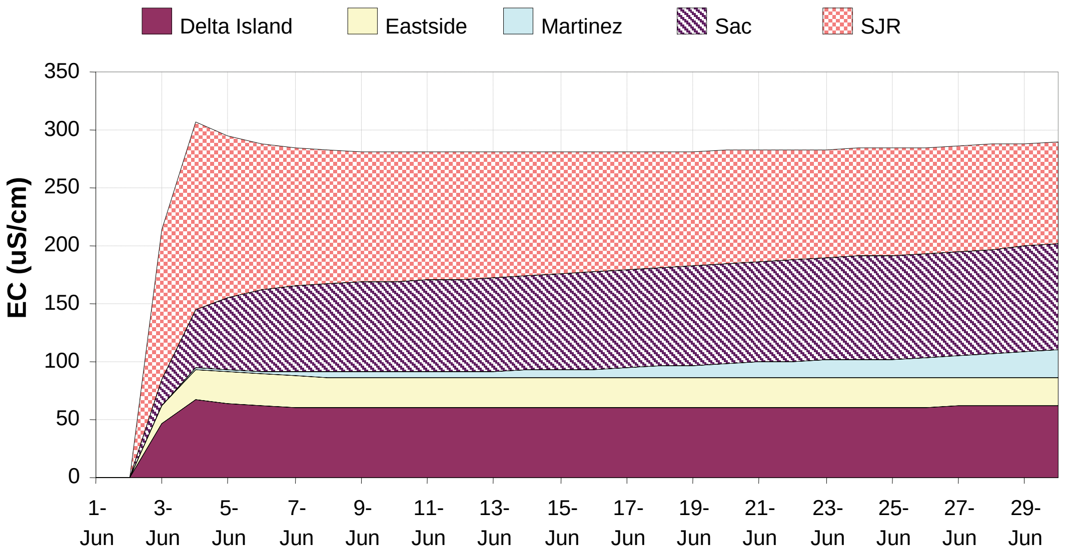


Figure 1.14 Pump out of Upper and Lower Jones tracts (photo)

Upper Jones Tract pumps are on the left and Lower Jones Tract pumps on the right of the railroad embankment

Chapter 2 Methodology

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Chapter 2 Methodology

This chapter describes the sampling procedures and field methods used by the Municipal Water Quality Investigations (MWQI) Field Support Unit. It also describes the laboratory analytical methods and quality assurance and quality control procedures used in the Jones Tract flood water quality investigations.

MWQI = Municipal Water Quality Investigations

DWR = Department of Water Resources

The MWQI Field Support Unit collected data on water quality parameters from Jones Tract using grab samples and YSI Model 85 hand-held meters for discrete sampling, and YSI Model 6600 sondes for continuous sampling. Discrete sampling occurred from June 4 to November 22, 2004. The water samples were sent to Department of Water Resources Bryte Chemical Laboratory and outside laboratories contracting with DWR for analyses. After the Jones Tract breach was filled in July 2004, the YSI sondes were placed in the water on Lower Jones Tract and Upper Jones Tract to collect continuous water quality monitoring data. The sondes were maintained by DWR staff from the Environmental Real-Time Monitoring and Support Section of the Environmental Water Quality and Estuarine Studies Branch (Division of Environmental Services) and the Watershed/California-Nevada Assessment Section in Central District (Division of Planning and Local Assistance).

CIMIS = California Irrigation Management Information System

CDEC = California Data Exchange Center

The California Irrigation Management Information System (CIMIS) in the DWR Office of Water Efficiency and Transfers set up and maintained a weather station next to the flooded area until December 2004. Data collected by this station included precipitation, evapotranspiration, solar radiation, relative humidity, air temperature, and wind speed.

All DSM2 (computer model) simulations of water movements and water quality characteristics (so called “fingerprints”) were developed by the DWR Bay Delta Office Modeling Group using data collected from Jones Tract and nearby California Data Exchange Center (CDEC) stations to assist in determining water movement in and out of the island and through the South Delta.

Figure 2.1 Aerial photo of Lower and Upper Jones tracts showing MWQI sampling stations

Table 2.1 Site name, latitude, longitude, and site description for Jones Tract sampling stations

2.1 Sampling Stations

1 meter = about 3.28 feet

Discrete water quality samples were collected from the pump-off discharge pipes and from on-island sites on Upper Jones Tract and Lower Jones Tract. Sample sites are shown in Figure 2.1; and a description of each site is given in Table 2.1. The on-island stations included 2 sites about 100 yards from the front of the pump intakes (LJI, UJI) and an additional site toward the middle of each tract (LJM, UJM). At the mid-island sites, samples were collected from both the top of the water column (1 meter below the surface; LJMT, UJMT) and the bottom of the water column (0.5 meters above the bottom; LJMB, UJMB).

The YSI sondes were placed at the Upper Jones Middle (UJM), Upper Jones Intake (UJI), Lower Jones Middle (LJM), Lower Jones Intake (LJI) sites. Two additional sondes were deployed at the Upper Jones Tract (UJD) and Lower Jones Tract (LJD) pump-out stations. Water from the discharge pipes was diverted to flow-through chambers on the sondes, enabling continuous monitoring of the outflow water.

LJD = Lower Jones Discharge

LJI = Lower Jones Intake

LJM = Lower Jones Middle

LJMB = Lower Jones Middle-bottom

LJMT = Lower Jones Intake-top

UJD = Upper Jones Discharge

UJI = Upper Jones Intake

UJM = Upper Jones Middle

UJMB = Upper Jones Middle – bottom

UJMT = Upper Jones Middle-top

In addition to monitoring sites on Jones Tract, 3 monitoring stations outside Jones Tract were sampled during the pump out to satisfy the California Regional Water Quality Control Board-Central Valley Region's discharge permit requirements, and to better understand water flows in the area. These sites were labeled "Site A" on the Middle River north of the pump stations, "Site B" on the Middle River south of the levee breach, and "Site C" in Topeka and Santa Fe Cut on the Old River west of the pumping stations.

2.2 Field Observations

The MWQI Field Unit staff also recorded field observations. Staff carried a calibrated electical conductivity (EC) meter, pH meter, temperature gauge, dissolved oxygen (DO) meter, and a turbidimeter in a mobile laboratory. Samples were collected from on-island discharge and nearby monitoring sites. These physical properties were recorded on site. Table 2.2 shows US Environmental Protection Agency (EPA) methods used in field observations.

EC = electrical conductivity

DO = dissolved oxygen

EPA = US Environmental Protection Agency

Table 2.2 Analytical methods (lab and field) and reporting limits of constituents

2.3 Sampling Procedures

MWQI field staff identified and planned the sampling sites, sampling frequency, and analyses before they began collecting the water samples. Water samples collected from Jones Tract were analyzed by the Bryte Laboratory for physical and chemical properties (Tables 2.2—2.4).

Table 2.3 Analytical methods used (contract labs) and reporting limits of constituents

Standard operating procedures for cleaning and preparing sample containers were strictly followed to ensure that the samples were not contaminated during collection. Labels were generated by the Bryte Field and Laboratory Information Management System (FLIMS) for the sample storage bottles taken to the field. Each of these labels listed site identification, tracking number, requested analysis, and sample preservation method.

Table 2.4 Analytical methods used (contract labs) for hydrocarbons, volatile and semivolatile constituents, and their reporting limits

FLIMS = Field and Laboratory Information Management System

The field unit drove a mobile laboratory van to the sampling sites and recorded the field measurements, sampling date and time on FLIMS-generated forms. FLIMS forms for each site include sampling date, site information, tracking number, laboratory instructions for sample handling including type of storage bottles, holding times, as well as requirements for on-site water filtration. FLIMS forms were used as a tracking system for the sample/data from the field to the lab to the posting of results in the Water Data Library database

The MWQI Field Support Unit also collected quality assurance/quality control samples as required by EPA-approved procedures. These samples included equipment blanks, field blanks, and site duplicates (Tables 2.5—2.7 described in sections 2.6.1—2.6.3). Sampling procedures were strictly adhered to as outlined by the MWQI Program Field Manual (DWR 1995).

(DWR 1995)
California Department of Water Resources. 1995. Municipal Water Quality Investigations Program Field Manual.

2.4 Discrete Samples: Field Methods and Sample Preservation

Water was collected, and a subsample was placed into a small container so that various physical characteristics could be measured. A small stirring bar was used to ensure sufficient sample movement across the probe. A Corning 314i meter was used to determine water temperature by observing the meter until a constant reading was observed. The temperature was reported in degrees Celsius (EPA 170.1 - field). The pH was measured also using a

Corning 314i ISFET meter. The probe was immersed until the instrument stabilized, and the pH was recorded to tenths of a pH unit (EPA 150.1 - field).

A Hach 2100P Turbidimeter was used to measure the turbidity of the sample water. Field staff calibrated it according to manufacturer instructions using 0.1, 20, 100, and 800 nephelometric turbidity units (NTU) formazine-based standards.

NTU = nephelometric turbidity unit

mg/L = milligrams per liter

The measuring cell was filled with agitated sample water and then lightly tapped to remove air bubbles. The sample was then placed into the turbidimeter in correct alignment with the measurement chamber. The cell was covered with a light shield and the turbidity was recorded in NTUs (EPA 180.1- field).

A YSI model 85 DO meter was equipped with a polarographic Clark type sensor. The probe of the DO meter was placed in a continuously stirred sample of water until the probe reached the temperature of the water. The DO concentration was recorded in milligrams per liter (mg/L) when the display reading was stable (EPA 360.1 - field). The instrument automatically corrected DO concentration for temperature.

The probe of a YSI model 85 EC meter, previously standardized with potassium chloride, was placed in a small bottle and completely immersed in sample water or directly in the floodwaters, when possible, and EC was measured with temperature corrections in microsiemens per centimeter (µS/cm) (EPA 120.1 - field).

µS/cm = microsiemens per centimeter

All containers with water samples were stored on ice and transported to the Bryte Lab or the contract labs by 5 p.m. on the day of sampling. On the occasions when the sampling runs were not completed until after 5 p.m., the samples were kept refrigerated until they could be delivered to the lab the next morning. Each set of samples brought into the lab was accompanied by FLIMS-generated chain-of-custody forms. The information was then recorded manually on the FLIMS electronic database. When samples were completely logged in, laboratory personnel were notified via the FLIMS system that samples needed to be analyzed. Samples were stored appropriately in the laboratories, until analyses were complete.

Samples collected in the field were placed in bottles containing appropriate fixatives when necessary. Different analytes required different storage bottles, and some required specific fixatives, such as phosphoric acid. Below is a summary of the field preservation methods used for each analyte.

To measure settleable solids, total suspended solids, turbidity, (EPA methods 160.2, 160.5, 180.1,), and ultraviolet absorbance (Standard Method 5910B), unfiltered water samples were stored in polyethylene bottles. For alkalinity, total dissolved solids (Standard Methods 2320B, 2540C) and dissolved nitrite and nitrate (Standard Method 4500-NO3-F) measurement, filtered water was stored in polyethylene bottles.

For dissolved nutrient analysis (EPA methods 200.7, 200.8), filtered water was stored in acid-washed polyethylene bottles containing nitric acid at pH < 2. For ammonia analysis (EPA 350.1), filtered water was stored in dark polyethylene bottles. For total Kjeldahl nitrogen analysis, unfiltered water was frozen in dark polyethylene bottles. Unfiltered water for total phosphorus analysis (EPA 365.4) was stored in dark polyethylene bottles. For orthophosphate analysis (EPA 365.1), filtered water was stored in polyethylene bottles.

For total organic carbon measurement (EPA 415.1 [Total] wet oxidation, EPA 415.1 [Total] combustion), unfiltered water was stored in acidified clear glass vials with phosphoric acid at pH < 2. For dissolved organic carbon analysis (EPA 415.1 [Dissolved] wet oxidation, EPA 415.1 [Dissolved] combustion), filtered water was stored in clear glass vials. The containers were not filled to the top to allow for acidification.

For organic pesticides analysis (EPA 608) and phosphorus and nitrogen pesticides (EPA 614), solvent-washed amber glass containers were used.

Amber glass vials were used to store unfiltered water for volatile organics analysis (EPA 8260), and amber 1-L glass containers were used for diesel range organics (EPA 8015). Solvent-washed amber glass containers were used for unfiltered water for semi-volatile organics analysis (EPA 8270). Solvent-washed glass containers were used to store unfiltered water for oil and grease analysis (EPA 413.1).

For bacterial analysis (Standard Method 9221B), unfiltered water was stored in sterilized polypropylene containers.

Chlorophyll and pheophytin samples were collected by filtering water samples, and the filter was transported in manila envelopes and placed in containers that blocked light.

2.4.1 Discrete Samples: Laboratory Analysis at Bryte Laboratory

All EPA methods (EPA) and Standard Methods (1998) used for analyses are listed in Tables 2.2, 2.3, and 2.4 (see section 2.3 Sampling Procedures).

Total dissolved solids dried at 180 ºC (Standard Methods 2540 C) was performed by vacuum filtering the sample through a 0.45-micron membrane filter and then transferring 100 mL of the filtrate to a tared evaporating dish and evaporating to dryness on a steam bath. The evaporating dish was then dried at 180 ºC in an oven overnight, cooled in a dessicator, weighed and the resultant residue reported in milligrams per liter.

mL = milliliter

Total suspended solids (EPA 160.2) analysis was performed by vacuum filtering 250 mL of sample through a 1.5-micron particle retention filter which was then dried at 105 ºC overnight, cooled in a dessicator, and weighed. The resultant residue was reported in milligrams per liter..

Settleable solids (EPA 160.5) test was performed by adding 1 liter of sample to an Imhoff Cone. After 45 minutes, the sample was lightly stirred and then measured at 60 minutes. The measured volume of SS was reported as milliliters per litter.

Ultraviolet absorption (Standard Method 5910 B) is used to estimate the amount of dissolved organic matter in the sample based on the principle that they absorb ultraviolet light in proportion to their concentration in the water. The sample was filtered through a 0.45-micron membrane filter to remove particulate matter, and the ultraviolet light absorption of the filtered water was measured at 254 nanometer (nm) within a spectrophotometer and reported as absorption per centimeter.

nm = nanometer

Alkalinity (Standard Method 2320 B) was used to determine the acid-neutralizing capacity of the water sample. Analysis was performed by titrating 20 mL of sample with 0.02N H_2SO_4 to an endpoint of pH 4.5. Alkalinity is calculated by the relationship that 1-mL 0.02N H_2SO_4 = 1-mg $CaCO_3$ and was reported as mg $CaCO_3$/L.

Inductively Coupled Argon Plasma-Atomic Emission Spectrometry (ICP-AES, EPA 200.7) was used to analyze calcium, sodium, magnesium, potassium, and boron concentrations. The sample was filtered through a 0.45-micron membrane filter, acidified with HNO_3 to pH < 2 and then aerosolized in a nebulizer before being introduced into 8000 ºK argon plasma where the elements were energized to an ionized state. Atoms of the elements drop back to the ground energy state by emitting a photon at a wavelength characteristic of each element, and the light was measured by a photosensitive photomultiplier tube. The intensity of the light emission was directly proportional to the element concentration in the sample and was reported as milligrams per liter.

Hardness by calculation (Standard Method 2340 B) is defined as the sum of the calcium and magnesium concentrations, both expressed as calcium carbonate in milligrams per liter. Hardness, mg equivalent $CaCO_3$/L = 2.497(Ca, mg/L) + 4.118(mg, mg/L).

Inductively Coupled Argon Plasma-Mass Spectrometry (ICPMS, EPA 200.8) was used to analyze dissolved metals: aluminum, arsenic, barium, chromium, cobalt, copper, iron, lead, lithium, manganese, molybdenum, nickel, selenium, strontium, vanadium, zinc, and mercury.

The sample was filtered through a 0.45-micron membrane filter, acidified with HNO_3 to pH < 2 and then aerosolized in a nebulizer before being introduced into 8000 ºK argon plasma where the analytes were ionized. Ions pass into a quadruple mass filter, which selected specific elements based on atomic mass, and were detected by an electron multiplier. The intensity of the detected signal was directly proportional to the element concentration in the sample, and is reported as milligrams per liter.

Inorganic anions by ion chromatography (IC, EPA 300.0) was used to analyze nitrate, bromide, chloride, fluoride, and sulfate. The sample was filtered through a 0.45-micron membrane filter and then introduced through an injection valve into the chromatograph, where it passed through a guard column to remove particulates or organic constituents that can foul the analytical column. The anions were then separated by the analytical column into individual peaks that were identified by retention time and then through a suppressor that removed cation interferences and finally detected by a conductivity detector. The area under the peaks was directly proportional to the concentration in the sample and reported as milligrams per liter.

Dissolved nutrients – nitrate+ nitrite (Standard Method 4500-NO_3-F), Ammonia (EPA 350.1) and orthophosphate (EPA 365.1) were analyzed by flow injection analysis (FIA). The sample was filtered through a 0.45-micron membrane filter and then injected into the carrier stream of the FIA that had the appropriate reagents continuously pumped through the system. The two combined in a mixing cell on the manifold to form a color reaction. The resultant dye was passed through a flow cell and measured by a colorimetric detector at the appropriate light wavelength. The absorbance was directly

FIA =flow injection analysis

proportional to the concentration in the sample and reported as milligram per liter of N or P.

Total nutrients: total phosphorous (EPA 365.4) and total kjeldahl nitrogen (EPA 351.2) were analyzed with a discrete analyzer. The unfiltered sample was digested with acid at high temperatures to convert all the forms of nitrogen and phosphorous to ammonia and orthophosphate. The resultant digest was put on the discrete analyzer where it was injected into a microcuvette and mixed with microliter volumes of reagents to form a color reaction. The resultant dye was measured by a photometric detector at the appropriate light wavelength. The absorbance was directly proportional to the concentration in the sample and was reported as milligrams per liter of N or P.

Oil and grease by gravimetric analysis (EPA 1664) was performed by serially extracting 1 liter of sample with three 60-mL aliquots of hexane which were passed through sodium sulfate to remove any water residue and then evaporated to dryness on a steam bath. The resultant residue was weighed and reported as milligrams per liter.

Organochlorine pesticides (EPA 608) and nitrogen phosphorous pesticides (EPA 614) were performed by liquid/liquid extraction capillary column large volume injection gas chromatography mass spectrometry (LVI/GC/MS). One liter of sample was added to a 2-L separatory funnel and serially extracted with three 60-ml aliquots of methylene chloride. The extract was dried with sodium sulfate and concentrated with a Kuderna-Danish flask to a final volume of 1 ml. We injected 100 uL of the extract into the LVI/GC/MS where the solvent was vented away at cryogenic temperatures. When the injection was completed, the vent was closed, and the injector was rapidly heated to vaporize the analytes into the gas phase that were then swept by the carrier gas into the capillary column where they were chromatographically separated by their column affinity and molecular weight. As the analytes exited the capillary column as separated peaks, they entered the ion source of the mass spectrometer where they were bombarded with electrons at 70 electronvolt (eV) to create positive ion fragments. These ion fragments were scanned by a quadruple mass filter and then detected by an electron multiplier. The result was a mass spectrum that is a fingerprint of the analyte of interest and is library-searchable for confirmation. An internal standard ion that is free of interferences is chosen to obtain the peak area used to calculate the amount in the sample; and results were reported as micrograms per liter.

LVI/GC/MS = large volume injection gas chromatography mass spectrometry

Semivolatile organic compounds (EPA 8270) analyses were performed by gas chromatography mass spectrometry (GC/MS). One liter of sample was added to a 2-L separatory funnel and serially extracted with three 60-mL aliquots of methylene chloride. The extract was dried with sodium sulfate and concentrated with a Kuderna-Danish flask to a final volume of 1 mL. Extract of 1 uL was injected into the GC/MS. As the analytes exited the capillary column as separated peaks, they entered the ion source of the mass spectrometer, and the mass spectrometer analysis proceeded identically to that described in the previous paragraph.

GC/MS = gas chromatography mass spectrometry

Volatile organic compounds (EPA 8260) was performed by purge and trap gas chromatography mass spectrometry (PT/GC/MS). Five milliliters of sample was put into a purge chamber where it was sparged with helium to

PT/GC/MS = purge and trap gas chromatography mass spectrometry extract the volatile compounds from the liquid water phase and transferred onto an absorbent trap. When the extraction was complete, the flow on the trap was reversed, and the trap was rapidly heated to transfer the analytes to the capillary column where they were chromatographically separated by their column affinity and molecular weight. As the analytes exited the capillary column as separated peaks, they entered the mass spectrometer where they were analyzed as described above.

Total trihalomethane formation potential (EPA 510.1) was performed by filtering the sample through a 0.45-micron membrane filter and then chlorinating the sample by adding 120-mg/L sodium hypochlorite/boric acid ($NaOCl/H_3BO_3$) buffer solution. The sample was put into 3 headspace-free vials and incubated at 25 ºC for 7 days. Following incubation, pH and residual chlorine were measured in one of the vials to confirm that the pH had been buffered to 8.3 and the residual chlorine was > 1 mg/L. The other 2 vials were quenched with sodium thiosulfate ($Na_2S_2O_3$) and then analyzed by PT/GC/MS as described above.

GRO = gasoline range organics

DRO = diesel range organics

FID = flame ionization detector

Nonhalogenated organics were quantified using GC/FID (EPA 8015B) to quantify petroleum hydrocarbons, including gasoline range organics (GROs), which are done by PT/GC/FID; and diesel range organics (DROs), which are done by liquid/liquid extraction GC/FID. GROs are volatile and correspond to molecules containing 6 to 10 carbon atoms having boiling points ranging between 60 ºC and 170 ºC. DROs are semivolatile and correspond to molecules containing 10 to 28 carbon atoms having boiling points ranging between 170 ºC and 430 ºC. The extraction and separation are the same as the other PT/GC and liquid/liquid extraction GC techniques. The detector in this analysis is a flame ionization detector (FID). The FID consists of a small hydrogen/air diffusion flame burning at the end of a jet. When the analytes enter the flame from the column, electrically charged intermediates are formed that are detected by an electrometer. The signal is directly proportional to the concentration in the sample and is reported in micrograms per liter.

Spectrometric determination of Chlorophyll A and Pheophytin A (Standard Method 10200 H) was performed by filtering 1 L of water through a 0.7-micron glass fiber filter and then grinding the filter with an aqueous acetone/magnesium carbonate 90:10 solution to extract the pigments of interest. The extract was filtered and placed in a cuvette in a spectrophotometer; absorbance was measured at 664 and 750 nm for chlorophyll *a*. The chlorophyll *a* is then converted to pheophytin *a* by the addition of 0.1-mL 0.1N HCl, and absorbance was measured at 665 and 750 nm. The concentrations were calculated and reported as milligram per cubic meter.

2.4.2 Discrete Samples: Organic Carbon

NDIR = nondispersive infrared detector

Organic carbon was measured by oxidizing the samples to carbon dioxide by catalytic combustion or by wet oxidation. In both methods, the carbon dioxide is detected by a nondispersive infrared detector (NDIR). Various carbon-containing compounds are present in the water, and the analysis steps determine the concentration of several forms of these compounds. These include inorganic carbon compounds such as carbon dioxide, carbonates, and bicarbonates; and organic carbon compounds such as living plant matter and detritus, human-made compounds, and dissolved organic matter. The carbon compounds that could be measured by these methods include:

a. soluble nonvolatile organic carbon such as sugars and humic and fulvic acids
b. soluble volatile organic carbon such as natural alcohols and mercaptans
c. insoluble, partially volatile carbon such as oils
d. insoluble particulate organic material such as cellulose fibers, algal cells, or organic detritus
e. organic material adsorbed or entrapped on insoluble inorganic suspended materials such as oily complex carbon molecules adsorbed onto silt particles

Two analysis methods are commonly used. In the wet oxidation method, dissolved carbonates and bicarbonates—inorganic carbon—are first removed by acidifying and purging with nitrogen before analyzing for carbon. This step may also remove most volatile carbon compounds in the sample. In the combustion method, an acidified subsample is used to measure the total inorganic carbon (TIC) concentration and another subsample is used to measure the total carbon (TC) concentration. The organic carbon concentration in the combustion method is calculated by subtracting the TIC concentration from the TC concentration.

TIC = total inorganic carbon

TC = total carbon

Although many organic compounds are water-soluble, many are also naturally occurring organic compounds that do not dissolve in water. Cellulose is an abundant carbon compound present in all plant cells in their early life, and the majority of them retain cellulose walls. These plants include rooted terrestrial and aquatic plants and algae. Lignin is another complex carbon compound, generally found in woody terrestrial plants. Both cellulose and lignin are carbohydrates made of long-chain 6 carbon units, and they are not soluble in water. However, they are often disassembled into more soluble forms, at least partially, by microbial action.

TOC, including dissolved organic carbon (DOC) and suspended particulate organic carbon, and DOC were measured by both methods. For TOC measurements, water samples were analyzed without filtration. For DOC measurements, water samples were first filtered through a 0.45-µm filter. Since particulate carbon is retained by the filter, a TOC measurement is expected to be greater than or equal to the DOC measurement.

TOC = total organic carbon

DOC = dissolved organic carbon

In Jones Tract samples, the average TOC measured by the combustion method was consistently higher than TOC measured by the wet oxidation method. This is typical of Delta waters in general.

TOC/DOC by oxidation (EPA method 415.1) were analyzed on a persulfate wet oxidation TOC analyzer. The unfiltered (TOC) or filtered (DOC) samples were acidified with phosphoric acid to $pH < 2$ and then purged with nitrogen to remove any inorganic carbon. The sample was then injected into the reaction chamber where it was mixed with sodium persulfate at 85 ºC to oxidize the organic carbon to CO_2, which was measured by a NDIR. The signal is directly proportional to the concentration in the sample and is reported as milligram as carbon (C).

TOC/DOC by combustion (EPA method 415.1,) were analyzed on a catalytic combustion TOC analyzer. The unfiltered (TOC) or filtered (DOC) sample was acidified with phosphoric acid to $pH < 2$ and then injected into a sparge chamber to measure the TIC. After completion, another aliquot of the sample was injected into the combustion chamber where it was oxidized to CO_2 by the platinum catalyst held at 680 ºC and then measured as TC by a NDIR. The TOC is calculated as TC – TIC as milligram per liter of carbon.

2.4.3 Discrete Samples: Coliform Bacteria Measurement (Sequoia Lab)

In response to worker-safety concerns, total coliform, fecal coliform, and *Escherichia coli* (*E. coli*) were monitored from June 16 to June 30, 2004, using both multiple tube fermentation technique and membrane filter technique. The membrane filter technique is more precise than the multiple tube fermentation technique, and the numerical results obtained from a single water sample analyzed by both methods are never identical.

MPN = most probable number

LTB = lauryl tryptose broth

Bacteria quantified by the fermentation technique were facultative anaerobic, gram-negative, non-spore-forming, rod-shaped bacteria that fermented lactose with gas and acid within 48 hours at 35 ^{0}C. The concentrations were expressed in most probable number (MPN). (Calculation of MPN uses probability formulas and is an estimate of the mean density of coliform bacteria in the sample). In this method, dehydrated lauryl tryptose broth (LTB) was added to distilled water and dissolved by heating so that later inoculation of 10 mL, or 1.0 mL, or 0.1 mL of the floodwater did not reduce the density of the medium to less than the standard concentration. The pH was adjusted to 6.8 +/- 0.2. Fermentation tubes were half filled with the medium, and the tubes were then inoculated with dilutions of the floodwater. The inoculated tubes were incubated at 35 °C for 24 hours, and gas-forming tubes were identified. Non-gas- and non-acid-forming tubes were incubated for another 24 hours, and gas and acid forming tubes were identified. All positive tubes were isolated, and confirmation was done by inoculating bright green lactose bile broth tubes with the positive tubes of LTB. The bright green lactose bile broth tubes were then incubated for 24 to 48 hours at 35 °C, and acid- and gas-forming tubes were confirmed to be positive for total coliform bacteria. The positive replications and dilutions of multiple tubes used in this fermentation technique were entered into a probability formula, and the total coliform bacteria were reported as MPN (Standard Method 9221B).

For positive fecal coliform tests, the samples were transferred from the positive LTB tubes into tubes containing 10 mL of EC media. These tubes were than incubated in a 44.5 ^{0}C water bath for 24 hours. Gas production in tubes within 24 hours was a positive test for fecal coliform. MPN values were calculated from the number of positive tubes (Standard Method 9221 E).

MUG = methylumbelliferyl-β–D-glucoronide

E.coli bacteria are able to cleave 4-methylumbelliferyl-β–D-glucoronide (MUG) with the release of fluorogen when grown on EC-MUG medium at 44.5 ^{0}C within 24 hours or less. All tubes with growth, gas, or acidity within 48 hours using Standard Method 9221 B were used to confirm for *E.coli*. The tubes were shaken gently, and a sterile applicator was used to transfer growth from each tube to EC-MUG broth. The inoculated EC-MUG medium was incubated at 44.5 ^{0}C for 24 hours. Presence of bright blue fluorescence under an ultraviolet lamp is considered a positive test for *E.coli*. MPN was calculated from the number of positive tests for *E.coli* (Standard Method 9221F).

The membrane filter technique identified all aerobic and facultative anaerobic, gram-negative, non-spore forming, rod-shaped bacteria that formed red colonies with metallic sheen within 24 hours at 35 ^{0}C on the Endo-type medium containing lactose. Coliform bacteria were identified by aldehydes produced from fermentation of lactose. In this method, varying amounts of sample water were filtered through a sterile filter under vacuum. The filter with the bacteria was then transferred to an agar-based M-Endo Les-type medium incubated for 24 hours at 35 ^{0}C. The colony count on the filter was determined under the microscope. Coliform bacteria colonies were verified by transferring to LTB incubating for 48 hours and then transferring to the appropriate media. Colony forming units in 100 mL (CFU/100 mL) of water sample was calculated by taking into account the dilution factor used before sample filtration (Standard Method 9222B).

CFU/100mL = colony forming unit in 100 millilters

In Standard Method 9222D, water sample size was selected to give 20 to 80 fecal coliform bacteria colonies per membrane. This sample is filtered through a membrane filter, and the membrane with the bacteria is transferred to a plate. The dishes were incubated for 24 hours at 44.5 ^{0}C. Fecal coliform bacteria produced colonies of various shades of blue. The numbers of colonies counted under a dissecting microscope were used to determine colony forming units in 100 mL of sample.

To measure *E.coli* by membrane-filter method, sample size was chosen, and membrane filter technique was followed as described in Standard Method 9222B. The metallic green sheen colonies were counted and recorded. The colonies were then transferred to LTB and incubated for 48 hours and then transferred to the appropriate medium. The filters were then incubated for 24 hours at 35.5 ^{0}C, and the typical and atypical colonies were transferred to LTB and incubated for 48 hours. The positive tubes were transferred to EC-MUG media and incubated for 24 hours in a 44.5 ^{0}C water bath. The tubes with blue fluorescence were counted under an ultraviolet light source. From the number of these colonies, colony forming units in 100 mL were calculated (Standard Method 9222G).

2.5 Continuous Sampling: YSI Model 6600 Hydrolab Sondes

Six YSI 6600 water quality sondes (YSI Incorporated) were used to monitor water quality at 15-minute intervals (96 readings per day). Sondes are multiparameter water quality recording instruments designed for long-term unattended recording. Each sonde had 384 Kbytes of logging memory, and the readings were transferred approximately monthly to a personal computer throughout the monitoring period. These instruments recorded DO concentration, DO percent saturation, EC, temperature, pH, salinity, turbidity, and chlorophyll concentration. The sondes were deployed at the following sites: UJD, UJI, UJM, LJD, LJI, and LJM (Figure 2.1, Table 2.1). These sites include the 4 on-island sites where weekly grab samples were collected. These 4 sondes were deployed 1-meter below the surface by hanging them from moored buoys on stainless steel cables. There were no sondes deployed at or near the bottom. However, as pumping lowered the water depth, the sondes recorded data closer to the bottom.

2.6 Quality Assurance and Quality Control Procedures

Grab samples collected at the various sites on Upper and Lower Jones tracts were stored in appropriate bottles with detailed labels and brought into the laboratory for storage and subsequent analysis. All samples were analyzed within prescribed holding times by DWR's Bryte Laboratory or commercial contract laboratories. All laboratories participating in this investigation are certified by the California Department of Health Services' Environmental Laboratory Accreditation Program (ELAP).

ELAP = Environmental Laboratory Accreditation Program (CA Department of Health Services)

Standard operating procedures were used in the laboratories to guide quality control. These procedures followed Bryte Chemical Lab's Quality Assurance Manual (DWR 2002). During the analytical process, standards were run daily or when the samples were analyzed. The analytical method was validated for each constituent by studying the Method Detection Limit (MDL), Instrument Detection Limit (IDL), and Established Reporting Limit (RL).

(DWR 2002)
California Department of Water Resources. 2002. Bryte Chemical Laboratory Quality Assurance Manual. Quality Assurance Technical Document 8. Sacramento: DWR, The Resources Agency.

Samples were analyzed in batches for each analytical method, and each batch was analyzed accompanied by quality control samples. QC samples included calibration standards, method blanks (MB), laboratory control samples (LCS), matrix spikes (MS), surrogate and internal standards, duplicates and check standards.

MDL = Method Detection Limit

IDL = Instrument Detection Limit

RL = Reporting Limit

QC = quality control

MB- method blanks

LCS = laboratory control samples

MS = matrix spikes

RPDs = relative percent differences

Laboratory precision was assessed by calculating the relative percent difference (RPD) between field duplicates, spike duplicates, sample duplicates, and LCS duplicates. These duplicates were run with each batch of samples; the equation used to calculate RPD is:

$$\text{RPD} = (D_1 - D_2) / [(D_1 + D_2)/2] \times 100$$

where D_1 is the larger sample numerical value and D_2 is the smaller sample value (DWR 2002).

Accuracy was determined by calculating percentage of matrix spike recoveries, LCS recoveries, surrogate recoveries and PE sample recoveries (DWR 2002). The equation to determine recovery accuracy is:

$$\% \text{ Recovery} = \underline{(\text{spiked sample} - \text{sample})} \times 100/(\text{spike concentration})$$

where "spiked" refers to a sample to which a known additional concentration has been added.

2.6.1 Field Duplicates

On every field run, duplicate samples were collected at a randomly selected station. These samples were used to monitor the precision of the field and laboratory procedures. RPDs were calculated and compared to establish control limits (Table 2.5). For this project, 2,545 field duplicates were analyzed and 40 (or 1.6%) exceeded the control limits. This small percentage indicated that the field and laboratory procedures were of acceptable precision.

Table 2.5 Field duplicates exceeding control limits

2.6.2 Field Blanks

Purified (deionized, or DI) water prepared at Bryte Laboratory was taken on all field runs. Samples of dionized water were passed through the field sampling procedures as though they were field samples, e.g., filtered or left unfiltered and returned to the lab in appropriate bottles. Unfiltered purified water sample provided an indication of contamination that might occur in the containers and the preservatives. Filtered water sample provided an indication of contamination that might occur during the filtration process in the mobile lab. In this study 853 field blanks were collected of which 45 (5.3%) exceeded the control limits (Table 2.6).

Table 2.6 Field blanks exceeding control limits

2.6.3 Internal Quality Controls

For every type of analysis, samples were grouped together in batches of 20. With each batch, one or more QC measures such as method blanks, matrix spikes, or sample duplicates were performed. The total number of QC analyses performed per analyte is shown in Table 2.7.

Table 2.7 Total laboratory QC batches grouped by analyte

The following sections (2.6.4—2.6.8) present the internal QC processes for the project.

2.6.4 Method Blanks

Method blanks quantify the contamination that might occur through sample preparation and analysis in the laboratory. For this project, 2,898 method blanks were analyzed, and three (0.10%) were outside the control limits. Table 2.8 lists the method blanks that exceeded the control limits, and Table 2.9 lists the frequency of batches outside the control limits.

Table 2.8 Method blank exceedences

2.6.5 Laboratory Control Samples

LCS (laboratory control samples) provide a way of checking the accuracy of an analytical method. LCS were made by adding a known concentration of an analyte to a pure water sample. The LCS were then analyzed and the results –often called recoveries– were compared to the laboratory control limits. During this study, 2,451 LCS recoveries were performed, and none exceeded the control limits. Therefore, the laboratory analyses for the project were deemed acceptable.

Table 2.9 Number of batches with method blank exceedences

2.6.6 Matrix Spike Duplicates

The precision of an analytical method in a sample matrix was calculated with matrix spike duplicates. The difference between duplicates was reported as an RPD, using the equation given above. RPDs were compared with laboratory QC limits as a conservative measure of precision. In this study, 1,515 matrix spike duplicates were performed. On 2 occasions (0.13%), Kjeldahl nitrogen duplicates exceeded the laboratory control limits (Table 2.10).

Table 2.10 Matrix spike duplicate exceedences

2.6.7 Matrix Spike Recoveries

Matrix interferences are often seen in environmental sample analyses. Matrix spike recoveries indicate the accuracy of recovering a known concentration of analyte in the matrix of interest (e.g., water, soil). These QC samples are prepared by adding (or “spiking”) a known concentration of an analyte to an environmental sample (the matrix) with known background analyte concentration. The concentration of the spike recovered should fall close to the calculated concentration, within acceptance limits. During this study, 3,086 matrix spike recoveries were performed. Nineteen (0.62%) of spike recoveries exceeded the control limits. The matrix spike recoveries that were outside the control limits are listed in Tables 2.11 and 2.12.

Table 2.11 Matrix spike recovery exceedences

2.6.8 Sample Duplicates

Field samples were divided into 2 aliquots. Each aliquot was analyzed to determine the repeatability of the analytical method. An RPD was calculated, and the results were compared with laboratory control limits. During the study, 132 sample duplicates were analyzed, and none exceeded the control limits.

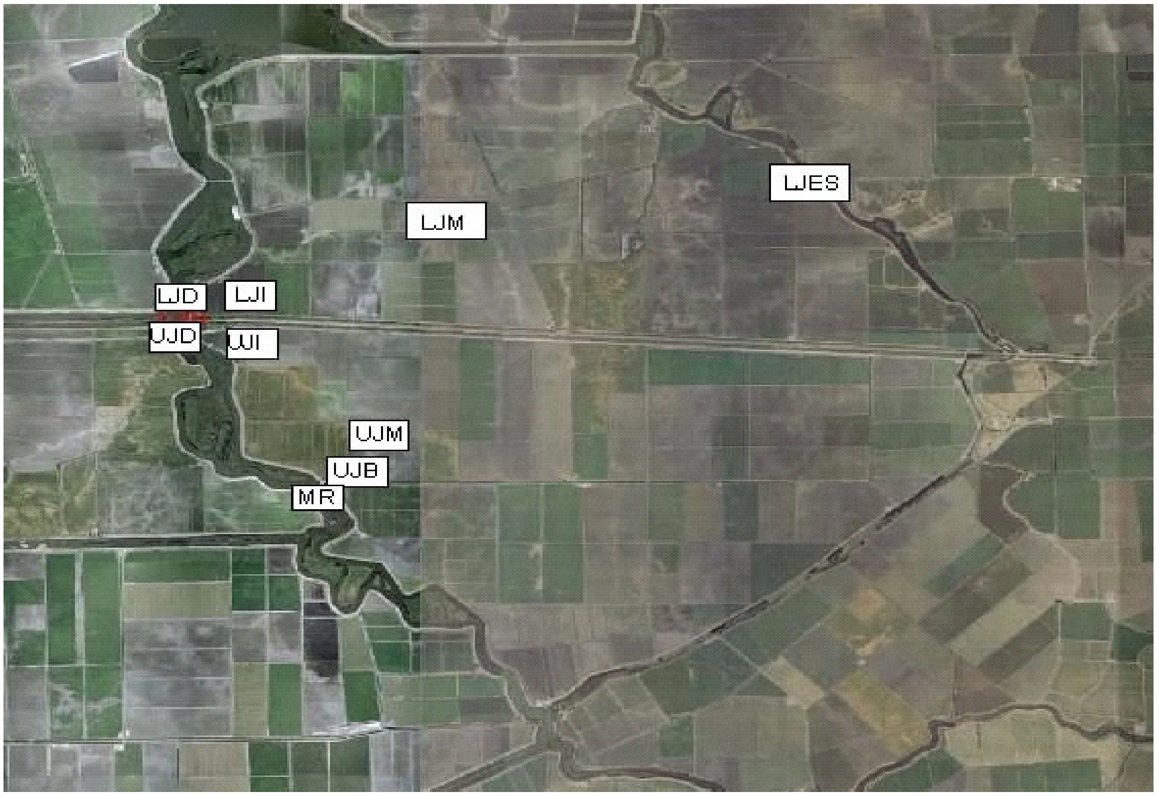
Table 2.12 Frequency of matrix spike recovery exceedences

Chapter 2 Methodology

Figure

Tables

Figure 2.1 Aerial photo of Lower and Upper Jones tracts showing MWQI sampling stations



LJD = Lower Jones Discharge
LJI = Lower Jones Intake
LJM = Lower Jones Middle
LJES = Lower Jones east shore
MR = Middle River

UJD = Upper Jones Discharge
UJI = Upper Jones Intake
UJM = Upper Jones Middle
UJB = Lower Jones Breach

Table 2.1 Site name, latitude, longitude, and site description for Jones Tract sampling stations

Site name	Latitude	Longitude	Site description
Lower Jones Discharge (LJD)	N37°56.434'	W121°31.881'	From discharge pipe sample port
Lower Jones Intake (LJI)	N37°56.485'	W121°31.646'	On-island 100 yards from intake
Lower Jones Middle – top (LJMT)	N37°56.785'	W121°30.722'	On-island, 1 m below surface
Lower Jones Middle – bottom (LJMB)	N37°56.785'	W121°30.722'	On-island, 0.5 m above bottom
Upper Jones Discharge (UJD)	N37°56.353'	W121°31.872'	From discharge pipe sample port
Upper Jones Intake (UJI)	N37°56.223'	W121°31.592'	On-island 100 yards from intake
Upper Jones Middle – top (UJMT)	N37°55.553'	W121°30.897'	On-island, 1 m below surface
Upper Jones Middle – bottom (UJMB)	N37°55.553'	W121°30.897'	On-island, 0.5 m above bottom
Middle River Site A (Site A)	N37°57.21”	W121°31.44”	Middle River north of pumps
Middle River Site B (Site B)	N37°55.15”	W121°30.59”	Middle River south of pumps
Middle River Site C (Site C)	N37°56.28”	W121°33.09”	Topeka/Santa Fe Cut Old River
Middle River (MR)	N37°55.146'	W121°30.903'	From shore 0.3 m below surface
Upper Jones Breach (UJB)	N37°55.252'	W121°30.975'	From shore 0.3 m below surface
Lower Jones East Shore (LJES)	N37°57.170'	W121°27.166'	From shore 0.3 m below surface
Lower Jones East Shore-duplicate (LJESD)	N37°57.170'	W121°27.166'	From shore 0.3 m below surface

Table 2.2 Analytical methods (lab and field) and reporting limits of constituents

Analyte	Method	Instrument	Reporting limit
Conductance (EC) (field)	EPA 120.1 (Field)	EC meter	1.0 µS/cm
pH (field)	EPA 150.1 (Field)	pH meter	0.1 pH Units
Water temperature (field)	EPA 170.1 (Field)	Thermometer / Electronic Probe	0.1 °C
Turbidity (field)	EPA 180.1 (Field)	Turbidimeter	1.0 NTU
Dibromochloromethane	EPA 510.1 (DWR modified)	GC/PID/ELCD	10. µg/L
Bromodichloromethane	EPA 510.1 (DWR modified)	GC/PID/ELCD	10. µg/L.
Chloroform	EPA 510.1 (DWR modified)	GC/PID/ELCD	10 µg/L
Total suspended solids	EPA 160.2	Balance	1.000 mg/L
Settleable solids	EPA 160.5	Imhoff cone	0.1 mL/L
Turbidity	EPA 180.1	Turbidimeter	1.0 NTU
Dissolved boron	EPA 200.7 (D)	ICP	0.100 mg/L
Dissolved calcium	EPA 200.7 (D)	ICP	1.000 mg/L
Dissolved magnesium	EPA 200.7 (D)	ICP	1.000 mg/L
Dissolved potassium	EPA 200.7 (D)	ICP	0.500 mg/L
Dissolved sodium	EPA 200.7 (D)	ICP	1.000 mg/L
Dissolved mercury	EPA 200.8 (Hg Dissolved)	ICP / MS	0.0002 mg/L
Dissolved aluminum	EPA 200.8 (D)	ICP / MS	0.010 mg/L
Dissolved antimony	EPA 200.8 (D)	ICP / MS	0.001 mg/L
Dissolved arsenic	EPA 200.8 (D)	ICP / MS	0.001mg/L
Dissolved barium	EPA 200.8 (D)	ICP / MS	0.050 mg/L
Dissolved chromium	EPA 200.8 (D)	ICP / MS	0.001 mg/L
Dissolved cobalt	EPA 200.8 (D)	ICP / MS	0.005 mg/L
Dissolved copper	EPA 200.8 (D)	ICP / MS	0.001 mg/L
Dissolved iron	EPA 200.8 (D)	ICP / MS	0.005 mg/L
Dissolved lead	EPA 200.8 (D)	ICP / MS	0.001 mg/L
Dissolved lithium	EPA 200.8 (D)	ICP / MS	0.005 mg/L
Dissolved magnesium	EPA 200.8 (D)	ICP / MS	1.000 mg/L
Dissolved manganese	EPA 200.8 (D)	ICP / MS	0.005 mg/L.
Dissolved molybdenum	EPA 200.8 (D)	ICP / MS	0.005 mg/L
Dissolved nickel	EPA 200.8 (D)	ICP / MS	0.001 mg/L
Dissolved selenium	EPA 200.8 (D)	ICP / MS	0.001 mg/L
Dissolved strontium	EPA 200.8 (D)	ICP / MS	0.005 mg/L
Dissolved vanadium	EPA 200.8 (D)	ICP / MS	0.005 mg/L
Dissolved zinc	EPA 200.8 (D)	ICP / MS	0.005 mg/L
Dissolved nitrate	EPA 300.0 28d Hold	IC	0.100 mg/L
Dissolved bromide	EPA 300.0 28d Hold	IC	0.010 mg/L
Dissolved chloride	EPA 300.0 28d Hold	IC	1.000. mg/L
Dissolved fluoride	EPA 300.0 28d Hold	IC	0.100 mg/L

Table 2.2 continued on next page

Analyte	Method	Instrument	Reporting limit
Table 2.2 continued from previous page			
Dissolved sulfate	EPA 300.0 28d Hold	IC	1.000. mg/L
Dissolved ammonia	EPA 350.1 Ammonia (D)	Autoanalyzer (colorimetric)	0.010 mg/L as N
Total Kjeldahl nitrogen	EPA 351.2	Autoanalyzer (colorimetric)	0.100 mg/L as N
Dissolved oxygen	EPA 360.1 (Field)	DO Meter	0.100 mg/L
Dissolved ortho-phosphate	EPA 365.1 (DWR Modified)	Auto Analyzer (colorimetric)	0.01 mg/L as P
Total phosphorus	EPA 365.4	Auto Analyzer (colorimetric)	0.01 mg/L
Dissolved organic carbon (Cmbst)	EPA 415.1 (D) Cmbst	TOC Analyzer	0.5 mg/L as C
Dissolved organic carbon (Ox)	EPA 415.1 (D) Wet Ox	TOC Analyzer	0.1 mg/L as C
Total organic carbon (Cmbst)	EPA 415.1 (T) Cmbst	TOC Analyzer	0.5 mg/L as C
Total organic carbon (Ox)	EPA 415.1 (T) Wet Ox	TOC Analyzer	0.1 mg/L as C
Trihalomethanes	EPA 510.1 DWR modified	PT/GC/MS	
Atrazine	EPA 608	GC/ELCD/ELCD	0.02 µg/L
Diuron	EPA 608	GC/ELCD/ELCD	0.25 µg/L
Metolachlor	EPA 608	GC/ELCD/ELCD	0.05 µg/L
Simazine	EPA 608	GC/ELCD/ELCD	0.02 µg/L
Diazinon	EPA 614	GC/NPD/FPD	0.01 µg/L
Molinate	EPA 614	GC/NPD/FPD	0.02 µg/L
Trifluralin (1)	EPA 614	GC/NPD/FPD	0.01 µg/L
Chlorophyll *a*	Std Method 10200 H	Spectrometer	0.05 µg/L
Pheophytin	Std Method 10200 H	Spectrometer	0.05 µg/L
Total alkalinity	Std Method 2320 B	Titrimeter	1.0 mg/L as CaCO3
Dissolved hardness	Std Method 2340 B	(calculated)	1.0 mg/L as CaCO3
Conductance (EC)	Std Method 2510-B	EC meter	1.0 µS/cm
Total dissolved solids	Std Method 2540 C	Balance	1.0 mg/L
Dissolved nitrite + nitrate	Std Method 4500-NO3-F Modified	Auto analyzer	0.01 mg/L as N
UV absorbance @254 nm	Std Method 5910B	Spectrometer	0.001 absorbance/cm

Table 2.3 Analytical methods used (contract labs) and reporting limits of constituents

Analyte	Method	Reporting limit
E.coli	SM 9221F, SM 9222G	20 MPN/100 ml
Fecal Coliforms	SM 9221E, SM 9222D	20 MPN/100 ml
Total Coliforms	SM 9221B, SM 9222B	20 MPN/100 ml
Biological Oxygen Demand	EPA 405.1	1.0 / 2.0 mg/L
Oil and Grease	EPA 1664A / EPA 413.1	5.0 mg/L
Chromium	EPA 200.7	0.0050 mg/L
Mercury	EPA 7470A	0.00020 mg/L
Ammonia	EPA 350.3	0.082 mg/L as N

Table 2.4 Analytical methods used (contract labs) for hydrocarbons, volatile and semivolatile constituents, and their reporting limits

Analyte	Method	Reporting limit
Benzene	EPA 8260B	0.5 µg/L
Toluene	EPA 8260B	0.5 µg/L
Ethylbenzene	EPA 8260B	0.5 µg/L
Xylenes	EPA 8260B	0.5 µg/L
Gasoline Range Organics. (C4 -C12)	EPA 8260B	50.0. µg/L
Diesel Range Organics (C10 - C28)	EPA 8015B	50.0. µg/L
Bromobenzene	EPA 8260B	0.5 µg/L
Bromochloromethane	EPA 8260B	0.5 µg/L
Bromodichloromethane	EPA 8260B	0.5 µg/L
Bromoform	EPA 8260B	0.5 µg/L
Bromomethane	EPA 8260B	1.0 µg/L
n- Butylbenzene	EPA 8260B	0.5 µg/L
sec-Butylbenzene	EPA 8260B	0.5 µg/L
tert- Butylbenzene	EPA 8260B	0.5 µg/L
Carbon tetrachloride	EPA 8260B	0.5 µg/L
Chlorobenzene	EPA 8260B	0.5 µg/L
Chloroethane	EPA 8260B	1.0 µg/L
Chloroform	EPA 8260B	0.5 µg/L
Chloromethane	EPA 8260B	1.0 µg/L
2-Chlorotoluene	EPA 8260B	0.5 µg/L
4-Chlorotoluene	EPA 8260B	0.5 µg/L
Dibromochloromethane	EPA 8260B	0.5 µg/L
1,2-Dibromomethane (EDB)	EPA 8260B	0.5 µg/L
Dibromomethane	EPA 8260B	0.5 µg/L
1,2,-Dibromo-3-chloropropane	EPA 8260B	1.0 µg/L
1,2-Dichlorobenzene	EPA 8260B	0.5 µg/L
1,3-Dichlorobenzene	EPA 8260B	0.5 µg/L

Table 2.4 continued on next page

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Analyte	Method	Reporting limit
1,4-Dichlorobenzene	EPA 8260B	0.5 µg/L
Dichlorodifluoromethane	EPA 8260B	0.5 µg/L
1,1-Dichloroethane	EPA 8260B	0.5 µg/L
1,2-Dichloroethane	EPA 8260B	0.5 µg/L
cis-1,2-Dichloroethane	EPA 8260B	0.5 µg/L
trans-1,2-Dichloroethane	EPA 8260B	0.5 µg/L
1,2-Dichloropropane	EPA 8260B	0.5 µg/L
1,3-Dichloropropane	EPA 8260B	0.5 µg/L
2,2-Dichloropropane	EPA 8260B	0.5 µg/L
1,1-Dichloropropane	EPA 8260B	0.5 µg/L
Ethylbenzene	EPA 8260B	0.5 µg/L
Hexachlorobutadiene	EPA 8260B	1.0 µg/L
Isopropylbenzene	EPA 8260B	0.5 µg/L
p-Isopropyltoluene	EPA 8260B	0.5 µg/L
Methylene chloride	EPA 8260B	1.0 µg/L
Methyltert-butyl ether	EPA 8260B	0.5 µg/L
Naphthalene	EPA 8260B	1.0 µg/L
n-Propylbenzene	EPA 8260B	0.5 µg/L
Styrene	EPA 8260B	0.5 µg/L
1,1,1,2-Tetrachloroethane	EPA 8260B	0.5 µg/L
1,1,2,2-Tetrachloroethane	EPA 8260B	1.0 µg/L
Tetrachloroethane	EPA 8260B	0.5 µg/L
Toluene	EPA 8260B	0.5 µg/L
1,2,3-Trichlorobenzene	EPA 8260B	0.5 µg/L
1,2,4-Trichlorobenzene	EPA 8260B	0.5 µg/L
1,1,1-Trichloroethane	EPA 8260B	0.5 µg/L
1,1,2-Trichloroethane	EPA 8260B	0.5 µg/L
Trichloroethane	EPA 8260B	0.5 µg/L
Trichlorofluoromethane	EPA 8260B	0.5 µg/L
1,2,3-Trichloropropane	EPA 8260B	1.0 µg/L
1,2,4-Trimethylbenzene	EPA 8260B	0.5 µg/L
1,3,5-Trimethylbenzene	EPA 8260B	0.5 µg/L
Vinyl chloride	EPA 8260B	0.5 µg/L
Xylenes (total)	EPA 8260B	0.5 µg/L
N-Nitrosodimethylamine	EPA 8270C	5.0 µg/L
Phenol	EPA 8270C	5.0 µg/L
Aniline	EPA 8270C	5.0 µg/L
Bis(2-chloroethlyl)ether	EPA 8270C	5.0 µg/L
2-Chlorophenol	EPA 8270C	10.0 µg/L
Benzyl alcohol	EPA 8270C	5.0 µg/L

Table 2.4 continued on next page

Table 2.4 continued on previous page

Analyte	Method	Reporting limit
1,2-Dichlorobenzene	EPA 8270C	5.0 µg/L
1,3-Dichlorobenzene	EPA 8270C	5.0 µg/L
1,4-Dichlorobenzene	EPA 8270C	5.0 µg/L
Benzyl alcohol	EPA 8270C	5.0 µg/L
2-Methylphenol	EPA 8270C	5.0 µg/L
Bis(2-chloroisopropyl)ether	EPA 8270C	5.0 µg/L
4-Methylphenol	EPA 8270C	5.0 µg/L
N-Nitrosodi-n-propylamine	EPA 8270C	5.0 µg/L
Hexachloroethane	EPA 8270C	5.0 µg/L
Nitrobenzene	EPA 8270C	5.0 µg/L
Isophorone	EPA 8270C	5.0 µg/L
2-Nitrophenol	EPA 8270C	20.0 µg/L
2,4-Dimethylphenol	EPA 8270C	5.0 µg/L
Bis(2-chloroethoxy)methane	EPA 8270C	5.0 µg/L
Benzoic acid	EPA 8270C	20.0 µg/L
2,4,-Dichlorophenol	EPA 8270C	10.0 µg/L
1,2,4-Trichlorobenzene	EPA 8270C	5.0 µg/L
Naphthalene	EPA 8270C	10.0 µg/L
4-chloroaniline	EPA 8270C	5.0 µg/L
Hexachlorobutadiene	EPA 8270C	5.0 µg/L
4-Chloro-3-methylphenol	EPA 8270C	5.0 µg/L
2-Methylnaphthaline	EPA 8270C	5.0 µg/L
Hexachlorocyclopentadiene	EPA 8270C	20.0 µg/L
2,4,6-Trichlorophenol	EPA 8270C	10.0 µg/L
2,4,5-Trichlorophenol	EPA 8270C	10.0 µg/L
2-Chloronaphthalene	EPA 8270C	5.0 µg/L
2-Nitroaniline	EPA 8270C	5.0 µg/L
Dimethyl phthalate	EPA 8270C	5.0 µg/L
Acenaphthylene	EPA 8270C	5.0 µg/L
2,4-Dinitrophenol	EPA 8270C	20.0 µg/L
4-Nitrophenol	EPA 8270C	20.0 µg/L
Dibenzofuran	EPA 8270C	5.0 µg/L
2,4-Dinitrotoluene	EPA 8270C	5.0 µg/L
Diethyl phthalate	EPA 8270C	5.0 µg/L
4-Chlorophenyl phenyl ether	EPA 8270C	5.0 µg/L
Fluorene	EPA 8270C	5.0 µg/L
4,6 Dinitro-2-methylphenol	EPA 8270C	20.0 µg/L
N-Nitrosodiphenylamine	EPA 8270C	5.0 µg/L
Azobenzene	EPA 8270C	5.0 µg/L
4-Nitroaniline	EPA 8270C	5.0 µg/L

Table 2.4 continued on next page

Analyte	Method	Reporting limit
Table 2.4 continued from previous page		
4-Bromophenyl phenyl ether	EPA 8270C	5.0 µg/L
Hexachlorobenzene	EPA 8270C	5.0 µg/L
Pentachlorophenol	EPA 8270C	20.0 µg/L
Phenanthrene	EPA 8270C	5.0 µg/L
Anthracene	EPA 8270C	5.0 µg/L
Carbazole	EPA 8270C	5.0 µg/L
Di-n-butyl phthalate	EPA 8270C	5.0 µg/L
Fluoranthene	EPA 8270C	5.0 µg/L
Pyrene	EPA 8270C	5.0 µg/L
Benzyl butyl phthalate	EPA 8270C	5.0 µg/L
3-3'-Dichlorobenzidene	EPA 8270C	10.0 µg/L
Bist(2-ethylhexyl)phthalate	EPA 8270C	5.0 µg/L
Benzo (a) anthracene	EPA 8270C	5.0 µg/L
Chrysene	EPA 8270C	5.0 µg/L
Di-n-octyl phthalate	EPA 8270C	5.0 µg/L
Benzo (b&k) fluoranthene (total)	EPA 8270C	10.0 µg/L
Benzo (a) pyrene	EPA 8270C	5.0 µg/L
Indeno (1,2,3-cd) pyrene	EPA 8270C	5.0 µg/L
Dibenz (a,h) anthracene	EPA 8270C	5.0 µg/L
Benzo (ghi) perylene	EPA 8270C	5.0 µg/L

Table 2.5 Field duplicates exceeding control limits

Analyte	Collection date	Sample number	Sample duplicate	Result 1	Result 2	Units	RPD %	RPD% limit
Atrazine	8/2/04	CA0804B0351	CA0804B0343	0.05	0.03	µg/L	50	40
Atrazine	10/12/04	CA1004B0871	CA1004B0873	0.11	0.17	µg/L	42.86	40
Chloroform	6/4/04	CA0604B0169	CA0604B0165	1119	206	µg/L	137.81	20
Chlorophyll a	6/16/04	CA0604B0196	CA0604B0195	7.25	4.75	µg/L	41.67	20
Dissolved Aluminum	7/28/04	CA0704B0323	CA0704B0319	0.011	0	mg/L	200	30
Dissolved Aluminum	8/26/04	CA0804B0575	CA0804B0574	0.051	0.097	mg/L	62.16	30
Dissolved Aluminum	11/8/04	CA1104B1070	CA1104B1072	0.052	0.028	mg/L	60	30
Dissolved Barium	11/15/04	CA1104B1233	CA1104B1235	0.05	0	mg/L	200	30
Dissolved Boron	8/2/04	CA0804B0351	CA0804B0343	0	0.1	mg/L	200	20
Dissolved Boron	8/12/04	CA0804B0458	CA0804B0457	0.2	0.1	mg/L	66.67	20
Dissolved Bromide	8/9/04	CA0804B0412	CA0804B0404	0.03	0.02	mg/L	40	20
Dissolved Bromide	8/16/04	CA0804B0490	CA0804B0488	0	0.01	mg/L	200	20
Dissolved Bromide	8/30/04	CA0804B0615	CA0804B0613	0.02	0.01	mg/L	66.67	20
Dissolved Bromide	9/7/04	CA0904B0676	CA0904B0674	0.03	0.02	mg/L	40	20
Dissolved Copper	8/26/04	CA0804B0575	CA0804B0574	0.002	0.003	mg/L	40	30
Dissolved Copper	11/8/04	CA1104B1070	CA1104B1072	0.009	0.004	mg/L	76.92	30
Dissolved Hardness	6/4/04	CA0604B0169	CA0604B0165	101	104	mg/L as CaCO3	2.93	20
Dissolved Iron	8/26/04	CA0804B0575	CA0804B0574	0.303	0.533	mg/L	55.02	30
Dissolved Manganese	7/28/04	CA0704B0323	CA0704B0319	0.005	0	mg/L	200	30
Dissolved Nitrate	8/2/04	CA0804B0351	CA0804B0343	0.1	0	mg/L	200	20
Dissolved Orthophosphate	6/30/04	CA0604B0212	CA0604B0211	0.03	0.02	mg/L as P	40	20
Dissolved Zinc	11/8/04	CA1104B1070	CA1104B1072	0.202	0.334	mg/L	49.25	30
Diuron	9/2/04	CA0904B0640	CA0904B0639	0	0.29	µg/L	200	40
Diuron	9/21/04	CA0904B0756	CA0904B0757	0	0.28	µg/L	200	40
Diuron	10/12/04	CA1004B0871	CA1004B0873	0	0.27	µg/L	200	40

Table 2.5 continued on next page

Analyte	Collection date	Sample number	Sample duplicate	Result 1	Result 2	Units	RPD %	RPD% limit
Table 2.5 continued on previous page								
Metolachlor	8/2/04	CA0804B0351	CA0804B0343	0.2	0.1	µg/L	66.67	40
Metolachlor	8/26/04	CA0804B0575	CA0804B0574	0.2	0.1	µg/L	66.67	40
Metolachlor	9/2/04	CA0904B0640	CA0904B0639	0.1	0.2	µg/L	66.67	40
Metolachlor	10/5/04	CA1004B0840	CA1004B0841	0.1	0.2	µg/L	66.67	40
Ortho-phosphate	8/5/04	CA0804B0389	CA0804B0385	0.01	0	mg/L as P	200	20
Pheophytin a	6/30/04	CA0604B0212	CA0604B0211	0	9.91	µg/L	200	20
Settleable Solids	9/14/04	CA0904B0721	CA0904B0723	0.2	0.3	mL/L	40	15
Settleable Solids	10/26/04	CA1004B0954	CA1004B0956	0.1	0	mL/L	200	15
Settleable Solids	11/2/04	CA1104B1023	CA1104B1025	0.2	0	mL/L	200	15
Settleable Solids	11/15/04	CA1104B1233	CA1104B1235	0.1	0	mL/L	200	15
Settleable Solids	11/22/04	CA1104B1258	CA1104B1260	0.4	0.5	mL/L	22.22	15
Total Organic Carbon	6/30/04	CA0604B0212	CA0604B0211	16.6	11.6	mg/L as C	35.46	30
Total Suspended Solids	8/5/04	CA0804B0389	CA0804B0385	6	14	mg/L	80	25
Total Suspended Solids	8/19/04	CA0804B0516	CA0804B0515	10	13	mg/L	26.09	25
Total Suspended Solids	8/30/04	CA0804B0615	CA0804B0613	32	44	mg/L	31.58	25

Table 2.6 Field blanks exceeding control limits

Analyte	Collection date	Sample number	Result	Reporting limit	Units
Dissolved Organic Carbon	6/4/04	CA0604B5019	0.3	0.1	mg/L as C
Dissolved Organic Carbon	6/10/04	CA0604B0187	0.6	0.1	mg/L as C
Dissolved Organic Carbon	6/16/04	CA0604B0200	0.2	0.1	mg/L as C
Dissolved Organic Carbon	6/23/04	CA0604B0208	0.2	0.1	mg/L as C
Dissolved Organic Carbon	6/30/04	CA0604B0216	0.2	0.1	mg/L as C
Dissolved Organic Carbon	7/7/04	CA0704B0251	0.2	0.1	mg/L as C
Dissolved Organic Carbon	7/15/04	CA0704B0297	0.2	0.1	mg/L as C
Dissolved Organic Carbon	7/21/04	CA0704B0310	0.2	0.1	mg/L as C
Dissolved Organic Carbon	8/2/04	CA0804B0355	0.2	0.1	mg/L as C
Dissolved Organic Carbon	8/5/04	CA0804B0393	0.3	0.1	mg/L as C
Dissolved Organic Carbon	8/12/04	CA0804B0462	0.2	0.1	mg/L as C
Dissolved Organic Carbon	8/16/04	CA0804B0494	0.2	0.1	mg/L as C
Dissolved Organic Carbon	8/23/04	CA0804B0555	0.2	0.1	mg/L as C
Dissolved Organic Carbon	8/26/04	CA0804B0579	0.2	0.1	mg/L as C
Total Organic Carbon	6/4/04	CA0604B5019	0.2	0.1	mg/L as C
Total Organic Carbon	6/10/04	CA0604B0186	0.2	0.1	mg/L as C
Total Organic Carbon	6/16/04	CA0604B0199	0.2	0.1	mg/L as C
Total Organic Carbon	6/23/04	CA0604B0207	0.2	0.1	mg/L as C
Total Organic Carbon	6/30/04	CA0604B0215	0.2	0.1	mg/L as C
Total Organic Carbon	7/15/04	CA0704B0296	0.2	0.1	mg/L as C
Total Organic Carbon	7/15/04	CA0704B0295	0.2	0.1	mg/L as C
Total Organic Carbon	7/21/04	CA0704B0308	0.2	0.1	mg/L as C
Total Organic Carbon	7/21/04	CA0704B0309	0.2	0.1	mg/L as C
Total Organic Carbon	8/2/04	CA0804B0353	0.2	0.1	mg/L as C
Total Organic Carbon	8/2/04	CA0804B0354	0.2	0.1	mg/L as C
Total Organic Carbon	8/5/04	CA0804B0391	0.2	0.1	mg/L as C
Total Organic Carbon	8/9/04	CA0804B0415	0.2	0.1	mg/L as C
Total Organic Carbon	8/9/04	CA0804B0414	0.2	0.1	mg/L as C
Total Organic Carbon	8/12/04	CA0804B0461	0.2	0.1	mg/L as C
Total Organic Carbon	8/16/04	CA0804B0492	0.2	0.1	mg/L as C
Total Organic Carbon	8/16/04	CA0804B0493	0.2	0.1	mg/L as C
Total Organic Carbon	8/23/04	CA0804B0554	0.2	0.1	mg/L as C
Total Organic Carbon	8/30/04	CA0804B0628	0.2	0.1	mg/L as C
Total Organic Carbon	9/7/04	CA0904B0690	0.2	0.1	mg/L as C
Total Organic Carbon	9/21/04	CA0904B0772	0.3	0.1	mg/L as C
Total Organic Carbon	9/28/04	CA0904B0818	0.3	0.1	mg/L as C
Total Organic Carbon	10/5/04	CA1004B0856	0.2	0.1	mg/L as C
Total Organic Carbon	10/12/04	CA1004B0899	0.2	0.1	mg/L as C
Total Organic Carbon	10/12/04	CA1004B0898	0.2	0.1	mg/L as C
Total Organic Carbon	10/19/04	CA1004B0939	0.2	0.1	mg/L as C

Table 2.6 continued on next page

Analyte	Collection date	Sample number	Result	Reporting limit	Units
Table 2.6 continued from previous page					
Total Organic Carbon	10/26/04	CA1004B0968	0.2	0.1	mg/L as C
Total Organic Carbon	10/26/04	CA1004B0969	0.2	0.1	mg/L as C
Total Organic Carbon	10/26/04	CA1004B0970	0.3	0.1	mg/L as C
Total Organic Carbon	11/15/04	CA1104B1248	0.2	0.1	mg/L as C
Total Organic Carbon	11/15/04	CA1104B1249	0.2	0.1	mg/L as C

Table 2.7 Total laboratory QC batches grouped by analyte

Analyte	Method	LCS recovery	RPD-LCS duplicates	Matrix Spike recovery	RPD-Matrix Spike duplicate	Method Blank	RPD sample duplicate	Surrogate recovery
Physical parameters								
Turbidity		46	23			46	38	
Total suspended solids						23	25	
Carbon								
TOC	EPA 415.1 (T) ox	82	41			41		
DOC	EPA 415.1 (D) ox	76	38			38		
TOC	EPA 415.1 (T) comb	64	32			32		
DOC	EPA 415.1 (D) comb	64	32			32		
UVA	Std Method 5910B	32	15			29	26	
THMFP								
2-Bromo-1-chloropropane	EPA 510.1(DWR)					10		
Bromodichloromethane	EPA 510.1(DWR)	14	7	6	3	10		
Bromoform	EPA 510.1(DWR)	14	7	6	3	10		
Chloroform	EPA 510.1 (DWR)	14	7	6	3	10		
Dibromochloromethane	EPA 510.1(DWR)	14	7	6	3	10		
Fluorobenzene	EPA 510.1 (DWR)	14		6				131
Chlorophyll	Std Method 10200 H					13		
Pheophytin	Std Method 10200 H					13		
Nutrients								
Ammonia	EPA 350.1	52	26	98	49	26		
Kjeldahl Nitogen	EPA 351.2	40	20	30	15	20		
Nitrate	EPA 300.0	66	33	158	79	31		
Nitrite and nitrate	Std. Method 4500	52	26	96	48	26		
Phosphorus	EPA 365.4	38	19	36	18	20		
Orthophosphate	EPA 365.1	48	24	94	47	24		

Table 2.7 Continued on next page

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Analyte	Method	LCS recovery	RPD-LCS duplicates	Matrix Spike recovery	RPD-Matrix Spike duplicate	Method Blank	RPD sample duplicate	Surrogate recovery
EC and common chemical constituents								
EC						32		
TDS						32	37	
Sodium	EPA 200.7	54	26	100	48	24		
Calcium	EPA 200.7	54	26	100	48	24		
Magnesium	EPA 200.7	54	26	100	48	24		
Sulfate	EPA 300.0	66	33	230	115	31		
Alkalinity	Std Method 2320	60	30	94	47	30		
Boron	EPA 200.7	54	26	96	47	24		
Potassium	EPA 200.7	54	26	92	45	24		
Chloride	EPA 300.0	66	33	242	121	31		
Bromide	EPA 300.0	66	33	162	81	31		
Trace Elements								
Aluminum	EPA 200.8	36	18	64	32	18		
Antimony	EPA 200.8	32	16	46	23	16		
Arsenic	EPA 200.8	36	18	76	38	18		
Barium	EPA 200.8	36	18	66	33	18		
Berylium	EPA 200.8	32	16	46	23	16		
Cadmium	EPA 200.8	32	16	44	22	16		
Chromium	EPA 200.8	36	18	68	34	18		
Cobalt	EPA 200.8	12	6	18	9	6		
Copper	EPA 200.8	36	18	66	33	18		
Fluoride	EPA 300.0	44	22	62	31	20		
Iron	EPA 200.8	36	18	66	33	18		
Lead	EPA 200.8	36	18	66	33	18		
Lithium	EPA 200.8	12	6	18	9	6		

Table 2.7 Continued on next page

Table 2.7 Continued from previous page

Analyte	Method	LCS recovery	RPD-LCS duplicates	Matrix Spike recovery	RPD-Matrix Spike duplicate	Method Blank	RPD sample duplicate	Surrogate recovery
Manganese	EPA 200.8	36	18	66	33	18		
Molybdenum	EPA 200.8	20	10	22	11	10		
Mercury	EPA 200.8	20	10	40	20	10		
Nickel	EPA 200.8	36	18	66	33	18		
Selenium	EPA 200.8	36	18	48	24	18		
Silver	EPA 200.8	36	18	64	32	18		
Strontium	EPA 200.8	22	11	18	9	11		
Thallium	EPA 200.8	12	6	18	9	6		
Vanadium	EPA 200.8	18	9	20	10	9		
Zinc	EPA 200.8	36	18	66	33	18		
Pesticides								
Diazinone	EPA 614					15		
Metolachlor	EPA 608					27		
Molinate	EPA 614					15		
Herbicides								
Atrazine	EPA 608					27		
Diuron	EPA 608					27		
Simazine	EPA 608					27		
Trifluralin	EPA 614	29	14	10	5	15		

Table 2.8 Method blank exceedences

Analyte	Method	Batch number	Result	Reporting limit	Units
Alkalinity	Std Method 2320 B	BL04B17769	5.4	1	mg/L as CaCO3
Conductance (EC)	Std Method 2510-B	BL04B17707	6.6	1	µS/cm
Kjeldahl Nitrogen	EPA 351.2	BL04B16787	0.165	0.1	mg/L as N

Table 2.9 Number of batches with method blank exceedences

Analyte	Method	Total batches	Batches with method blanks out of limit	Frequency of samples out of limits (%)
Alkalinity	Std Method 2320 B	30	1	3.3
Conductance (EC)	Std Method 2510-B	32	1	3.1
Kjeldahl Nitrogen	EPA 351.2	20	1	5

Table 2.10 Matrix spike duplicate exceedences

Analyte	Method	Batch number	Recovery (%)	Control limits (%)
Kjeldahl Nitrogen	EPA 351.2	BL04B17034	32.69	0 - 25
Kjeldahl Nitrogen	EPA 351.2	BL04B17214	28.83	0 - 25

Table 2.11 Matrix spike recovery exceedences

Analyte	Method	Batch number	Recovery (%)	Control limits (%)
Kjeldahl Nitrogen	EPA 351.2	BL04B17034	65.25	70 - 130
Kjeldahl Nitrogen	EPA 351.2	BL04B17281	150.00	70 - 130
Kjeldahl Nitrogen	EPA 351.2	BL04B17281	132.75	70 - 130
Calcium	EPA 200.7 (D)	BL04B18055	68.3	80 - 120
Calcium	EPA 200.7 (D)	BL04B18055	70.3	80 -120
Magnesium	EPA 200.7 (D)	BL04B17563	66.1	80 - 120
Magnesium	EPA 200.7 (D)	BL04B17563	69.1	80 -120
Magnesium	EPA 200.7 (D)	BL04B18055	75.2	80 - 120
Magnesium	EPA 200.7 (D)	BL04B18055	76.2	80 -120
Potassium	EPA 200.7 (D)	BL04B18055	74.48	80 - 120
Potassium	EPA 200.7 (D)	BL04B18055	74.48	80 -120
Sodium	EPA 200.7 (D)	BL04B16880	70.1	80 - 120
Sodium	EPA 200.7 (D)	BL04B16880	65.11	80 -120
Sodium	EPA 200.7 (D)	BL04B17563	74.6	80 - 120
Sodium	EPA 200.7 (D)	BL04B17563	73.6	80 -120
Sodium	EPA 200.7 (D)	BL04B18055	66.8	80 - 120
Sodium	EPA 200.7 (D)	BL04B18055	69.8	80 -120
Sodium	EPA 200.7 (D)	BL04B18161	74	80 - 120
Sodium	EPA 200.7 (D)	BL04B18161	79	80 -120

Table 2.12 Frequency of matrix spike recovery exceedences

Analyte	Total matrix spikes	Matrix spikes recoveries out of limit	Frequency of matrix spike recoveries out of limits (%)
Kjeldahl nitrogen	30	3	10
Calcium	100	2	2
Magnesium	100	4	4
Potassium	92	2	2
Sodium	100	8	8

Chapter 3 Results and Discussion

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Chapter 3 Results and Discussion

This chapter discusses observations and test results of the Department of Water Resources (DWR) water quality monitoring following the June 3, 2004, levee break at Jones Tract, described in more detail in Chapter 1. As a result of the break, both Upper and Lower Jones Tracts flooded, creating a new 12,000-acre lake in the central-southern region of the Sacramento-San Joaquin River Delta (the Delta). Monitoring was conducted from June 4, 2004, through November 22, 2004. The levee break was closed on 30 June, 2004.

3.1 Physical Parameters, pH, DO, BOD, and Weather Data

This section discusses the observations of temperature, dissolved oxygen (DO), pH, biochemical oxygen demand (BOD), turbidity, total suspended solids (TSS), and total settleable solids (SS). Grab samples were used to measure these physical characteristics in water. In addition, temperature, DO, and pH were monitored with automated sondes placed in the on-island water after the levee was repaired. Precipitation, evapotranspiration, solar radiation, relative humidity, temperature, and wind speed at Jones Tract and its vicinity also are reported in this section.

DO = dissolved oxygen

BOD = biochemical oxygen demand

TSS = total suspended solids

SS = total settleable solids

3.1.1 Temperature Field Data

From June 4 to June 30, Lower Jones east side water temperature fluctuated from 25 ^{0}C to 27.5 ^{0}C. At the same time, the Upper Jones breach temperature fluctuated from 22.7 ^{0}C to 26.1 ^{0}C (Figures 3.1.1a-b). Solar radiation likely contributed to the difference in temperature. Because the Upper Jones breach was constantly subjected to the ebb and flow of tides, it too had lower water temperature than Lower Jones, which was not directly open to the river.

Figure 3.1.1a Temperature at Jones Tract (Bryte Lab field data)

Following the levee repair, from July 7 to September 14, the water temperatures at Lower and Upper Jones were very similar and were both above 20 ^{0}C. After mid-September the water temperature fell as the air temperature fell, ending at 17.6 ^{0}C at Upper Jones Discharge and 11.2 ^{0}C at Lower Jones Discharge on November 2 and 22 respectively (Figures 3.1.1a-b).

Figure 3.1.1b Average temperature at Upper and Lower Jones Tract (Bryte Lab field data)

3.1.1.1 Discharge Pipes

Water temperatures at the discharge pipes were monitored with sondes. The temperatures were similar to the grab samples collected from Lower and Upper Jones (Figure 3.1.2).

Figure 3.1.2 Average daily temperature at Upper Jones Discharge (Sonde data, n = 7,757)

3.1.1.2 Diurnal Changes in Water Temperature

Figure 3.1.3 Water temperature at Upper Jones Intake

UJI = Upper Jones Intake

The sondes were submerged one meter below the surface after the breach was filled. The sondes recorded the water quality data one meter below the surface during the beginning of the pump-out. As the pump-out proceeded and water levels lowered, the sondes recorded closer and closer to the bottom. The sondes recorded water temperature, DO, and pH every 15 minutes. These measurements were useful in understanding the diurnal changes during the pump-out period. Each day, the water temperature varied between a minimum at dawn and a maximum in the early afternoon. Daily temperature variation averaged 2.4 °C in July, but could be as much as 4.6 °C. Figure 3.1.3 shows the short- and long-term variation of temperature at Upper Jones Intake (UJI). The maximum temperature was 28.6 °C at

3:30 p.m. (Daylight time) on July 26; that date also had the maximal temperature range of 4.6 °C. Between July and August, the highest average temperature for each hour of the day was observed at 1 p.m. (Daylight time), and occurred somewhat later in the autumn months (Figure 3.1.4). It is also evident that after August, time of year has a larger effect on temperature variation than time of day.

Figure 3.1.4 Typical daily water temperature pattern at Upper Jones Tract Intake

Similar observations were made at Lower Jones Tract Middle station (LJM) in the middle of the flooded tract. The monthly averaged temperatures at LJM in a diurnal cycle in August ranged from 24.3 °C to 26.3 °C (Figure 3.1.5).

LJM = Lower Jones Middle Station

Figure 3.1.5 Typical daily water temperature pattern at Upper Jones Tract Middle Station

3.1.1.3 Temperature and Dissolved Oxygen

On seasonal time scales, average DO increased with decreasing water temperature (Figures 3.1.6, 3.1.7, 3.1.8, 3.1.9). On shorter time scales, photosynthesis and respiration had a larger effect on DO (Figures 3.1.13, 3.1.14, 3.1.15, 3.1.16). Toward the end of the pump-out period, shallow water caused the sondes to sample water near the bottom, and DO concentrations generally dropped (e.g., Figure 3.1.7)

Figure 3.1.6 Daily average temperature, DO, and pH at Lower Jones Intake

Figure 3.1.7 Average temperature, DO, and pH at Lower Jones Middle

3.1.2 Dissolved Oxygen (DO)

DO is required to maintain the health of aquatic ecosystems. Oxygen is produced by photosynthesis, but is also used by plants, animals, and microorganisms that live in water. Most fish need DO that is higher than 4 mg/L, and environmental regulations often require discharge water to have DO of 6 mg/L or higher.

Figure 3.1.8 Average temperature, DO, and pH at Upper Jones Intake

Figure 3.1.9 Average temperature, DO, and pH at Upper Jones Middle

Oxygen makes up 21% of all gases in air. Only a fraction of a percentage of atmospheric oxygen, however, dissolves in water. Oxygen dissolves in water through diffusion from the atmosphere and is facilitated by wind-mixing. This transfers oxygen to the water, especially in shallow aquatic systems that are not strongly stratified. Colder water can hold more DO than warm water as the solubility of oxygen is greater in colder water than in warm water. At the same time, cold temperatures reduce respiration rates in microorganisms that use DO.

mg/L = milligrams per liter

Phytoplankton and submersed aquatic macrophytes in the photic zone of lakes infuse oxygen into the water during the day during photosynthesis. Absence of photosynthesis, and respiration by these organisms and others, reduces oxygen concentration in the water at night. With little or no wind, shallow systems like Jones Tract can easily stratify in hot summer afternoons but convectively mix at night when surface waters cool. With just a moderate wind, a large shallow lake like Jones Tract can easily mix all the way to the bottom. Nevertheless, low DO conditions were observed on Jones Tract—especially on hot afternoons when there was little or no wind.

3.1.2.1 Field Data

Grab samples and field data including DO measurements were collected from 10 sites on Jones Tract starting the day after the levee break (June 4) and ending on November 22, 2004. These sites are described in Chapter 2 Methodology. DO was measured at these sites by EPA 360.1 (field) method.

Figure 3.1.10a DO in Jones Tract (Bryte lab)

Figure 3.1.10b Average DO in Jones Tract

DO concentrations on Jones Tract were typically lower than those in Middle River, adjacent to Jones Tract. DO concentration varied from 6.6 mg/L to

8.6 mg/L in Middle River from July 7 through October 19. DO was only 2.6 mg/L in Lower Jones when it was still filling on June 4, the day after the breach. DO concentrations in Jones Tract ranged between close to zero mg/L and about 12 mg /L from June through November (Figures 3.1.10a-b). DO concentrations were frequently less than 6 mg/L.

DO concentrations were variable but similar in both Lower Jones and Upper Jones. From July through September when water temperatures were consistently warm (around 25 ºC), average DO concentrations were low, about 5.9 mg/L. In the discharge water, which was pulled from the bottom of the water column, DO was often less than 6 mg/L. Concentrations of DO near the surface were often higher than concentrations near the bottom. Short-term or weak stratification in both temperature and DO was observed during relatively calm periods, but on windy days field staff observed that the water column was well mixed. All grab-sample field data were collected during daylight hours when DO tends to be at its highest due to photosynthetic activity.

3.1.2.2 Daily Average DO, Temperature, and Chlorophyll

Daily average DO concentrations were calculated from the 15-minute sonde data. Daily to weekly variations in DO concentrations do not appear to be strongly related to temperature variations (Figures 3.1.6 through 3.1.9).

Figure 3.1.11 shows DO and chlorophyll for the LJM site. Before mid-October increases or decreases in chlorophyll tend to correspond with respective increases or decreases in DO. Other factors like wind-mixing probably also affected DO concentrations, but Figure 3.1.12 shows a shorter time (August-September) for Lower Jones Intake (LJI) and suggests a strong relationship between phytoplankton dynamics and DO concentrations.

Figure 3.1.11 Average DO and chlorophyll at Lower Jones Middle

Figure 3.1.12 Average chlorophyll and DO at Lower Jones Intake

LJI = Lower Jones Intake

3.1.2.3 Diurnal Variations, Typical Patterns

Typical daily or diurnal patterns of DO concentrations were calculated from the sonde data for each month. These patterns are only for conditions one meter below the surface. Sondes were not deployed near the bottom, but field measurements show that DO concentrations near the bottom were generally far less than concentrations near the surface. Typical daily or diurnal patterns were created by calculating daily average DO concentrations for each day of each month from the 15-minute data (Figures 3.1.13 through 3.1.16).

UJM = Upper Jones Middle

At all 4 sites, DO concentrations increased during the daylight hours. At UJI and Upper Jones Middle (UJM) the difference in DO between early morning and afternoon is about 3.5 to 4.4 mg/L. The variation and the higher concentrations of DO were probably due to photosynthetic production. DO declines after dark were probably due to respiration from both photosynthetic and heterotrophic (non-photosynthetic) organisms. The nighttime DO declines were most pronounced in July after the flood and became progressively weaker in subsequent months. Similarly, the greatest daytime DO concentrations and rates of increase were in July and August, dropping off in September and October. Water taken from near the bottom, as at the UJI (Figure 3.1.14), shows DO concentration increased in the pump-out water as the water surface dropped to approach the intake depth.

Figure 3.1.13 Typical daily DO pattern at Upper Jones Middle

Figure 3.1.14 Typical daily DO pattern at Upper Jones Intake

Figure 3.1.15 Typical daily DO pattern at Lower Jones Middle

Figure 3.1.16 Typical daily DO pattern at Lower Jones Intake

3.1.3 pH

3.1.3.1 Field Observations

After the break in the levee, pH varied from 6.5 to 8.6 at Upper Jones breach and Lower Jones east side. After the levee was fixed in July, the median pH did not change much and fluctuated between 6.9 and 8.7 (Figures 3.1.17a-b). The range in pH readings were similar to those found in other Delta monitoring stations (DWR 2005).

Figure 3.1.17a pH at Jones Tract (Bryte Lab-field)

Figure 3.1.17b Average pH at Jones Tract (Bryte Lab-field

DWR. 2005 June. The Municipal Water Quality Investigations Program Summary and Findings from Data Collected Oct 2001 through Sep 2003.

3.1.3.2 pH and DO

Variations in daily average DO concentrations appear to be correlated with pH values. Changes in DO concentrations are similar to pH changes at all 4 sites (Figures 3.1.18, 3.1.19, 3.1.20, 3.1.21). However, variations in the photosynthetic activity of phytoplankton probably were responsible for much of the observed variations in both pH and DO. The sudden decrease in DO measured by the sonde at LJM (Figure 3.1.19) was almost certainly due to instrument problems.

Oxygen is pH neutral. When DO increases or decreases because of photosynthesis or respiration, it does not change the pH of the water directly. The pH of the water is affected by dissolved inorganic carbon concentrations, which are also affected by biological activity. During the day, when carbon dioxide is absorbed by photosynthetic organisms, the carbonic acid concentration drops, and pH increases. At the same time, oxygen is released from daytime photosynthetic activity, and DO concentrations increase. At night, respiration consumes DO and produces carbon dioxide (carbonic acid), which lowers pH. Thus, although DO and pH appear to be correlated, the relationship is mediated by biological processes and is not directly linked.

Figure 3.1.18 Average DO and pH at LJI

Figure 3.1.19 Average DO and pH at LJM

Figure 3.1.20 Average DO and pH at UJI

Figure 3.1.21 Average DO and pH at UJM

3.1.4 Biochemical Oxygen Demand (BOD)

BOD determines the extent to which oxygen within the sample can support microbial life. Lower Jones discharge and Upper Jones discharge were monitored for BOD after the levee was filled and pump-out had started. The BOD was recorded at both discharges from July 28 to November 22. The BOD at both discharges was similar throughout the period, fluctuating between 4 and 57 mg/L (Figure 3.1.22).

Figure 3.1.22 Biochemcial oxygen demand at Jones Tract

3.1.5 Turbidity

Turbidity is caused by suspended clay, silt, microscopic organisms, and other finely divided organic and inorganic matter. Nephlometers that measure turbidity of water detect the amount of light scattered at 90^0 to the incident light beam. Higher turbidity is observed when larger concentrations of particulate matter that scatter light are present in the water. Thus, in some circumstances, turbidity can provide a surrogate measurement of TSS or particulate matter concentration.

Figure 3.1.23a Turbidity in the Jones Tract (Bryte Lab)

3.1.5.1 Field Observations

Figures 3.1.23a-b show that turbidity at Upper Jones breach (UJB) was 36.7 NTUs on June 4 as the river water flowed into Upper Jones Tract. Turbidity at Lower Jones east side (LJES) was 357 NTUs as the water level increased rapidly over the fields. The turbidity at both these stations later fluctuated between 4.7 and 38.6 before the levee was filled. After the levee was filled, the average turbidity decreased to 7.1 in Lower Jones by July 15 and 6.3 at

Figure 3.1.23b Average turbidity in the Jones Tract (Bryte Lab)

UJB = Upper Jones breach

LJES = Lower Jones east side

Upper Jones by July 21. As pumping of floodwater proceeded, the turbidity increased from July to November. Spikes in turbidity readings were seen throughout the monitoring. These are thought to have been caused by wind-driven resuspension, which would be expected to increase with decreasing water depth during the pump-out.

3.1.6 Total Suspended Solids (TSS)

The water is filtered through a glass fiber filter, and the change in weight of the dried filter is recorded as TSS. Those levels were recorded at Lower Jones discharge and Upper Jones discharge after the levee was filled in early July 2004 (Figure 3.1.24). The initial TSS at both discharges in July was low. On July 28 TSS at Lower Jones discharge and Upper Jones discharge was 20 mg/L and 10 mg/L, respectively. These TSS levels increased from July to November as the water levels reduced. The spiking in TSS levels was seen in both discharges during the monitoring period.

Figure 3.1.24 Total suspended solids at Jones Tract (Bryte Lab)

3.1.6.1 Relationship Between Turbidity and Total Suspended Solids

Turbidity was plotted with TSS to understand its effect on the turbidity readings. The change in turbidity throughout the monitoring closely followed the change in TSS in both Upper Jones discharge and Lower Jones discharge. Regression of turbidity versus TSS form Upper and Lower Jones discharges gave an r^2 value of 0.91. These results show that TSS greatly influenced the turbidity readings at Jones Tract (Figures 3.1.25a-c).

Figure 3.1.25a Turbidity and Total Suspended Solids at LJD

Figure 3.1.25b Turbidity and total suspended solids at UJD

Figure 3.1.25c Turbidity vs total suspended solids at LJD and UJD

3.1.7 Total Settleable Solids (SS) at Lower Jones Discharge and Upper Jones Discharge

Settleable solids are material that settles out of suspension in a given time. The amount of total settleable solids (SS) were usually undetectable in both Upper and Lower Jones discharges. On September 14 the settleable solids were as high as 0.9 mg/L at Upper Jones discharge and 0.3 mg/L in Lower Jones discharge. On October 5, 19, and November 22 detectable levels of SS were recorded in Lower Jones discharge (Figure 3.1.26).

Figure 3.1.26 Total settleable solids in Jones Tract (Bryte Lab)

3.1.8 Wind speed, Total Suspended Solids, and Total Settleable Solids

The TSS and SS in Jones Tract increased and decreased periodically during the monitored period. Average daily wind-speed values from California Irrigation Management Information System (CIMIS) station at Jones Tract were recovered for the days that the grab samples were collected at the Jones Tract. These were plotted with the TSS and SS readings from Upper Jones Discharge and Lower Jones Discharge. The TSS and SS values at the discharges seem to increase when the average wind speed increased. Since the wind speed was not available for June and October, this figure shows the TSS, SS, and average daily wind speed for July, August, and September (Figure 3.1.27).

CIMIS = California Irrigation Management Information System

DWR = Department of Water Resources

Figure 3.1.27 Average daily wind speed at Jones Tract, total suspended solids and total settlable solids at UJD and LJD

3.1.9 CIMIS stations

DWR provides weather data to registered users through CIMIS, which maintains data from a network of weather stations. After the levee break a new weather station was installed at Jones Tract. The station was on grass (Latitude 37°55'34"N and Longitude 121°26'01"W), and the data were logged from July to December. This station had technical difficulties in October and did not record any data. Brentwood station in Contra Costa County (Latitude

$37^o55'43"$N and Longitude $121^o39'31"$W) was the closest active weather station that continually recorded data from the day of the levee break to the end of the pump-out. The Brentwood station data were used to fill in the gaps in the data collected from the Jones Tract.

3.1.9.1 Precipitation

The Jones Tract station never recorded precipitation; therefore, the precipitation readings from nearby Brentwood were graphed on Figure 3.1.28. About 0.5 on an inch of rain fell in August and about 0.25 of an inch of rain fell in September. Most of the precipitation occurred from October to December.

Figure 3.1.28 Precipitation at Brentwood weather station

ETo = evapotranspiration

3.1.9.2 ETo at Jones Tract

CIMIS weather stations were originally designed to estimate crop water use for irrigation scheduling. Each station calculates the evapotranspiration (ET), which is the loss of water to the atmosphere from the soil and plant surfaces. The Jones Tract station was on grass, and the evapotranspiration from the grass and soil was recorded as ETo. As expected, evapotranspiration declined with declining solar radiation (Figures 3.1.29a-b). The r^2 value for the linear correlation between ETo and solar radiation was 0.93 (Figure 3.1.30). As relative humidity increased in November and December, ETo approached zero (Figure 3.1.29c). A negative correlation ($r^2 = 0.72$) between ETo and relative humidity was observed at Jones Tract (Figure 3.1.31).

Figure 3.1.29a Evapotranspiration in Jones Tract

Figure 3.1.29b Solar radiation in Jones Tract

Figure 3.1.29c Relative humidity at Jones Tract

Figure 3.1.30 Relationship between solar radiation and ETo at Jones Tract

Figure 3.1.31 Relationship between Eto and relative humidity at Jones Tract

3.1.9.3 ETo, Solar Radiation, and Relative Humidity at Jones Tract and Brentwood

Because data for ETo, relative humidity, and solar radiation were not recorded before July 28 and for the month of October at Jones Tract, the missing data were obtained from the Brentwood station. The average daily ETo declined from June to December (Figure 3.1.32). When regression analysis was done with the data from Jones Tract and Brentwood stations on the days that ETo was recorded at both stations, r^2 value was 0.92 (Figure 3.1.33). Therefore, Brentwood ETo readings are considered to be very similar to those from the Jones Tract.

The average daily solar radiation also declined from June to December. The missing Jones Tract data were filled in with the Brentwood station observations (Figure 3.1.34). The correlation between the Jones Tract data and Brentwood data showed an r^2 value of 0.92 (Figure 3.1.35).

The relative humidity increased from June to December. The missing relative humidity data were filled in with Brentwood station recordings (Figure 3.1.36). A very strong positive correlation of relative humidity ($r^2 = 0.94$) was observed on days that both stations recorded data (Figure 3.1.37).

Figure 3.1.32 ETo at Jones Tract and Brentwood data on days that Jones Tract was not monitored

Figure 3.1.33 ETo at Jones Tract and Brentwood

Figure 3.1.34 Average daily solar radiation at Jones Tract with Brentwood data when Jones Tract was not monitored

Figure 3.1.35 Relationship of solar radiation at Jones Tract and Brentwood

Figure 3.1.36 Estimated average daily relative humidity at Jones Tract using Brentwood data

Figure 3.1.37 Average air temperature at Brentwood and Jones Tract

3.1.9.4 Air Temperature

Average daily air temperature readings at Jones Tract and Brentwood were very similar. The r^2 value was 0.98 for the regression analysis of air temperature readings at both these stations. The air temperature values from June 1 to July 28 and for the month of October were obtained from the Brentwood station and graphed with the Jones Tract data (Figure 3.1.38). The relationship between air temperature values on days that both stations recorded the data is given in Figure 3.1.39. The air temperature was above

Figure 3.1.38 Average daily air temperature at Jones Tract with Brentwood data when Jones Tract was not monitored

Figure 3.1.39 Average air temperature at Brentwood and Jones Tract

80 ^{0}F in June and gradually reduced to less than 40 ^{0}F in December (Figure 3.1.38).

3.1.9.5 Wind Speed

Wind speed at Jones Tract was not recorded until July 28 and the data for the month of October were not available at the Jones Tract station (Figure 3.1.40). Regression analysis showed that the r^2 was 0.64 for wind speed at Jones Tract and Brentwood (Figure 3.9.41). Both station readings are graphed in Figure 3.1.40.

Figure 3.1.40 Average daily wind speed at Brentwood and at Jones Tract

Figure 3.1.41 Relationship between average daily wind speed at Jones Tract and Brentwood

From June to December, the wind speed values at both stations varied from 1.8 mph to 15.8 mph (2.9 to 25.4 km/hour; Figure 3.1.40).

3.1.10 Summary

Field instruments and sondes recorded similar temperatures in the floodwater. Before the levee was repaired, Upper Jones Tract, which was open to the Middle River, had lower temperatures than the Lower Jones Tract, which was relatively isolated from Upper Jones Tract by the railroad embankment. After the levee was repaired, the water temperatures at both locations were very similar.

Temperature changes did not closely follow the concentration changes in DO.

DO concentrations were frequently below the 6 mg/L criterion often used to protect many Delta fish species. Concentration of DO in the surface water was higher than at the bottom. This indicates oxygen use by microbial activity in the water column and in the sediment. DO concentration increased in the pump-out water as the water surface dropped to approach the intake depth

On a daily time scale, the data suggest that there was a strong relationship between DO, phytoplankton activity, and respiration. This is especially evident in July and August.

Variations in DO concentration appear to be similar to the changes in the pH values, mediated by photosynthesis and respiration processes.

BOD was very similar at Lower and Upper Jones Tract.

Turbidity and TSS were strongly correlated with an r^2 value of 0.91 (i.e., 91% of the variation in one is explained by variation in the other). Turbidity measurements, therefore, provide a good estimate of TSS concentration.

TSS and SS increased when wind speed increased, indicating that wind energy is sufficient to resuspend sediment in a flooded island of this depth.

Precipitation near Jones Tract was very low between June and October during the time when most of the floodwater was pumped out.

3.2 Organic Carbon

A major motivation for the DWR Jones Tract monitoring study was to take advantage of this natural experiment, however unfortunate, to test competing hypotheses about the dynamics of organic carbon (OC) in a flooded Delta island. Here we present the results of several related studies and analyses:

- OC loading in a flooded, peat soil island
- Evidence of transport of Jones Tract dissolved organic carbon (DOC) to the H.O. Banks Pumping Plant during the pump-out period
- Carbon and nitrogen isotope analysis (^{13}C, ^{14}C, ^{15}N)

OC = organic carbon

DOC = dissolved organic carbon

TOC = total organic carbon

Water samples were collected in Jones Tract (see Chapter 2 for methods) and analyzed for, among other things, total organic carbon (TOC), DOC (dissolved and particulate carbon), and concentrations of stable isotope ^{13}C and naturally occurring ^{14}C and ^{15}N. The DOC and TOC data provided important information about the magnitude of DOC flux out of the peat soil. The isotope data provided information about how long ago the carbon that produced the observed DOC was taken up by plant photosynthesis; i.e., whether the dominant source of DOC was recent photosynthesis or much older soil organic matter. The data strongly suggest that the DOC flux from a flooded Delta island are in agreement with previous DWR estimates based on smaller-scale studies (DWR 2004) and that most of the carbon in the DOC was from relatively old peat soil sources.

DWR 2004. In-Delta Storage Program State Feasibility Study Draft Report on Water Quality. DWR, Division of Planning and Local Assistance. Chapter 3, Water Quality Field Investigations.

3.2.1 Initial Predictions of DOC Production from Flooded Peat Soils

Less than two weeks after the levee breach, staff from Municipal Water Quality Investigations (MWQI) were asked how fast DOC concentrations in Jones Tract water might increase and how high those concentrations might get before all of the water was pumped off the island. MWQI had been studying the questions related to DOC loading from flooded organic-rich Delta peat soils for many years, including studies by Jung and others (see references). Based on these and subsequent studies, MWQI staff estimated an areal flux or yield rate of about 0.5 grams of DOC per square meter per day (0.5 gC m^{-2} d^{-1}). Based on initial assumptions that the area of Jones Tract was about 12,000 acres with an average depth of about 4 meters, MWQI staff predicted that the DOC concentration in Jones Tract water could be expected to increase by about 1 mg/L per week. These predictions were based on studies described below.

MWQI = Municipal Water Quality Investigations

3.2.1.1 Mesocosm Experiments (SMARTS)

The potential DOC production rate of flooded peat soil was studied by DWR staff in a set of mesocosm tanks dubbed the SMARTS facility (Special Multipurpose Applied Research Technology Station; Jung 1998). The facility is described in detail in Jung and Weisser (2000). In February 2002, the four 6-foot-high and four 11-foot-high open-topped tanks were filled with 1.5 feet (0.5 meters) of Delta island peat soil (Rindge Muck) collected from Bacon Island, placed in the bottom, and then filled with fresh Sacramento River water. This peat soil had 46% organic matter by combustion of 70 °C oven-dried soil in a muffle furnace and 26% carbon by Perkin-Elmer model 2400 CHN analyzer. A tall tank (the ninth tank) containing only water served as a control. Water samples were then taken about every 2 weeks for the next

SMARTS= Special Multipurpose Applied Research Technology Station

Jung, M. and L. Weisser. 2000 Dec. Final report on experiment #2: Seasonal water quality changes in flooded peat soil environments due to peat soil, water depth, and water exchange rate.

4 years. Fresh water was added to replace water lost to evaporation. The experimental design is described in more detail in DWR 2004.

The trend in OC concentrations in these tanks is summarized in Figure 3.2.1a-b. During the first year of flooding, TOC concentrations increased at a linear rate of about 0.4 to 0.5 gC m^{-2} day^{-1} independent of water depth until cold temperatures and winter rains flattened out the signal (Figure 3.2.1a). The second, third, and fourth years of study resulted in a similar linear increase in concentrations independent of depth, but there was an interannual decline in that rate (Figure 3.2.1b). While a linear fit is an oversimplification, 4 years of continuous flooding nevertheless resulted in a multiyear trend of continuing increasing OC at a rate of approximately 0.10 to 0.15 gC m^{-2} day^{-1}. Without continuous flooding or with annual re-exposure and reoxidation of the peat soils, the rate of OC increase would likely remain closer to that observed in the first year of flooding in the tanks, or that observed in the Jones Tract flood (0.5 gC m^{-2} day^{-1}). But this is a hypothesis that remains to be tested.

Figure 3.2.1a First year TOC trends from SMARTS tanks, comparable to Jones Tract flood per square meter per day

Figure 3.2.1b Long-term TOC trends from SMARTS tanks

3.2.1.2 Other Studies Reported in the Literature

During analysis of Jones Tract data, DWR staff discovered journal articles describing a laboratory study and theoretical model that pertained to the carbon flux rate question. Aguilar and Thibodeaux (2005) found DOC production rates from flooded peat soils that were similar to the findings of the DWR mesocosm tanks study and Jones Tract measurements. In a companion paper, they modeled flooded delta peat soil with 15% carbon, specifically (Thibodeaux and Aguilar 2005). They identified 2 production processes with distinct rates. The first process is a quick release, producing an initial DOC concentration of 3.6 mg/L with uncertainty range 2.65 – 4.29 mg/L, acting on time scales of hours to days.

Aguilar, L. and L.J. Thibodeaux. 2005. *Kinetics of peat soil dissolved organic carbon release from bed sediment to water. Part 1. Laboratory simulation.* Chemosphere 58:1309-1318.

The second process is a microbially mediated production of soluble OC, which continues more or less indefinitely. They computed a linear loading rate of approximately 0.24 mg/L^{-1} day^{-1} for a hypothetical reservoir 3 meters deep. This value is higher but on the same order as that observed at Jones Tract and in the DWR mesocosm experiments. Assuming an average water depth of 4 meters, as was the case in the Jones Tract flood, would thus result in a lower hypothetical rate of about 0.16 mg l^{-1} day^{-1}. Areal loading rates (e.g. 0.5 gC m^{-2} day^{-1}) avoid the problem accounting for depth (i.e., dilution) when comparing rates among different studies and systems, which is consistent with the finding from the mesocosm studies that loading or flux is independent of depth.

Aguilar and Thibodeaux call the first, quick release, process the “the tea-bag effect.” Unfortunately, there is potential for confusion caused by the use of this term for different processes. DWR and Delta Wetlands documents (DWR 2006, Reddy 2005) also use the term “tea bag effect” but to mean a longer-term, months-to-annual-scale decline in the release of carbon from flooded peat soil, as one would get from the repeated use of a tea bag to make successively weaker cups of tea. Here, we refrain from using the term, or use it in the latter sense.

DWR. 2006 May. 2006 Supplemental Report to 2004 Draft State Feasibility Study In-Delta Storage Project.

Reddy, K.R. 2005. Review of Delta Wetlands Water Quality: Release and Generation of Dissolved Organic Carbon from Flooded Peatlands. Final Report –2005 to In-Delta Section. DWR.

3.2.2 Organic Carbon Results from the Jones Tract Flood

Figure 3.2.2 TOC and DOC on Jones Tract

Figure 3.2.2 shows all the OC data collected during the Jones Tract monitoring. This includes both TOC and DOC concentrations and all locations in Jones Tract (Upper and Lower) that were measured by both wet oxidation and combustion analytical methods on an approximately weekly basis. The slope of the regression line indicates that there was an average daily increase in TOC/DOC concentrations of 0.135 ± 0.008 mg L^{-1} day^{-1} or 0.95 mg L^{-1} per week increase. The measured rate of increase of TOC and DOC concentrations in Jones Tract agreed well with the predicted rate of approximately 1 mg/L per week. This predicted rate was based on a loading rate of about 0.5 gC m^{-2} day^{-1} and an average depth of 4 meters.

3.2.3 Comparison of Organic Carbon Fractions and Analytical Methods

Figure 3.2.3 Lower Jones Tract DOC by wet oxidation

Figure 3.2.4 Comparison of Upper and Lower Jones Tract samples, showing larger initial DOC concentration in Upper Jones, and statistically identical rate of increase

Much of the variation in the data shown in Figure 3.2.2 can be isolated and quantified by classifying the data by chemical form or fraction (TOC vs DOC), and by the 2 different analytical methods used (wet oxidation vs combustion analysis). These data are shown in Figures 3.2.3 and 3.2.4. In addition, data from both Upper and Lower Jones are shown together in Figure 3.2.2, and further analysis suggests that location affects concentration. Regardless of analytical method or location, DOC contributed an average 85% or more of TOC (std. dev. 9.5%; n=184 paired TOC and DOC samples, combining both analytical methods and both tracts). Also, the combustion method has been found to produce results that are about 20% higher than the wet oxidation method. Concentrations on Lower Jones started out higher because Upper Jones was flushed out with tidal flows of fresher river water for 3 weeks while the breach was still open (Figure 3.2.4). Lower Jones was relatively isolated from the Delta channels as it was only narrowly connected to Upper Jones via a passage under a railroad trestle near the east side of the island, opposite and about 5 miles from the breach. Despite the scatter in Figure 3.2.2, the slope and correlation coefficient of $r^2 = 0.69$ are highly significant ($n = 440$; $p < 0.001$). Figure 3.2.3 shows that the correlation coefficient increases to $r^2 = 0.95$ when known sources of variation are separated by chemical fraction (DOC vs TOC), method (wet oxidation vs combustion), and sample location (Lower Jones vs Upper Jones). The 0.12 mg/L per day rate of DOC increase shown in Figure 3.2.3 is also consistent with the predicted rate of increase of about 1 mg/L per week. The prediction was based on an areal loading rate of about 0.5 gC m^{-2} day^{-1} and an average depth of about 4 meters.

The variables expected to affect OC concentration were analyzed by multivariate regression. These included time in days, location (Upper vs Lower Jones Tract), chemical species (TOC vs DOC), and laboratory analytical method (combustion or oxidation). The variables of location, chemical species, and method were represented categorically (Upper equaled zero, Lower equaled 1; TOC equals 1, DOC equals zero; oxidation equals 1, combustion equals zero).

In the first analysis, only location and time were considered. The regression equation is:

$$OC = 2.53 + 3.42(\text{Lower is } 1) + 0.114(\text{Days})$$
$$(r^2 = 95.4\%)$$

Predictor	Coefficient ± Std. Error	T	P
Constant (mg/L)	2.53 ± 0.252	10.02	<0.001
Time (Days)	0.114 ± 0.00273	41.73	<0.001
Lower Tract is 1	3.42 ± 0.196	17.46	<0.001

This can be interpreted as the OC concentration increasing at a rate of 0.114 mgC L^{-1} day^{-1}, Lower Jones Tract having an average 3.42 mg/L higher OC concentration than Upper Jones Tract, and the constant approximating the initial OC concentration of incoming water.

The analysis was expanded to include the other variables. Multivariate regression found that time, location, chemical species (DOC or TOC), and method are all significant predictors of OC, ($p<0.001$), but the variations among replicate analyses were not ($p=0.213$; $n=61$ replicates); that is, replicate analyses had no overall bias or trend. This analysis produced the regression equation:

$$OC = 3.14 + 0.129(\text{Days}) + 3.58(\text{Lower Tract is } 1) + 2.50(\text{TOC is } 1) – 2.51(\text{Oxide is } 1)$$
$$(r^2 = 89.7\%)$$

The interpretation of time and location are as before, with the flux rate somewhat larger, 0.129 mgC L^{-1} day^{-1}. Additional results were that the average difference between TOC and DOC was about 2.5 mg/L and that the oxidation analytical method produced a result about 2.5 mg/L less than that of the combustion method.

Predictor	Coefficient ± Std. Error	T	P
Constant	3.14 ± 0.249	12.59	<0.001
Time (Days)	0.129 ± 0.00241	53.60	<0.001
Lower Tract is 1	3.58 ± 0.175	20.44	<0.001
TOC is 1	2.50 ± 0.174	14.33	<0.001
Oxide is 1	-2.51 ± 0.175	-14.37	<0.001

Concentrating on DOC only, the regression results are similar. The regression equation was:

$$OC = 3.49 + 0.117(\text{Days}) + 3.56(\text{Lower Tract is } 1) - 1.27\ \text{OxidIs1}$$
$$(r^2 = 91.5\%)$$

Predictor	Coefficient ± Std. Error	T	P
Constant	3.49 ± 0.266	13.12	<0.001
Time (Days)	0.118 ± 0.00274	42.66	<0.001
Lower Tract is 1	3.56 ± 0.196	18.22	<0.001
Oxide is 1	-1.27 ± 0.195	-6.52	<0.001

3.2.4 Modeling Carbon Flux and the Problem of Depth Uncertainty

The predicted rate of OC concentration increase of 1 mg/L per week and the measured rates of increase shown in Figures 3.2.2 through 3.2.4 are based on the assumption of constant flux rate and water volume. This assumption is reasonable for about the first 50 days of the flood episode. However, after the pump-out started in the middle of July, the depth and volume of water on the island began to decrease. Unfortunately, comprehensive and accurate stage or depth data are not available as these instruments (and their data) were stolen near the end of the pump-out. Figure 3.2.5 shows 3 different estimates for the average depth of water on Jones Tract. The bottom (gray) line shows estimates from the Division of Engineering (DOE) that were sent out almost daily via an e-mail spreadsheet report. The second (dashed) line shows the Delta Modeling Group's modeled or estimated depths based on other available information. The third solid) line is based on field measurements done by MWQI staff using a boat-mounted depth sounder and a weighted tape measure. The MWQI field measurements are probably accurate to within 1 or 2 inches.

Figure 3.2.5 Average depth estimates for Jones Tract

DOE = Division of Engineering

The 3 starting depths shown in Figure 3.2.5 vary from 12 to 18 feet, but all estimates suggest that the depth declined steadily at a rate of about 0.11 feet (3.5 cm) per day. The initial DOE depth estimate of 12 feet was based on information provided by the local reclamation district. This estimate was obviously too low, as 5 feet was added to the depth on October 29 when the estimated depth reached zero but water could be seen still covering the hoods of pickup trucks out on the flooded island. DOE revised depth estimates again by adding 2 feet in November and another foot in December. Thus, with these additions, the DOE estimates suggest that the average depth of Jones might have initially been as much as 20 feet. Rainfall and seepage might have also affected the DOE estimates. Detailed topographic or bathymetric information (area capacity curves) for Upper and Lower Jones Tracts were not available at the time of the flooding or during pump-out. However, detailed land surface elevation information is available for two nearby and similar Delta islands—Webb Tract and Bacon Island (Figure 3.2.6 and 3.2.7, respectively).

Figure 3.2.6 Topography or bathymetry (area vs elevation) on Webb Tract

Figure 3.2.7 Topography or bathymetry (area vs elevation) on Bacon Island

3.2.5 Area and Volume

Most reports on the area of Jones Tract tend to be in better agreement than for depth. Most seem to agree that the total flooded area of the Jones Tract was about 12,000 acres (48.6 km^2). Reports for depth and therefore the full volume of water in Jones Tract vary substantially, from less than 100 thousand acre-feet (taf) to almost 200 taf depending on the source. MWQI depth measurements were done repeatedly using a weighted construction tape measure from a boat while moored to permanent sample station buoys. These measurements provide probably the most accurate and precise depth and, therefore, volume estimates available. The initial average depth on Jones Tract appears to have been at least 15 feet and was probably closer to 18 feet. At an average depth of 15 feet, the volume of Jones Tract is 180 taf. Initial depth measurements done by MWQI staff with a boat and depth sounder and covering large transects of both islands were consistent with a very flat (laser leveled) bathymetry and an average depth of about 15 feet.

taf = thousand acre-feet

Accurate land surface elevation measurements have been done for Bacon Island to generate area capacity curves for the CALFED In-Delta Storage Program modeling. Similar measurements and area capacity curves could be made to verify the depth and volume of Jones Tract. Bacon Island is next to Jones Tract and should be similar in terms of land surface elevation (subsidence) or depth. If Bacon Island were flooded to a stage of +2 feet mean sea level, about the same stage as Middle River and Jones Tract, the average depth on Bacon Island would be 19.1 feet.

The islands, including Jones Tract, were surveyed in January 2007 using LIDAR. These land elevation data—and therefore floodwater depth—suggest that island storage was on the order of 124,000 acre-feet, with the southeast upper tract having a higher elevation than the northwest lower tract. This, with a total area of 12,000 acres, would imply an initial depth of only approximately 10 feet. This discrepancy remains to be resolved.

LIDAR = Light Detection and Ranging, analogous to RADAR

3.2.6 Theoretical Carbon Model: Integrating Depth, Area, and Temperature

Regardless of lack of consensus on the depth and exact volume of Jones Tract, a constant areal rate of DOC flux (0.5 gC m^{-2} d^{-1}) and a linear decrease in water volume should produce a non-linear increase in DOC concentrations as volume and thus dilution capacity approach zero (e.g., the simple model illustrated by a dotted line in Figure 3.2.8). However, the DOC data shown in Figure 3.2.8 suggest that there was a relatively steady, linear increase in DOC concentrations (emphasized by the solid linear regression line). For about the first 50 days after flooding (until July 12) there was no pumping, therefore no significant decline in depth. With constant volume and flux, a linear rate of increase makes sense. The dotted line in Figure 3.2.8 represents the non-linear increase in concentration that might have been expected with constant input flux combined with declining depth (and therefore volume).

Figure 3.2.8 Lower Jones Tract DOC by wet oxidation, with predicted concentrations if volume decreased as observed and flux from peat were constant

Why was there no accelerating increase in DOC concentrations near the end of the pump-out? The answer may be that DOC flux was not constant, and in fact decreased over time. The pump-out began in summer and extended into the relatively cooler autumn. It is generally agreed that there should be a direct relationship between DOC flux (growth) and temperature (e.g., Thibodeaux and Aguilar 2005, Q_{10} temperature coefficient). Previous modeling for the CALFED In-Delta Storage Program based on DWR mesocosm data used a 0.47 gC m^{-2} d^{-1} rate during the warm, growing season (March through October) and a zero rate during the cold months of November through February. There may have been a decrease in the areal rate of DOC flux observed on Jones Tract due to declining water and flooded soil temperatures that occurred after mid-September, which was about 100 days after flooding (Figure 3.2.9, 3.2.10).

Figure 3.2.9 Water temperatures on Jones Tract

Figure 3.2.10 Monthly average water temperature at Clifton Court Forebay

3.2.7 Organic Carbon Yield Model for Jones Tract

The following organic carbon-yield model suggests that there was a relatively constant or slightly increasing yield or flux rate of about 0.5 gC m^{-2} d^{-1} for the first half of the flooded period and declining rates in the last three months, which reached a minimum of about 0.1 gC m^{-2} d^{-1} in November. Most of the differences among individual monthly rates are not statistically significant. Nevertheless, there probably was a real decline in the flux rate, especially in October and November compared to July and August, and this decline was probably related to declining water/soil temperatures.

This monthly or seasonal variation (decline) was most likely not due to an interannual or longer-term decline. Previous mesocosm (SMARTS) studies suggest that if Jones Tract had remained flooded, the lower cool season rates observed in October and November would have increased again later when temperatures rose the following spring. Based on SMARTS results, maximum rates would be expected to have reached a lower rate, something like 0.4 gC/m2/d in year 2 of flooding instead of the 0.5 gC/m2/d maximum rate initially seen in year one. This is the "tea bag effect," an interannual decline of about 0.1 gC/m2/d or about 20% from year one to year two of continuous flooding, and without re-exposure of the soils.

After pump-out began on Upper and Lower Jones Tracts there were several competing sources and sinks of TOC and DOC. The model is complicated by the changing water level as pump-out progressed. To estimate the rate at which TOC/DOC entered the water column, a model in the form of a first order linear inhomogeneous differential equation was constructed. This model assumed the change in depth is linear over a short period, evaporation and seepage are negligible compared to pump-out, the area of soil-water interface from the sides of the islands (levees) are small compared to the bottom and that convection and wind sufficiently mix the volume to maintain homogeneity. The model equation development appears in Appendix A (Organic Carbon production Model for Jones Tract).

Appendix A Organic Carbon Production Model for Jones Tract

The following quantities were measured at Jones Tract or can be directly calculated from measured quantities:

- reservoir depth and area
- total or initial volume of water
- TOC and/or DOC concentrations

The model provides the rate (*b*) at which OC enters the system per unit area of flooded land. In this differential equation model, the rate of change in the total mass of OC in the system was tracked. The model can be used with the assumptions that the flooded area is constant, that the depth and therefore volume decreases at a linear rate, and that the time scale of complete mixing is short compared to the time scale of the pump-out. Figure 3.2.5 shows that the initial average depth was about 15 feet (4.6 m) and that depth decreased linearly at a rate of about 0.11 feet (3.5 cm) per day. The model can also be used with the assumptions that the area of inundation decreased non-linearly similar to what is predicted by area capacity curves for other Delta peat islands (e.g., Figures 3.2.6 through 3.2.7). It is also assumed that the flux rate *b* is relatively constant within the time step between sample events. Defining M_{tot} as the total mass of DOC, A as the constant area of the island bottom (m^2), $b = \varepsilon * A$ as the total mass of DOC that enters from the entire area of the island bottom (gC day^{-1}), F_{out} as the pump-out rate (m^{-3} day^{-1}) and $V(t)$ is the reservoir—or flooded island—volume (m^3) at a given time t (days), the following ordinary differential equation in M_{tot} is obtained (b divided by the total area of the island gives the areal rate ε with units of (gC m^{-2} d^{-1})).

$$\frac{dM_{tot}}{dt} = b(t) - \frac{M_{tot}}{V(t)} F_{out}$$

We know the initial volume V_0 and can therefore calculate $V(t)$ at any arbitrary time t as

$$V(t) = V_0 - F_{out}\, t \qquad 1.1$$

Equation 1.1 is valid so long as the pump-out rate F_{out} is constant over a suitable interval.

The differential equation then becomes:

$$\frac{dM_{tot}}{dt} = b(t) - \left(\frac{M_{tot} F_{out}}{V_0 - F_{out}\ t} \right) \qquad 1.2$$

This can be solved to produce useful results for analysis (see Appendix A for the full derivation). The result is

$$C(t) = \frac{M_{tot}(t)}{(V_0 - F_{out} t)} = C_0 + \frac{b(t)}{F_{out}} \ln\left(\frac{V_0}{V_0 - F_{out} t}\right) \qquad 1.3$$

Or, solving for the areal flux rate in terms of measured quantities

$$\varepsilon(t) = \frac{b(t)}{A} = \frac{(C(t) - C_0) F_{out}}{A \ln\left(\frac{V_0}{V_0 - F_{out}\ t}\right)} \qquad 1.4$$

In principle, the model would produce an undefined result at the completion of pumping, when the reservoir volume reaches zero. The denominator of the natural log function ($V_0 - F_{out} t$) could be zero when the pump-out is complete. The equation would be undefined at this point, which reflects the practical reality that it is not meaningful to discuss the concentration of a zero volume solution. As a purely mathematical expression, as volume approaches zero and there is a non-zero rate of carbon (b) still entering the system, we would expect the concentration $C(t)$ to increase without bounds, as reflected by equation 1.3, above. However, this is of mathematical, rather than practical concern. The model is otherwise well behaved. For instance, at time $t = 0$, Equation 1.3 reduces simply to $C(t) = C_0$, as it should.

This equation for M_{tot} is valid for any sufficiently small step (such that the time step delta-t is not equal to 0) where we can assume the pump-out rate is about constant, and the change in volume is approximately linear. Figure 3.2.5 shows that despite a wide range in depth estimates depending on the source of the data, all data and information suggest a consistent, linear decrease in depth throughout most of the pump-out. The rate of carbon yield in gC m^{-2} d^{-1} was calculated for each time step by using the measured TOC or DOC concentration $C(t)$ at each time step delta-t and the corresponding previous concentration for the initial concentration M_0 in equation A.23 and the discrete-time equivalent M_{tot} in equations 1.2 and 1.3.

3.2.8 Model Results

Figure 3.2.11 shows the monthly areal rates (gC m^{-2} d^{-1}) of OC yield as calculated by the OC yield model (diamonds and dotted line). This figure also shows that assuming that flux rates are a strong function of temperature (Thibodeaux and Aguilar 2005), a sinusoidally varying seasonal model appears to describe well the variation in the monthly areal rates (bold line). The monthly average soil or water temperatures in the Delta appear to vary

Figure 3.2.11 Monthly average carbon yield rates in g m2 d-1, monthly average water temperature, modeled yield rate, and In-Delta Storage estimated rate

similarly (open squares; see also Figure 3.2.9 for another example of measurements specific to Jones Tract). The seasonal flux model predicts that flux would vary from about 0.5 gC m^{-2} d^{-1} during the hottest months to almost zero in January, and would vary sinusoidally, with temperature.

This model represents data from an initial year of flooding of a peat soil island. This model could also be applicable to a peat soil island that is flooded, drained, and re-flooded with peat soils exposed to air between flooding. The In-Delta Storage project of DWR's Integrated Storage Investigation (ISI) steady-state rate used in previous investigations is plotted for comparison (open triangles). Assuming the temperature-mediated flux rate model is accurate, the annual average flux rate would be approximately 0.25 gC m^{-2} d^{-1}). The annual average IDS steady state rate is 0.12 gC m^{-2} d^{-1}, varying from about 0.16 to 0.05 gC m^{-2} d^{-1}.

IDS = In-Delta Storage

ISI= Integrated Storage Investigation

Figure 3.2.12 shows the DSM2 DOC modeled fingerprint for Banks Pumping Plant. (The Delta Simulation Model, discussed briefly in Ch 2, Methods, calculates water quantity and water quality for the Delta. This figure suggests that, during the pump-out, there was a sustained DOC increase at Banks of about 1 mg L^{-1} greater than the historical observed average. This impact may have resulted from a Jones Tract total pump-out rate that averaged about 700 cfs (20 m^3 sec^{-1}). For details on how the quantities in the figure were calculated, see Chapter 2 Section 2.4.

Figure 3.2.12 DSM2 fingerprint for DOC at Banks

cfs = cubic feet per second

3.2.9 Grab Sample Results

Figure 3.2.13 shows measured DOC concentrations at Banks Pumping Plant in 2004 and the 1986 through 2003 historical mean along with the ± 95% confidence limits. The measured data from 2004 grab samples agree well with the DSM2-modeled effects shown in Figure 3.2.12. The departure of the 2004 data from the long-term mean between about July 27 and December 12 also suggests that the Jones Tract pump-out contributed about 0.5 to 1 mg/L additional DOC at Banks relative to the historical mean. The increase in DOC at the end of the year is due to basin-wide seasonal precipitation, but a baseline likely elevated by about 1 mg/L from the Jones Tract pump-out probably made this increase larger than normal.

Figure 3.2.13 DOC concentrations at Banks Pumping Plant from 2004 grab samples and the historical mean from 1986 through 2003 (n=18)

3.2.10 Carbon Isotope analysis

As part of chemical analysis of Jones Tract water samples, the relative age of the carbon in the water was measured by ^{14}C (Carbon-14) analysis. Carbon-14 is a naturally occurring radioactive isotope of carbon that comprises a small fraction of the total carbon in the ecosystem. Carbon exists in 3 isotopic forms, ^{12}C (98.9%), ^{13}C (1.1%), and ^{14}C (~1 part per trillion), all with 6 protons but differing numbers of neutrons. Carbon-14 is produced at a more or less constant rate in the atmosphere by collisions between nitrogen atoms and neutrons produced by cosmic rays. Carbon-14 decays at a constant rate: Within a population of ^{14}C atoms, half of them will decay in 5,730± 40 years. Plants, including algae, incorporate ^{14}C into their tissues during photosynthesis. Since this rate is slow relative to the movement of carbon through food chains, carbon in living biomass at earth's surface (e.g., algae or other plant matter) contains approximately atmospheric levels of ^{14}C. However, as soon as the organic material is isolated from the biological cycle through organism death and burial in the sediments, the abundance of ^{14}C begins to decline. After 5,730 years only half remains. After another 5,730 years only a quarter remains. This process is the basis of carbon dating.

Carbon-14 analysis indicates that at both Upper and Lower Jones Tracts DOC started off and remained at about 0.78 fraction modern carbon (Figure 3.2.14). This analysis of whole water DOC is difficult and elaborate and requires extraction of DOC, conversions of that dissolved material to a solid and then to CO_2 before isotopic analysis. Thus, it was only possible to analyze a small number (12) of samples relative to the hundreds of TOC/DOC analyses. Despite some apparent variation in the set of samples taken on July 8, the pattern is nevertheless consistent with a single overwhelming and old (e.g., 1,500 to 2,000 years old) carbon source like peat rather than modern carbon sources such as recent algal productivity or crop residues. The ^{14}C values are also consistent with those measured for other peat soil and agricultural drain samples studied by DWR. Table 3.2.1 lists the sample carbon and nitrogen analysis. Analyses were also performed for stable isotope ^{15}N, but results showed no clear patterns, so they are not discussed here.

Figure 3.2.14 Carbon-14 fraction of modern carbon (fmc) of Jones Tract whole water samples

Table 3.2.1 Carbon isotope analysis of Jones Tract whole water samples

Another stable isotope analytical approach involved $\delta^{13}C$ analysis (Table 3.2.1). Unlike ^{14}C, ^{13}C is stable; it does not decay radioactively. However, because ^{13}C is slightly heavier than ^{12}C, biological chemical reactions selectively take up ^{12}C and leave behind ^{13}C in a process called isotopic fractionation. As carbon moves up the food chain from atmospheric CO_2 to plants to herbivores to predators, ^{13}C becomes increasingly depleted in the tissue of each successive organism. By comparing the ratio of ^{13}C to ^{12}C in an organic sample to the ratio of ^{13}C to ^{12}C in a standard, one can discern where a particular organism fits in the food web. In this case, the method was used to compare waters from different sources.

The $\delta^{13}C$ values of whole water DOC at Jones Tract are consistent with carbon isotope values measured in other agricultural drains of the Delta. Because of overlapping ranges of variation, $\delta^{13}C$ values are unable to resolve whole water Sacramento River, San Joaquin River, and agricultural drain DOC sources, which vary from –26.3 to –27.2 per mill. The values fall within the range typical of emergent vascular plants, perhaps related to the prehistoric tules that formed the peat soils (Cloern and others 2002).

Cloern, James E., Elizabeth A. Canuel, and David Harris. 2002. *Stable carbon and nitrogen isotope composition of aquatic terrestrial plants of the San Francisco Bay estuarine system.* Limnol. Oceanogr. 47(3):713-729.

3.3 Trihalomethanes and Bromide

3.3.1 Introduction

Trihalomethanes are monitored in drinking water because they are known to be carcinogens. Trihalomethanes are chemical compounds containing 3 halogen atoms (e.g., chlorine, bromine, fluorine) substituted for the 3 hydrogen atoms normally present in a methane molecule. These compounds are formed when natural OC compounds found in water are chlorinated during the drinking water disinfection process, and are thus often referred to as disinfection byproducts (DBPs). Delta waters contain significant concentrations of OC compounds from sources in the tributary watersheds and from the Delta itself. Another DBP of concern is bromine. During chlorination, naturally occurring bromides in the water are released as bromine. The chlorine and bromine in turn react with the OC compounds to produce trihalomethanes. Bromide in Delta waters comes primarily from seawater intrusion. Previous studies have shown that the bromide-to-chloride

DBPs = disinfection byproducts

(Br/Cl) ratio at Delta monitoring stations is similar to the ratio found in seawater.

The concentrations of the DBPs chloroform, bromodichloromethane, and dibromochloromethane formed by laboratory analysis of floodwater samples are discussed in this section. Trihalomethane formation potential (THMFP) is a laboratory measure of the concentrations of DBPs after the chlorination procedure. These concentrations are measured in the laboratory after chlorination, not measured *in situ*. Trihalomethanes tested in Jones Tract samples were chloroform ($CHCl_3$), bromodichloromethane ($CHBrCl_2$) and dibromochloromethane ($CHBr_2Cl$). The concentrations of these compounds in the Jones Tract samples are also compared to the concentrations found in samples from the Middle River. We present the correlation between bromodichloromethane and concentration of bromide. We also discuss the observation that the Br/Cl ratio in the floodwater was higher than that typical of seawater. Trihalomethane precursors are believed to be in the DOC fraction in the water. The relationship between chloroform concentration and DOC is discussed in this section. The trihalomethanes are known to correlate to the ultraviolet absorption at 254 nm, and this correlation was studied in samples taken from Jones Tract floodwater.

Br/Cl = bromide to chloride

THMFP = trihalomethane formation potential

Water samples collected from Jones Tract were filtered through a 0.45-micron filter and incubated with chlorine for 7 days, buffered to pH 8.3 and at 25 °C. The individual trihalomethanes produced were identified and measured by purge and trap gas chromatography mass spectrometry.

3.3.2 Chloroform

The quantity of chloroform produced by chlorination of water samples from Jones Tract was plotted against the date of collection. Water collected from Lower Jones always produced more chloroform than water collected from Upper Jones. After the levee breach was closed in July, chloroform concentration rose rapidly. Chloroform concentrations rose to levels higher than 1,000 μg/L (1 mg/L) in both Upper and Lower Jones after August 2 (Figures 3.3.1a-b).

Figure 3.3.1a Chloroform at Jones Tract (Bryte Lab), June–Nov 2004

Figure 3.3.1b Average chloroform at Jones Tract (Bryte Lab), June–Nov 2004

The grab samples collected from Upper Jones agricultural drains from 1988 to 1991 have shown that THMFP seldom exceeded 1,500 μg/L (DWR 1994 Nov). In the floodwater in 2004, the Lower Jones chloroform concentrations were above 1,500 μg/L after August 2. This high concentration of chloroform is very likely to have been due to higher concentrations of DOC and TOC increased as the OC compounds from the peat soils continued to dissolve during the pump-out (see Section 3.2).

DWR. 1994 Nov. Five-year Report of the Municipal Water Quality Investigations Program. Summary and Findings During Five Dry Years, January 1987–December 1991.

The Lower Jones sample chloroform concentration was 1,100 μg/L on the day after the levee break. It decreased to 467 μg/L by June 23. It increased to 3,751 μg/L on October 12 and then decreased to 2,536 μg/L on November 11 near the end of the monitoring period (Figure 3.3.1a-b). During the same period (October 12 to November 22), the water temperature decreased by about 10 °C (Figures 3.3.1a-b, 3.1.1).

Chloroform concentration from the Upper Jones sample was 202 μg/L on the day after the levee break, which was comparable to the concentrations from the Middle River sample. The concentrations increased gradually to 2,204 μg/L on October 5 and then decreased to 1,720 μg/L on October 26, the last day of monitoring at Upper Jones (Figure 3.3.1a-b). Chloroform concentrations from Middle River samples were low and did not exceed 236 µg/L (Table 3.3.1a-b) between June 4 and July 7. The average and median chloroform concentration was 217 µg/L during this period (Table 3.3.1).

Table 3.3.1a Chloroform at Jones Tract (Bryte Lab), June–Nov 2004

Table 3.3.1b Average chloroform at Jones Tract (Bryte Lab), June–Nov 2004

3.3.3 Bromodichloromethane

The second highest trihalomethane formed in the Jones Tract water samples was bromodichloromethane ($CHBrCl_2$). The Lower Jones sample concentration was 83 µg/L and from Upper Jones was 52 µg/L on the day after the levee break. At Upper Jones, the concentration of bromodichloromethane peaked at 274 µg/L on October 10, 2004. The concentration from Lower Jones peaked at 326 µg/L on October 12. The concentrations from Lower Jones continued to rise, with a final measurement of 363 µg/L on November 22 (Figure 3.3.2a-b). The Middle River samples produced relatively low concentrations of bromodichloromethane that averaged 66 µg/L (Table 3.3.1b).

Figure 3.3.2a Bromodichloromethane in Jones Tract (Bryte Lab), June–Nov 2004

Figure 3.3.2b Average bromodichloromethane in Jones Tract (Bryte Lab), June–Nov 2004

3.3.4 Average Bromodichloromethane, Bromide, and Chloride at Upper and Lower Jones

Much of the bromide (and some of the chloride) in Delta waters are known to come from seawater, either from recent intrusion or from eroded marine sediments. Figure 3.3.3 shows that bromodichloromethane DBP increased as the amount of bromide increased in the water. The Br/Cl ratio in seawater is relatively constant. In Jones Tract floodwaters, the change in chloride was gradual throughout the monitoring period compared to bromide (Figure 3.3.4). The chloride concentrations from Upper and Lower Jones were very similar. However, during the monitoring period, bromide concentration was often higher at Lower Jones than Upper Jones (Figure 3.3.4). Sudden increases of bromide concentrations were seen in Lower Jones in October and November but were not observed in chloride levels (Figure 3.3.4).

Figure 3.3.3 Average bromodichloromethane and bromide at Lower Jones and Upper Jones

Figure 3.3.4 Average bromide and chloride in Jones Tract

3.3.5 Average Chloride and Sodium at Upper Jones and Lower Jones

The sodium-to-chloride ratio remains relatively constant in both Upper and Lower Jones Tracts (Figure 3.3.5). Overall concentrations increase gradually, probably due to a combination of soil leaching and evaporation. By comparing Figure 3.3.4 to Figure 3.3.5, one can see that the Br/Cl ratio in the floodwater is not constant.

Figure 3.3.5 Average chloride and sodium at Jones Tract

3.3.6 The Relationship between Bromide and Chloride at Jones Tract

Although the correlation between bromide and chloride was very low for the combined data from Upper and Lower Jones Tracts ($r^2 = 0.16$; Figure 3.3.6a), the correlation was better within Lower Jones ($r^2 = 0.55$), with a Br/Cl ratio of 0.006 (Figure 3.3.6b). This Br/Cl ratio in the Jones Tract floodwater is much higher than the seawater ratio of about 0.0034. The correlation was not significant in the Upper Jones Tract data ($r^2 = 0.013$; Figure 3.3.6c)

Figure 3.3.6a Relationship between bromide and chloride at Upper and Lower Jones

Figure 3.3.6b Relationship between chloride and bromide at Lower Jones Tract

Figure 3.3.6c Relationship between bromide and chloride at Upper Jones Tract

Previous studies have found Br/Cl ratios in the Delta-Mendota Canal and San Joaquin River of 0.0032 and 0.0031, respectively (CALFED 2000 July). The Br/Cl ratio at 10 MWQI water quality monitoring stations was 0.0035 (r^2 = 0.996; DWR 2003 July). Because the Br/Cl ratio in Jones Tract was observed to be much higher than either San Joaquin River water or typical seawater, it is possible that other sources of bromide in addition to that due to seawater may have contributed. The monitoring data itself do not enable us to positively identify other sources of bromide in the floodwater. However, there are several possible explanations for the observations.

CALFED 2000 July. Bay Delta Program, Water Quality Program.

DWR. 2003 July. The Municipal Water Quality Investigations Program Summary and Findings from Data Collected from August 1998 through September 2001.

The CALFED Water Quality Program Plan (CALFED 2000 July) suggests that residues left in the soil by fumigation with methyl bromide would increase the Br/Cl ratio in Delta waters. Although such increase in Br/Cl ratio is not found in the Delta monitoring stations, a pool of floodwater over a field may accumulate bromide if bromide residues were present in the soils. Soil fumigation with methyl bromide in the Delta ended in 2005.

It is also possible that Jones Tract floodwater, having come from Sacramento River water-dominated Middle River channels, have had an unusually low chloride concentration, and thus are producing a relatively higher Br/Cl ratio in Jones Tract. At the time of the levee break on June 4, electrical conductivity (EC) at Bacon Island was about 150 µS/cm, if the sensor was calibrated properly. The sensor jumped from about 250 to about 350 µS/cm on June 9 in the middle of the day, as if it were serviced on that day; therefore, EC on June 4 may have been higher than 150, perhaps approximately 210. A sensor nearby at Holland Tract recorded approximately 235 µS/cm.

EC = electrical conductivity

Groundwater is another possible source of excess bromide. At Empire Tract, north of Jones Tract, groundwater contains bromide thought to be of connate origin (ancient seawater pockets in the earth). The volume of drainage from the Empire Tract is low and does not increase the bromide concentrations significantly in the Delta waters (CALFED 2000 July). It is not certain whether Jones Tract has connate water that could have contributed to the observed increases in bromide.

3.3.7 Dibromochloromethane at Jones Tract

A low concentration of dibromochloromethane was detected in samples collected and chlorinated from Upper Jones breach in June. Dibromochloromethane concentrations were much smaller than the concentrations of chloroform or bromodichloromethane detected in the same period. Concentration of dibromochloromethane were below reporting limits in Upper and Lower Jones water samples collected and chlorinated from July to the end of the monitoring period (Figure 3.3.7a).

Figure 3.3.7a Dibromochloromethane at Jones Tract (Bryte Lab), June–Nov 2004

Figure 3.3.7b Average dibromochloromethane at Jones Tract (Bryte Lab), June–Nov 2004

The Middle River was sampled from June 4 to July 7. All chlorinated samples had detectable levels of dibromochloromethane, and the average concentrations were higher than in samples collected from Lower Jones (Table 3.3.1b compare to Figure 3.3.7b).

3.3.8 Ultraviolet Light Absorbance, DOC, and Trihalomethane Concentrations

Some naturally occurring water-borne organic compounds such as lignin, tannin, humic substances, and various aromatic substances strongly absorb UV light. DOC comprises a wide range of compounds and—as operationally defined by most researchers studying DOC— suspended matter that pass through 0.45 μm filters. Other studies have shown correlation between UV absorption and precursors of trihalomethanes and other DBPs (Standard Methods 1998). Filtered water samples from Jones Tract were submitted to UV light absorbance analysis to investigate these relationships.

Standard Methods. 1998. Examination of Water and Waste Water, 20th Edition.

In Jones Tract floodwaters, the UV absorbance values are correlated to the concentrations of the trihalomethane precursors. Chloroform, the most abundant trihalomethane formed in the floodwaters, was strongly correlated to the UV absorbance (Figure 3.3.8) with an r^2 value of 0.98. The bromodichloromethane was correlated to UV absorbance with an r^2 of 0.86 (Figure 3.3.9). The UV absorbance was not recorded in the samples collected after September, and whether this relationship holds for higher concentrations of chloroform and bromodichloromethane cannot be shown directly with these data. However, DOC and UV absorbance are highly correlated, and DOC, bromodichloromethane, and chloroform concentrations all continued to increase after September.

Figure 3.3.8 Relationship between UV absorbance at 254 nm and chloroform

Figure 3.3.9 Relationship between UV absorbance at 254 nm and bromodichloromethane

Because trihalomethanes are formed from DOC compounds, the relationship between DOC and chloroform was studied. The correlation coefficient, r^2, for DOC (via oxidation analysis) and chloroform concentration was 0.83 and for DOC (via combustion analysis) and chloroform concentration r^2 was 0.78 (Figures 3.3.10 and 3.3.11). However, when chloroform concentrations of 2,000 μg/L and higher were eliminated from the study and 52 observations were used, the r^2 value for DOC (oxidation) and chloroform concentrations increased to 0.91 and for DOC (combustion) and chloroform concentrations increased to 0.90 (figures not shown).

Figure 3.3.10 Relationship between dissolved organic carbon (ox) and chloroform concentrations

Figure 3.3.11 Relationship between dissolved organic carbon (comb) and chloroform concentrations

It is not clear why higher chloroform concentrations were not as well correlated with the DOC values. The chloroform concentrations of 2,000 μg/L or higher were produced from mid-September to November (Figure 3.3.1a-b). A possible explanation is that compounds such as methane are byproducts of natural decomposition of organic material under anaerobic conditions in flooded soils. Methane can easily be converted to chloroform during chlorination. Near the end of the pump-out, as water level dropped, the water sampled was naturally closer to the bottom. This water could have acquired large amounts of organic decomposition products from the peat and the field plants that resulted in chloroform production that was independent of the DOC levels.

3.3.9 Summary

Trihalomethanes are formed during drinking water chlorination. Using a laboratory method to measure the concentration of disinfection biproducts, chloroform, bromodichloromethane, and dibromochloromethane were measured at Upper Jones and Lower Jones.

The chloroform concentration at Lower Jones increased over time, and was more than 1,500 µg/L after August 2004. The concentration exceeded 1,500 µg/L at Upper Jones after September. However, in contrast, THMFP at upper Jones agricultural drains monitored from 1988 to 1991 seldom exceeded 1,500 µg/L.

Bromodichloromethane is the second highest trihalomethane formed from Jones Tract floodwaters. The bromodichloromethane concentrations increased with the increase in bromide in the floodwater.

Although both bromide and chloride come from seawater, the change in bromide concentration with time was different to the change in chloride concentration. The trends were not parallel, indicating that sources other than seawater may have been contributing.

The ratio of bromide/chloride is approximately 0.0034 in seawater and at other Delta monitoring stations. The Br/Cl ratio observed at Lower Jones was 0.006 with an r^2 value of 0.55. The ratio was higher at Jones Tract than that typically observed in the Delta. The linear correlation of bromide and chloride observed in seawater and in the water samples from the Delta was not seen in the floodwater at Jones Tract (Figure 3.3.6a-b).

Dibromochloromethane concentrations in the chlorinated samples of floodwater were below the reporting limit after the levee was repaired in July (Figure 3.3.7). Between June and September, chloroform and bromodichloromethane concentrations correlated with UV absorption at 254 nm.

DOC concentrations correlated with chloroform concentrations with an r^2 of 0.9 at chloroform concentrations less than 2,000 µg/L. Chloroform concentrations that were higher than 2,000 µg/L did not correlate as well with DOC concentrations. The higher chloroform concentrations were observed in chlorinated samples collected close to the bottom in October and November near the end of the pump-out.

3.4 Nutrients

3.4.1 Introduction

Nitrogen and phosphorus compounds found in water are often limiting macronutrients for algal growth. In turbid Delta waters, especially in deep water, light penetration is often the limiting resource. However, where water is shallow, or where mixing enables algal cells to receive enough light, or if suspended sediment settles out, nutrients can become the limiting resource. Nutrients in Jones Tract floodwater came from river water and the flooded fields of Jones Tract itself. Nitrogen and phosphorus compounds were added as fertilizers to the soils at Jones Tract as part of routine farming practices before the levee breach. Additional nitrogen and phosphorus entered the water from farm wastes, decaying plant and animal matter, and stored fertilizers.

Because a change in available nutrients can trigger algal blooms in the Delta, the nutrient concentrations were monitored from the day after the flood as part of MWQI's sampling plan. Ammonia, Kjeldahl nitrogen, nitrate, nitrite plus nitrate, total phosphorus, and orthophosphate levels were monitored in the floodwaters. During the pump-out process, 3 Middle River sampling stations were sampled for nitrite plus nitrate, nitrate, and ammonia. These concentrations were compared to the amounts generally found in the Delta monitoring stations as well as to Middle River concentrations during the monitoring period. Calculated values of Kjeldahl nitrogen concentrations minus ammonium concentrations are reported in this section to show that the organic nitrogen was very high in the floodwater.

3.4.2 Ammonia

Ammonia is a nitrogen compound (NH_3 or NH_4^+) often found in natural waters under certain conditions. Under low oxygen conditions, ammonia can be formed by microbial reduction of nitrate (NO_3). Under oxygenated conditions, another microbial pathway tends to oxidize ammonia to nitrate. A high concentration of dissolved ammonia can be toxic to fish at high pH. Ammonia can be a potent source of nitrogen for plant and algae growth in dilute concentrations, but becomes toxic at higher concentrations.

3.4.2.1 Ammonia at Jones Tract

Ammonia concentrations changed rapidly from week to week, and often the levels were below the reporting limit. When ammonia was detectable, the levels were often higher than 0.2 mg/L as N, reaching levels as high as 0.47 mg/L as N and 0.51 mg/L as N at Lower Jones discharge and Upper Jones discharge respectively (Figure 3.4.1a). Ammonia levels more than 0.5 mg/L as N were previously observed in the Sacramento River at the Hood monitoring station, which receives water from a major wastewater treatment plant. Such high levels of ammonia were not observed in the Delta during regular monitoring in 2002 and 2003 water years (DWR 2005 June). Ammonia levels varied from 0.01 to 0.14 mg/L as N in the Middle River. The average ammonia measured in Lower Jones was more than 4 times the levels in the Middle River. At Upper Jones the average ammonia levels were more than 3 times the concentrations in the Middle River (Figure 3.4.1b, Table 3.4.1). However, the pH, temperature, and other conditions were such

Figure 3.4.1a Ammonia at Jones Tract (Bryte Lab and Contract Lab), June–Nov 2004

Figure 3.4.1b Average ammonia at Upper and Lower Jones Tract (Bryte Lab and Contract Lab data)

Table 3.4.1 Average ammonia at Upper and Lower Jones Tract

that these total ammonia concentrations were well below those that are toxic to fish (EPA 1999).

EPA. 1999 Dec. 1999 Update of Ambient Water Quality Criteria for Ammonia. EPA-822-R-99-014.

The area covered by the water was mainly agricultural land, and ammonia could have been used regularly as a fertilizer. Ammonia in the Jones Tract soil and the natural degradation of organic matter under flooded and anoxic conditions could have contributed to high levels of ammonia after the levee break.

3.4.3 Kjeldahl Nitrogen at Jones Tract

The laboratory method that measures Kjeldahl nitrogen converts organic nitrogen in proteins and peptides to ammonium. Free ammonia is also converted to ammonium. All the ammonium is then quantified and reported as Kjeldahl nitrogen in mg/L as N.

Kjeldahl nitrogen was 1.8 mg/L as N on June 10 at Lower Jones, and it decreased to 1.3 mg/L on June 23. This decrease could have been due to dilution by water coming in from the Upper Jones, which had a much lower concentration of Kjeldahl nitrogen. At Lower Jones Kjeldahl nitrogen increased from June 23 to September 21 and ended at 1.8 mg/L as N. Upper Jones Kjeldahl nitrogen was 0.3 mg/L on June 10, and it gradually increased to an average of 1.8 mg/L on September 21 when the monitoring ended (Figure 3.4.2a-b).

Figure 3.4.2a Kjeldahl nitrogen in Jones Tract (Bryte Lab), June–Sep 2004

Figure 3.4.2b Average Kjeldahl nitrogen in Jones Tract (Bryte Lab), June–Sep 2004

Most values of Kjeldahl nitrogen recorded at Jones Tract between June and September were higher than 1 mg/L as N. All samples in Lower Jones, which is more isolated from the Middle River than Upper Jones, and the concentrations of Upper Jones samples after the levee repair were always higher than 1 mg/L as N. These levels are higher than those previously observed in other Delta monitoring stations (DWR 2005 June). The concentration at Middle River varied between 0.2 mg/L and 0.5 mg/L as N. The average Kjeldahl nitrogen recorded at Lower Jones and Upper Jones was about 4 times the levels seen at Middle River (Table 3.4.1). Natural decay of farm crops under water may have contributed to higher levels of Kjeldahl nitrogen at Jones Tract. The contribution from the peat soils also could have increased the Kjeldahl nitrogen in the floodwater.

3.4.4 Nitrate at Jones Tract

Nitrate is commonly found in fertilizers. During the growing season, the agricultural fields of Jones Tract may have been treated with ammonia and nitrate fertilizers. Nitrate can also be formed during decomposition of organic material in the soil. Nitrates in the soil are efficiently absorbed by plants and are converted to proteins and peptides. A large amount of chemically free nitrate is not usually found in the soil.

Initial concentrations of dissolved nitrate were 2 mg/L at the Upper Jones breach on June 4 and 21.8 mg/L at Lower Jones on the same day. The levels of nitrate became undetectable in both Upper and Lower Jones Tract in July, and then increased to detectable levels in August (Figure 3.4.3). The extreme initial Lower Jones value was not graphed as it would have reduced the resolution of the remaining data in the figure.

Figure 3.4.3 Nitrate at Jones Tract (Bryte Lab), June–Nov 2004)

The initial high levels of detectable nitrates could have been due to soluble nitrates in the Jones Tract soil. These levels became undetectable with dilution of incoming river water and uptake by algae. Because nitrates are easily absorbed by microorganisms in water, detectable levels were not seen in the Jones Tract until August. When nitrate became detectable, the concentration did not rise above 3.2 mg/L in Lower Jones and 1.8 mg/L at Upper Jones (Figure 3.4.3).

Levels of nitrate did not increase uniformly from August to November. The levels fluctuated dramatically from month to month. This may have been due to blooms and crashes of algal populations, but comparisons of nitrate with algal concentration as chlorophyll are not clear. After the levee was repaired, the nitrate found in the water was lower than the amounts seen in the San Joaquin River near Vernalis in water years 2002 and 2003 (DWR 2003 July). Nitrate levels in the Middle River varied from 0.5 mg/L to 4 mg/L during the monitoring period. The average and the median nitrate levels in the Middle River were comparable to the concentrations found in the Jones Tract floodwater (Table 3.4.1).

3.4.5 Nitrite Plus Nitrate Introduction

Nitrite is formed during decay of animal and plant material. In soil and in water, nitrite is very reactive and is quickly turned to nitrate in the presence of oxygen. The concentration of nitrite is much smaller than nitrate in most environmental settings.

3.4.5.1 Nitrite Plus Nitrate in Jones Tract

At Lower Jones east side location the concentration of nitrite plus nitrate was 5.2 mg/L as N on June 4. This observation was not graphed as it would have reduced the clarity of Figure 3.4.4b. On the same date, the level of nitrite plus nitrate at Upper Jones breach was 0.51 mg/L as N. The levels then decreased to 0.01 mg/L in Lower Jones on June 10, and 0.09 mg/L at Upper Jones on June 16. The nitrite plus nitrate levels ended at 0.45 mg/L as N and 0.22 mg/L as N at Upper Jones intake and Lower Jones Middle, respectively, on September 21 (Figures 3.4.4a-b).

Figure 3.4.4a Nitrite and nitrate in Jones Tract (Bryte Lab), June–Nov 2004

Figure 3.4.4b Average nitrite and nitrate in Jones Tract (Bryte Lab), June–Nov 2004

The nitrite plus nitrate concentrations increased and decreased periodically during floodwater monitoring from June to September. The levels of nitrite plus nitrate were lower than levels found at Delta channel monitoring stations and the San Joaquin River near Vernalis during 2002 and 2003 water years (DWR 2005 June). Nitrite plus nitrate levels in the Middle River varied from 0.12 mg/L as N to 0.75 mg/L as N during the monitoring period. The median levels of nitrite plus nitrate in the Middle River from June to September was almost 3 times the concentrations found at Upper Jones Tract (Table 3.4.1).

3.4.6 Phophorus Compounds

Phosphorus compounds are not abundant in the environment. Human activities such as artificial fertilizer use and wastewater discharge introduce phosphorus compounds to waterways. Phosphorus is a necessary nutrient for plant and animal DNA, membranes, and other tissues. It is produced by soil-weathering and recycled in water and soils in small quantities during decay of organic material. Phosphorus reacts readily and forms strong chemical bonds.

MCL = maximum contaminant level

Total phosphorus includes inorganic dissolved phosphorus (orthophosphate) as well as phosphorus contained in organic matter (organic phosphorus). A maximum contaminant level (MCL) in drinking water is not established for orthophosphate or total phosphorus. The phosphorus levels at Jones Tract were not very high, but were always measurable during the study. After the levee was repaired, total phosphorus and orthophosphate in the floodwater were comparable to levels at the H.O. Banks Pumping Plant in the Delta (DWR 2005 June).

3.4.7 Phosphorus at Jones Tract

Lower Jones east side total phosphorus was 0.66 mg/L on the day after the levee break (Figure 3.4.5a-b). It decreased to 0.15 mg/L on June 23 and increased up to 0.24 mg/L the next week. Water from Upper Jones breach had a lower phosphorus level of 0.15 mg /L on the day after the levee break, and it decreased to 0.08 mg/L the week after. It then increased to 0.14 mg/L on June 30 (Figures 3.4.5a-b). After the levee was repaired, the phosphorus levels of both Upper and Lower Jones remained relatively unchanged, ranging between 0.08 mg/L and 0.17 mg/L during monitoring, which ended on September 21.

Figure 3.4.5a Total phosphorus in Jones Tract (Bryte Lab), June–Sep 2004

After the levee was repaired, the range in total phosphorus concentrations in Upper and Lower Jones was less than those found in San Joaquin River recorded in 2002 and 2003 water years, but were comparable to or slightly more than those found in H.O. Banks Pumping Plant and Delta channel monitoring stations in 2002 and 2003 water years (DWR 2005 June). The total phosphorus at Middle River during the monitoring period varied from 0.04 mg/L to 0.09 mg/L. The average and median levels of phosphorus in the Middle River during the flood recovery process were less than half the levels found in the Jones Tract floodwaters (Table 3.4.1).

Figure 3.4.5b Average total phosphorus in Jones Tract (Bryte Lab), June–Sep 2004

3.4.8 Orthophosphate at Jones Tract

The day after the levee break, orthophosphate concentrations at Upper Jones breach and Lower Jones east side were 0.05 and 0.03 mg/L as P, respectively (Figures 3.4.6a-b). These levels fluctuated between 0.01 and 0.06 mg/L as P in Upper and Lower Jones until the levee was repaired. After the levee was repaired, the levels of orthophosphates increased and peaked in August at 0.17 mg/L as P and 0.16 mg/L as P in Upper Jones middle bottom and Lower Jones intake, respectively. All samples had a similar increase in orthophosphate in August. Compounds dissolving from agricultural soils, as well as remineralized phosphorus from plant and algae decay, may have been sources of orthophosphate at this time. The levels in both Upper and Lower Jones dropped below the reporting limit in September, and the levels remained low until the end of the monitoring. Microorganisms absorb dissolved orthophosphates, and this may have been the reason for the gradual decrease in concentrations in the water. Phosphorus may have been a limiting nutrient for algal growth during this period.

Figure 3.4.6a Orthophosphate in Jones Tract (Bryte Lab), June–Sep 2004

Figure 3.4.6b Average orthophosphate in Upper and Lower Jones Tract (Bryte Lab), June–Sep 2004

Orthophosphate levels in the Middle River varied from 0.04 mg/L as P to 0.09 mg/L as P.

3.4.9 Kjeldahl Nitrogen Minus Ammonia

Kjeldahl nitrogen quantifies the nitrogen in free ammonia and organic nitrogen. If both Kjeldahl nitrogen and ammonia are measured by the same analytical method, it is possible to calculate the concentration of the organic nitrogen by subtracting the ammonia from the Kjeldahl nitrogen measurements. Different analytical methods, however, were used by DWR's Bryte Laboratories (Bryte Lab) to analyze Kjeldahl nitrogen and ammonia in Jones Tract samples. Despite the method differences, these values provide a rough estimate of organic nitrogen concentration, and these estimates were unusually high.

On certain days, the free ammonia recorded in Jones Tract was much higher than the concentrations usually found in the Delta. This would not be unexpected if decomposition rates were very high and DO was minimal, as it was during many periods and near the soil-water interface. The difference between the Kjeldahl nitrogen and ammonia was calculated and plotted to determine whether the unusually high amount of Kjeldahl nitrogen in Jones Tract was due to the high ammonia concentrations. When the difference in Kjeldahl nitrogen and ammonia was calculated and plotted as in Figures 3.4.7a-b, however, it did not significantly reduce the total Kjeldahl nitrogen. This diagram confirms that organic nitrogen was high in the Jones Tract after the levee was repaired until the end of the monitoring period on September 21.

Figure 3.4.7a Kjeldahl nitrogen – ammonia

Figure 3.4.7b Average Kjeldahl nitrogen – ammonia

3.4.10 Taste and Odor (T&O) observations

In the past few years, taste and odor have received much attention in the discussion of potential drinking water issues related to storing water in flooded Delta islands. In late July and early August 2004, the State Water Project (SWP) and Jones Tract received extensive media attention because of taste and odor problems in drinking water. Methylisoborneol (MIB, also called 2-methylisoborneol), produced by algae, was identified as the compound that was causing the taste and odor problems. The Jones Tract water was not monitored for MIB by MWQI staff, but an unpleasant smell that may have been due to MIB was detected by field personnel during the pump-out. Samples analyzed by DWR O&M Water Quality branch found very high concentrations of MIB in July and August, 2004. The cyanobacterial algal species, *Planktothrix perornata* was identified as the main producer of MIB.

SWP = State Water Project

MIB = Methylisoborneol

The amounts of Kjeldahl nitrogen (that includes organic nitrogen) and total phosphorus (that includes organic phosphorus) had reached more than 1.0 mg/L and 0.1 mg/L, respectively, before the Jones Tract breach was closed. The Kjeldahl nitrogen concentrations at this time were about 3 times the average Middle River concentration. The total phosphorus also was much higher than the average found in the Middle River. The OC levels at Clifton Court Forebay increased by about 1 mg/L in late June to early July, and the DSM2 fingerprint shows that this amount was due to the Jones Tract water. In organic matter, carbon is covalently bonded to organic nitrogen and phosphorus. The subsequent taste and odor problems due to algae in SWP water at Banks may have been increased by high concentrations of nutrients that were transported out of Jones Tract during tidal ebb and flow and eventually drawn into Clifton Court Forebay in late June and early July. Higher summer temperatures increase algal growth in the presence of nutrients and light, and mixing in shallow water may have provided conditions favorable to algal species that produce MIB and geosmin.

3.4.11 Summary

1. Ammonia levels, when detected, were higher than the concentrations normally seen in the Delta.
2. After the levee breach was closed, nutrient levels in the floodwater were comparable with the levels in the Delta reported in 2002 and 2003 water years.
    a. Kjeldahl nitrogen levels were always above 0.1 mg/L as N. This level was higher than the amounts seen in the San Joaquin River and the Delta monitoring stations.
    b. Nitrate was not higher than levels observed in Delta channels.
    c. Nitrite plus nitrate was lower than levels at Delta channel stations and San Joaquin River.
    d. Total phosphorus and orthophosphate at Jones Tract was comparable to levels at the H.O. Banks Pumping Plant.
3. The nutrient levels in the floodwater were comparable to the levels in the Middle River during the monitoring period and found to be much higher.
    a. Average ammonia levels at Lower Jones Tract were 4 times the levels found at Middle River. The ammonia levels at Upper Jones Tract were more than twice the levels at Middle River. The high ammonia levels were probably coupled to low oxygen concentrations near the sediments.
    b. The average Kjeldahl nitrogen levels at Lower Jones Tract and Upper Jones Tract were more than 4 times the levels found at Middle River. The Kjeldahl nitrogen levels in the floodwater were high because there was increased levels of organic nitrogen in the water.
    c. The average nitrite plus nitrate levels in the Middle River were higher than the levels found at Lower and Upper Jones.
    d. Orthophosphate levels in the floodwater were comparable to the levels in the Middle River. However, the average total phosphorus levels in Upper and Lower Jones were twice the amounts found at Middle River showing that the increase in phosphorus was due to the additional organic phosphorus in the water.

3.5 Electrical Conductivity, Common Elements, Alkalinity, and Hardness

3.5.1 Introduction

EC indirectly measures the salinity of water. The concentration of ionic solutes in water determines the EC. Salinity of Delta water is influenced by seawater intrusion and the San Joaquin River that bring ionic species such as sodium (Na^+), calcium (Ca^{2+}), magnesium (Mg^{2+}), potassium (K^+), chloride (Cl^-), and sulfate (SO_4^{2-}). These ions were the major components of ionic solutes in the floodwater at Jones Tract. In addition to EC and the common elements that determine EC in the water, alkalinity and boron at Jones Tact are discussed in this section.

Total dissolved solids (TDS) is measured by evaporating filtered water to dryness and measuring the weight of the residue. This TDS derived from mineralized water consists of sodium, calcium, magnesium, potassium, chloride, sulfate, silicates, fluoride, and alkalinity (Standard Methods 1998). In Delta water, EC and TDS are strongly correlated (DWR 2005 June, DWR 2003 July).

TDS = total dissolved solids

EC was measured by 3 methods at Jones Tract. EC of grab samples was measured by field hand-held instrument and at Bryte Lab, and sondes placed in the floodwater measured EC *in situ*. EC was measured with field instruments and by the Bryte Lab from the day after the levee break. Sondes were placed at Upper Jones and Lower Jones in July and August after the levee was filled. Sonde EC measurements are comparable to the lab observations and are reported in this section.

3.5.2 Electrical Conductivity

3.5.2.1 Field and Lab Observations of Electrical Conductivity

EC data measured by field hand-held instruments and by Bryte Lab were very similar (Figures 3.5.1a-b, 3.5.2a-b). On June 4, EC at Lower Jones east side was 412 and 404 µS/cm measured in the field and at the lab, respectively. On the same day the EC was lower at Upper Jones breach. EC at Upper Jones breach was 304 and 293 µS/cm measured in the field and by the lab, respectively. This initial difference in EC between Upper and Lower Jones decreased with time, and once the breach was filled, EC in the upper and lower tracts became very similar until the end of September. As the water levels reduced faster in the Upper Jones, the EC at Upper Jones became higher than the Lower Jones. The EC at Upper Jones on October 26 was 420 and 425 µS/cm measured by field and lab methods, respectively. On the same day, the EC at Lower Jones was 386 and 392 µS/cm measured by field and lab methods, respectively. The Bryte lab measured EC of Lower Jones samples until November 22; EC was 512 µS/cm on that date.

Figure 3.5.1a EC at Jones Tract (Bryte Lab), June–Nov 2004

Figure 3.5.1b Average EC at Jones Tract (Bryte Lab), June–Nov 2004

Figure 3.5.2a EC at Jones Tract (Bryte field data), June–Oct 2004

Figure 3.5.2b Average EC at Jones Tract (Bryte field data), June–Oct 2004

3.5.2.2 EC Sonde Measurements

Sonde data were collected from Upper Jones Intake from July, after the breach was filled, through November. The data were recorded every 15 minutes. Daily average EC at Upper Jones Intake was calculated and plotted against time. The average EC increased gradually from 317 μS/cm on July 8 to 473 μS/cm on November 24. The EC readings recovered from the sonde are similar to those measured by hand-held field and lab methods (Figure 3.5.3).

Figure 3.5.3 Average specific conductivity at Upper Jones Intake (sonde data), July–Nov 2004

3.5.3 Total Dissolved Solids

3.5.3.1 Levels of Total Dissolved Solids in the Floodwater

TDS at Jones Tract was closely correlated to EC. The changes in levels of TDS were similar to the changes in EC during the same period. TDS was higher at Lower Jones east side compared to Upper Jones breach on the day after the levee break (Figure 3.5.1, 3.5.4a-b). TDS was 225 mg/L at Lower Jones and 162 mg/L at Upper Jones on June 4. This difference in TDS disappeared at Lower and Upper Jones after the levee was filled. After August as the Upper Jones water levels lowered faster with the pump-out, TDS levels became a little higher and ended at 241 mg/L on November 2. The last TDS observation at Lower Jones was 317 mg/L on November 22 (Figures 3.5.4a-b).

Figure 3.5.4a TDS in Jones Tract (Bryte Lab), June–Nov 2004

Figure 3.5.4b Average TDS at Jones Tract (Bryte Lab), June–Nov 2004

3.5.3.2 Relationship Between EC and TDS

EC is correlated to TDS with an r^2 value of 0.89 (Figure 3.5.5). The r^2 value we usually see in the Delta water, however, is closer to 0.99 (DWR 2005 June, DWR 2003 July). However, the slope of the EC vs TDS graph is 0.6, which is comparable to the slope of the graphs drawn with observations from grab samples collected from the Delta monitoring stations (Figure 3.5.5). TDS is measured by drying the filtered water sample at 105 °C. Usually, the Delta grab samples have average carbon concentrations of less than 8 mg/L. At Jones Tract, the relatively high concentration of organic carbon compounds may have contributed to higher TDS values. This may explain the greater variation in TDS values and poorer correlation with EC at Jones Tract.

Figure 3.5.5 Relationship between EC and TDS

The graphs of EC vs sodium, calcium, and magnesium and EC vs chloride and sulfate also had lower correlation than what is usually observed in Delta water (Figures 3.5.6, 3.5.7).

Figure 3.5.6 The relationship between EC and Na+Ca+Mg

Figure 3.5.7 Relationship between EC and Cl + SO4

3.5.4 Sodium

Seawater intrusions bring sodium into the Delta. Natural deposits of salts in the soil also can contribute to the amount of sodium and the salinity of Delta water. Sodium in the grab samples came from the floodwater and the Jones Tract soils. Although the amount of sodium increased with time, the concentration in Jones Tract did not go above the average concentrations seen in the Delta channels and the Delta diversion stations.

3.5.4.1 Sodium Concentrations in the Floodwater

The concentration of sodium was 33 mg/L at Upper Jones and 26 mg/L at Lower Jones on the day after the levee break. These concentrations became similar at both Upper and Lower Jones after the levee was filled. Sodium concentration increased gradually after October at Upper Jones and ended at

39 mg/L in November 2. Sodium concentration in Lower Jones increased in November and ended at 46 mg/L on November 22 (Figure 3.5.8a-b).

Figure 3.5.8a Sodium in Jones Tract (Bryte Lab), June–Nov 2004

Figure 3.5.8b Average sodium in Jones Tract (Bryte Lab), June–Nov 2004

The range in sodium concentration was 23 to 46 mg/L in the Jones Tract floodwaters. This range is much lower than the concentrations usually found in the Old River, Banks Pumping Plant, and the Delta-Mendota Canal. Because the flooding occurred in June, most of the floodwater was of low salinity. The Delta Cross Channel was open, and the reservoir releases immediately after the break brought low sodium water into Jones Tract. Once the breach was filled, seawater intrusions were prevented from entering Jones Tract. The increase in sodium at the end of the pump-out could be the result of several mechanisms, such as leaching from soils, groundwater flow under the levees, or evaporation.

3.5.5 Calcium

Calcium was brought into the Jones Tract with floodwater, but it also occurs naturally in soils. Calcium is a component of fertilizers used at Jones Tract.

3.5.5.1 Calcium Concentration in the Water

The concentration of calcium at Upper Jones was 16 mg/L and at Lower Jones was 22 mg/L on June 4. The difference in concentrations between Upper and Lower Jones reduced with time and became nearly identical after the levee was repaired. From September, the concentrations increased in Upper Jones and ended at 22 mg/L on November 11. Lower Jones calcium levels increased in November and ended at 32 mg/L on November 22 (Figures 3.5.9a-b).

Figure 3.5.9a Calcium in Jones Tract (Bryte Lab), June–Nov 2004

Figure 3.5.9b Average Calcium at Jones Tract (Bryte Lab), June–Nov 2004

The range in calcium concentrations was 15 to 32 mg/L at Jones Tract. This range was higher than the concentrations observed in 2002 and 2003 water years at Banks Pumping Plant (11 – 23 mg/L) and Old River at Bacon Island (10 – 20 mg/L). The range, however, was lower than at Vernalis (17 – 50 mg/L) in 2002 and 2003 water years (DWR 2005 June). The slightly higher calcium levels at Jones Tract may be due to calcium dissolving from soils into the floodwater.

3.5.6 Magnesium

Magnesium was brought into the Jones Tract by floodwater. It also occurs naturally in soils and is a component of fertilizers.

3.5.6.1 Magnesium in the Floodwater

On June 4 the magnesium level at Lower Jones East Side was 10 mg/L; at Upper Jones breach, it was 9 mg/L. The magnesium levels at Lower Jones and Upper Jones were similar throughout the monitoring. When the monitoring ended, the magnesium concentration at Upper Jones was 11 mg/L on November 2, and at Lower Jones, it was 14 mg/L on November 22 (Figures 3.5.10a-b).

Figure 3.5.10a Magnesium in Jones Tract (Bryte Lab), June–Nov 2004

Figure 3.5.10b Average magnesium in Jones Tract (Bryte Lab), June–Nov 2004

The range in magnesium concentration at Jones Tract was 8 to 14 mg/L. This level is comparable to magnesium found in Old River at Bacon Island (8 – 14 mg/L), and Old River at Station 9 (7 – 15 mg/L) in 2002 and 2003 water years. The concentration of magnesium in the San Joaquin River near Vernalis (9 -26 mg/L) in 2002 and 2003 water years was higher than the amounts observed at Jones Tract.

3.5.7 Potassium

Seawater intrusions bring potassium into the Delta. It is an essential element in fertilizers. Plants actively absorb potassium against the concentration gradient and accumulate it in the plant cells.

3.5.7.1 Potassium in the Floodwater

Potassium levels were 6.6 mg/L at Lower Jones and 1.7 mg/L at Upper Jones on June 4. The concentration at Lower Jones reduced to 3.8 mg/L on June 10. The concentration of potassium increased gradually at both Lower Jones and Upper Jones from mid-June to mid-October. In November the concentrations fell at both sites and ended at 3.6 mg/L at Upper Jones on November 2 and 5.4 mg/L at Lower Jones on November 22. Throughout the monitoring the potassium levels were higher at Lower Jones compared to Upper Jones (Figures 3.5.11a-b).

Figure 3.5.11a Potassium in Jones Tract (Bryte Lab), June–Nov 2004

Figure 3.5.11b Average potassium in Jones Tract (Bryte Lab), June–Nov 2004

3.5.8 Chloride

Seawater intrusions bring chloride into the Delta. Therefore, irrigation water in the Delta has chloride. Every year Delta fields are flooded and pumped out during late fall or early winter to reduce salts in the soils. Chloride in the Jones Tract was derived from floodwater and the salts in the soils.

The change in chloride levels in Upper Jones and Lower Jones was similar to the change in sodium (Figures 3.5.8, 3.5.12a-b). This observation was expected, as both ions come into the Delta with the seawater.

Figure 3.5.12a Chloride in the Jones Tract (Bryte Lab), June–Nov 2004

Figure 3.5.12b Average chloride in Jones Tract (Bryte Lab), June–Nov 2004

3.5.8.1 Chloride in the Water

Chloride level at Lower Jones East Side was 44 mg/L and at Upper Jones breach was 30 mg/L on June 4. The levels became 33 mg/L at Lower Jones and 26 mg/L at Upper Jones on June 10. The levels at both Upper and Lower Jones became quite similar after the levee was filled and remained that way until September 21. After September, chloride at Upper Jones discharge became higher than the Lower Jones discharge and ended at 54 mg/L on November 2. The chloride level at Lower Jones ended at 58 mg/L on November 22. The range in chloride level at Jones Tract was 23 to 58 mg/L (Figure 3.5.12).

3.5.9 Sulfate

Sulfate at Jones Tract came from the floodwater, soil, and fertilizers. The sulfate at Lower Jones was 44 mg/L and at Upper Jones was 25 mg/L on June 4. The sulfate level reduced to 30 mg/L at Lower Jones and 22 mg/L at Upper Jones on June 10. The levels in Upper Jones and Lower Jones remained between 20 to 32 mg/L until October 26. After that the Lower Jones sulfate levels increased gradually and ended at 59 mg/L on November 22. The sulfate range was 20–59 mg/L at Jones Tract. These levels are higher than the levels found in Old River at Station 9 (10–28 mg/L) and Old River at Bacon Island (8–40 mg/L) in 2002 and 2003 water years. The sulfate at Jones Tract, however, was lower than the concentrations observed in San Joaquin River near Vernalis (40-157 mg/L) in 2002 and 2003 water years (Figure 3.5.13a-b).

Figure 3.5.13a Sulfate in Jones Tract (Bryte Lab), June–Nov 2004

Figure 3.5.13b Average sulfate in Jones Tract (Bryte Lab), June–Nov 2004

3.5.10 Alkalinity

Alkalinity measures the sum of all titratable bases. It indicates the acid-neutralizing capacity of water. It mainly measures carbonate, bicarbonate, and hydroxide concentration in water. Borate, phosphate, and silicate also contribute to the alkalinity measurement.

Alkalinity at Jones Tract came from the soil and the floodwater. Phosphate and silicate in the soils contribute to this measurement.

3.5.10.1 Alkalinity at Jones Tract

Alkalinity at Lower Jones was 52 mg/L as $CaCO_3$, and Upper Jones was 67 mg/L as $CaCO_3$ on June 4. After the levee was fixed, alkalinity was 75 mg/L as $CaCO_3$ in Upper and Lower Jones on July 15. The alkalinity increased gradually in Upper Jones and ended at 88 mg/L as $CaCO_3$ on November 2. The alkalinity was lower at Lower Jones compared to Upper Jones during the major part of the monitoring period. In November alkalinity increased gradually at Lower Jones and ended at 99 mg/L as $CaCO_3$ on November 22 (Figure 3.5.14a-b).

Figure 3.5.14a Alkalinity at Jones Tract (Bryte Lab), June–Nov 2004

Figure 3.5.14b Average alkalinity at Jones Tract (Bryte Lab), June–Nov 2004

Range in alkalinity at Jones Tract was 52 to 105 mg/L as $CaCO_3$. This range is comparable to the alkalinity observed at Old River at Bacon Island (54 – 89 mg/L as $CaCO_3$) and Old River at Station 9 (55 -90 mg/L as $CaCO_3$) in 2002 and 2003 water years (Reference MWQI report 2003).

3.5.11 Dissolved Hardness

Hardness is defined as the sum of calcium and magnesium concentrations expressed as calcium carbonate in mg/L. Floodwater, soil, and fertilizers in Jones Tract contributed to the measurement of total calcium and magnesium.

The hardness vs time graph (Figure 3.5.15a-b) is very similar to the calcium concentration vs time (Figure 3.5.9). This may be due to the concentration of calcium in Jones Tract (range = 15–32 mg/L) that is about double the magnesium (range = 8–14 mg/L). Therefore, calcium concentration will contribute more toward the measurement of hardness.

Figure 3.5.15a Dissolved hardness at Jones Tract (Bryte Lab), June–Nov 2004

3.5.11.1 Hardness in the Floodwater

Hardness at Lower Jones and Upper Jones on June 4 was 96 and 77 mg/L as $CaCO_3$, respectively. From June 30 to October 5, the hardness measure at Jones Tract was between 80 and 100 mg/L as $CaCO_3$. Hardness at Lower Jones climbed after this date and ended at 138 mg/L $CaCO_3$ on November 22 (Figure 3.5.15)

Figure 3.5.15b Average dissolved hardness at Jones Tract (Bryte Lab), June–Nov 2004

Range in hardness at Jones Tract was 70 to 138 mg/L as $CaCO_3$. This range was higher than Banks Pumping Plant (52–113 mg/L as $CaCO_3$), Old River at Station 9 (52–111 mg/L as $CaCO_3$), and Old River at Bacon Island (50-117 mg/L as $CaCO_3$) observations for 2002 and 2003 water years. Hardness at Jones Tract in 2004 was lower than observations at San Joaquin River near Vernalis (75 -227 mg/L $CaCO_3$) in 2002 and 2003 water years (DWR 2003 July).

3.5.12 Boron

Seawater intrusions bring boron into the Delta. Western San Joaquin Valley has boron-rich groundwater. The boron that was monitored in the water at Jones Tract after the levee break came from the floodwater as well as the soils in the fields.

3.5.12.1 Boron in the Floodwater

Boron at Lower Jones East Side was 0.2 mg/L on June 4. Boron at Lower Jones fluctuated between 0.1 and 0.2 mg/L throughout the monitoring.

The boron concentration at Upper Jones breach was 0.1 mg/L on June 4. From June 10 to 23, boron was not detectable at Upper Jones. After the levee was filled, boron concentration at Upper Jones remained constant at 0.1 mg/L. The range in boron concentration at Jones Tract was 0.1 to 0.2 mg/L (Figures 3.5.16a-b). This level is similar to concentrations found at Old River at Station 9 (range 0.1–0.3 mg/L) and Old River at Bacon Island (0.1 mg/L) in 2002 and 2003 water years. The boron concentrations in Jones Tract in 2004 was lower than the San Joaquin River near Vernalis (range = 0.2–0.8 mg/L) observations in 2002 and 2003 water years.

Figure 3.5.16a Boron in Jones Tract (Bryte Lab), June–Nov 2004

Figure 3.5.16b Average boron in Jones Tract (Bryte Lab), June–Nov 2004

3.5.13 Middle River

The constituents that were measured in the floodwater were also measured in the Middle River. After the levee was filled, 3 stations in the Middle River were sampled. The EC, TDS, chloride, and sodium levels at Middle River were comparable to the concentrations found in the floodwater. Some elements that are in fertilizers, however, were in higher concentrations in the floodwater. Potassium, an essential macronutrient for plant growth, is not found in abundance in nature. The floodwater contained much more of the element than river water. Calcium also is added with fertilizers, and the concentration in the floodwater was more than the river water. The slightly higher calcium levels corresponded to a little higher alkalinity and hardness in the floodwater compared to the river water (Tables 3.5.1, 3.5.2).

Table 3.5.1 Alkalinity

The boron levels in the Middle River were often below the reporting limit (Table 3.5.2). The boron levels were detectable in all the samples of floodwater after the levee was filled (Figure 3.5.16a-b). In some cases, boron is applied as a micronutrient to plants. Whether the boron came from the fertilizers or from other sources of boron in Jones Tract cannot be determined from our data.

Table 3.5.2 Water hardness and boron concentrations

3.5.14 Summary

1. Seawater intrusions and the San Joaquin River bring sodium (Na^+), calcium (Ca^{2+}), magnesium (Mg^{2+}), potassium (K^+), chloride (Cl^-), and sulfate (SO_4^{2-}) into the Delta. These were the major ions in the floodwater at Jones Tract.
2. These ions determine the EC of the water. EC was measured by field instruments, standard laboratory methods, and sondes. All these methods gave similar results. The EC at Jones Tract did not rise above 512 μS/cm (Figure 3.5.1).
3. The changes in EC, TDS, sodium, calcium, magnesium, chloride, and hardness were very similar (Figure: 3.5.1, 3.5.4, 3.5.5, 3.5.6, 3.5.7, 3.5.9, 3.5.12). In all cases the concentrations were higher at Lower Jones than Upper Jones just after the levee break. After the levee breach was closed, the concentrations were very similar in both Lower Jones and Upper Jones. In October, as the water levels dropped faster at Upper Jones the amounts increased and became higher than Lower Jones. In November, as the water levels became lower at Lower Jones the concentrations increased and ended at the highest values on November 22.
4. The correlation of EC to TDS was lower than that previously observed in Delta water. Higher than normal concentrations of carbon compounds that accumulated during the pump-out may have skewed the TDS readings.
5. Potassium concentration at Lower Jones Tract was higher than at Upper Jones Tract throughout the monitoring (Figure 3.5.11). Potassium levels were higher in the floodwater compared to the Middle River.
6. Sulfate at Lower Jones Tract was higher than Upper Jones until the end of October (Figure 3.5.13).
7. Before the levee break was repaired, alkalinity was lower at Upper Jones Tract than at Lower Jones Tract. After the levee was filled, the Upper Jones Tract alkalinity was higher than the Lower Jones until the end of October (Figure 3.5.14).
8. When detected, the concentration of boron at Jones Tract was between 0.1 and 0.2 mg/L (Figure 3.5.16). Boron was always present in samples collected after the levee was repaired, but levels of boron could not be detected in most samples collected from the Middle River (Table 3.5.2).

3.6 Trace Elements

3.6.1 Introduction

This section discusses the presence of iron, manganese, zinc, aluminum, nickel, arsenic, barium, chromium, copper, strontium, molybdenum, vanadium, cobalt, lithium, selenium, antimony, mercury, and lead. All these elements were monitored from July, after the levee breach was closed. On July 21, grab samples were collected for trace element analysis from 4 different stations at Upper Jones. Upper Jones intake, Upper Jones middle bottom, and Upper Jones middle top were discontinued after this date and Upper Jones discharge was monitored until November. Grab samples were collected from Lower Jones discharge from July 28 to November 22 for trace element analysis.

In large quantities, these metals are harmful to human health. To protect the drinking water, federal or California standards have been established for most of these metals. Primary MCLs established by the federal government are enforceable, but federal secondary MCL cannot be enforced. Secondary MCLs established by the State are enforceable. Taste, odor, and color of drinking water are affected when MCLs are exceeded.

At Jones Tract all the above elements were below MCLs except iron and manganese. Secondary federal MCLs for iron and manganese are 0.3 mg/L and 0.05 mg/L, respectively. Concentrations of iron and manganese exceeded these levels during the monitoring. Clothes may be stained and characteristic taste and odor will be detected in the drinking water when iron and manganese concentrations exceed the MCLs.

3.6.2 Anoxic Conditions, Iron, and Manganese

Sondes were floated 1 meter below the water surface (see Chapter 2 Methodology for locations). These instruments did not record oxygen levels close to the bottom. Grab samples, however, showed that the oxygen levels were far below those recorded close to the surface.

Usually in nature, iron and manganese are found in soluble ferric and manganic compounds. At Jones Tract the iron and manganese concentrations exceeded the federal MCL levels of 0.3 mg/L for iron and 0.05 mg/L for manganese.

Jones Tract showed reddish-brown mottling as the water receded (Figure 3.6.1). Similar phenomena are known to occur in wetland soils that flood intermittently. Wetland soils flooded for an extended time become blue-gray due to chemical reduction of iron to ferrous compounds. Wetting and drying processes, however, form mottles on the soil by reoxidation of ferrous compounds to ferric compounds. Intermittently exposed wetland soils form spots (mottles) that are orange reddish-brown due to oxidized iron, and reddish-brown black because of manganese (Mitsch and Gosselink 1993). Mottling is mediated by microbial processes in anaerobic conditions. Such mottling needs sustained anaerobic conditions, temperatures higher than 5 °C and the presence of organic matter as substrate for microbial activity.

Figure 3.6.1 Mottle formation at Upper Jones Tract as the water receded from the shore (photo)

Mitsch, W.J. and J.G. Gosselink. 1993. Wetlands. Van Nostrand Reinhold New York Publication.

The mottling seen at Upper Jones may show an underlying problem of these soils contributing dissolved iron and manganese to the floodwater. Jones Tract floodwater had more than a normal concentration of iron and manganese. The mottling effect seen on the soil after the water receded may indicate that the microbial activity was similar to those in intermittently flooded wetlands. When soils are covered by water and anaerobic conditions prevail, iron in the soil becomes transformed to ferrous ions and manganic compounds to manganous compounds (Mitsch and Gosselink 1993). Ferrous ions dissolve easily, increasing the iron concentration in water. Similarly, manganous compounds dissolve in water increasing the concentration of manganese in the water.

3.6.3 Iron

Iron at Upper Jones was 0.141 mg/L on July 21. The iron concentration at Upper Jones fluctuated until the end of the monitoring. The iron concentration did not rise above the MCL of 0.3 mg/L at Upper Jones.

Iron at Lower Jones discharge was 0.184 mg/L on July 28. On August 5, the level rose to 0.347 mg/L. The iron concentrations fluctuated between 0.184 and 0.643 mg/L at Lower Jones, and most of the time the levels were above the MCL of 0.3 mg/L. The iron concentration at Lower Jones discharge was usually higher than Upper Jones discharge (Figure 3.6.2).

Figure 3.6.2 Iron at Jones Tract (Bryte Lab), July–Nov 2004

The higher iron concentration at Lower Jones Tract may have been due to a difference in anaerobic conditions during the pump-out. Lower Jones water depths would have been generally deeper, and perhaps more strongly anoxic conditions. Or, perhaps less likely, there was an underlying difference in soil iron concentration in the two tracks.

3.6.4 Manganese

Average manganese concentration from 4 stations at Upper Jones was 0.021 mg/L on July 21. The concentration at Upper Jones discharge increased to 0.083 mg/L on July 28. Manganese levels were usually less than the Lower Jones discharge. The amount of manganese was undetectable on July 28 at Lower Jones discharge. These levels gradually rose to 0.047 mg/L on August 5. The levels fluctuated throughout the monitoring. The concentration of manganese at Upper and Lower Jones, however, was usually above the MCL. The manganese level at Lower Jones sharply increased from November 2 and ended at 0.401 mg/L on November 22 (Figure 3.6.3).

Figure 3.6.3 Manganese in the Jones Tract (Bryte Lab), July–Nov 2004

In anaerobic conditions insoluble manganic compounds in wetland soils are reduced to soluble manganous compounds (Mitch and Gosselink 1993). Such transformations are prevalent in organic peat soils in the wetlands. Since Jones Tract soils contained high concentration of peat, similar reduction of manganese compounds could have occurred after the soil was covered by the floodwater.

3.6.5 Zinc

On July 21, the average zinc concentration from samples collected from 4 stations at Upper Jones was 0.013 mg/L. The concentration at Upper Jones declined and became undetectable on August 5. Zinc was detected again on August 19 at 0.014 mg/L and then became undetectable until the end of the monitoring.

Zinc was undetectable at Lower Jones on July 28. When detected, the levels fluctuated between 0.006 mg/L to 0.334 mg/L. Zinc levels were usually low and undetectable (Figure 3.6.4).

Figure 3.6.4 Zinc in Jones Tract (Bryte Lab), July–Nov 2004

3.6.6 Aluminum

Average aluminum at Upper Jones was 0.018 mg/L on July 21. Aluminum was undetectable at Upper and Lower Jones on July 28. The levels increased and decreased periodically at both Upper Jones and Lower Jones. The pattern of change in aluminum levels at both Upper and Lower Jones was similar. However, the concentrations at Lower Jones were usually higher than those of Upper Jones (Figure 3.6.5). The aluminum concentration at Jones Tract never exceeded the MCL of 0.2 µg/L.

Figure 3.6.5 Aluminum in the Jones Tract (Bryte Lab), July–Nov 2004

3.6.7 Nickel

Nickel concentration at Upper Jones Tract was 3 µg/L on July 21. On July 28 the nickel concentration at Lower Jones was 4 µg/L. The nickel levels fluctuated and gradually increased at Upper Jones and Lower Jones until the end of the monitoring. On the last day of monitoring, nickel concentration at Upper Jones was 5 µg/L and at Lower Jones was 8 µg/L (Figure 3.6.6). The concentration of nickel at Jones Tract increased from July to November but never reached the MCL of 100 µg/L.

Figure 3.6.6 Nickel at Jones Tract (Bryte Lab), July–Nov 2004

3.6.8 Arsenic

On July 28 arsenic at Lower Jones was 6 µg/L and at Upper Jones 5 µg/L. The concentrations gradually decreased and ended at 4 µg/L at Lower Jones and 3 µg/L at Upper Jones (Figure 3.6.7). Arsenic levels never exceeded the MCL of 50 µg/L.

Figure 3.6.7 Arsenic in Jones Tract (Bryte Lab), July–Nov 2004

3.6.9 Barium

Barium levels at Upper Jones and Lower Jones were usually undetectable. From July to August the barium levels were detectable on 3 different days at Upper Jones. On August 2 and 23 barium was detectable at Lower Jones. When detected, the concentration of barium was lower at Lower Jones compared to Upper Jones (Figure 3.6.8). The barium levels at Jones Tract never exceeded the MCL of 2 mg/L.

Figure 3.6.8 Barium in Jones Tract (Bryte Lab), July–Nov 2004

3.6.10 Chromium

The chromium level at Upper Jones intake was 2 µg/L on July 21. On the same day, all other Upper Jones stations had chromium levels of 1 µg/L. Chromium level at Lower Jones discharge was 2 µg/L on July 28. The chromium content in Upper and Lower Jones was similar during most of the monitoring, and the concentrations fluctuated between 1 µg/L to 4 µg/L (Figure 3.6.9). Chromium levels did not exceed the MCL of 100 µg/L.

Figure 3.6.9 Chromium at Jones Tract (Bryte Lab), July–Nov 2004

3.6.11 Copper

Copper at Upper Jones Middle (Bottom) was 1 µg/L on July 7. All other stations at Upper Jones Tract had copper concentration of 2 µg/L on the same day. The concentrations of copper at Upper Jones Tract fluctuated between 1 and 5 µg/L and ended at 3 µg/L on November 22 (Figure 3.6.10).

Figure 3.6.10 Copper at Jones Tract (Bryte Lab), July–Nov 2004

Copper at Lower Jones Tract was 2 µg/L on July 28. The concentration at Lower Jones fluctuated between 2 µg/L and 4 µg/L and ended at 3 µg/L on November 22. Copper concentrations did not exceed the MCL of 1.3 mg/L.

3.6.12 Other Trace Elements

Concentrations of strontium, molybdenum, vanadium, cobalt, lithium, selenium, and antimony were monitored on 2 days in July. Mercury was monitored from August to September, and lead was sampled from July to November (Table 3.6.1).

Table 3.6.1 Trace elements

Strontium is in the same group of elements as calcium and magnesium. There is no MCL for strontium in the drinking water standards. The strontium concentration ranged from 0.307 mg/L to 0.354 mg/L at Jones Tract.

Molybdenum concentrations varied between 7 and 8 µg/L in July. Vanadium concentrations varied from 5 to 6 µg/L. Vanadium and molybdenum do not have defined MCLs. Although there is no MCL for molybdenum, the concentrations were below the US Environmental Protection Agency (EPA) lifetime health advisory for molybdenum in drinking water of 40 µg/l. Cobalt, lithium, selenium, antimony, mercury, and lead levels were below detection limits at Jones Tract.

3.6.13 Trace elements in the Middle River

California Regional Water Quality Control Board required that DWR monitor the receiving water when discharging Jones Tract water into the Middle River. Tables 3.6.2a-b shows some of the elements that were monitored in the Middle River. In the Middle River, concentrations of all the elements never rose above the MCLs.

Tables 3.6.2a-b Summary of inorganic metallic constituents

The average amount of iron in the Lower Jones Tract was about 7 times that of the Middle River, and the concentrations at Upper Jones Tract were above 3 times the amount in the river water. Similarly, the average manganese concentration in the Lower Jones Tract was above 7 times the concentration at Middle River. The Upper Jones Tract average manganese was about 4 times the Middle River concentration.

3.6.14 Summary

1. Iron, manganese, zinc, aluminum, nickel, arsenic, barium, chromium, copper, strontium, molybdenum, vanadium, cobalt, lithium, selenium, antimony, mercury, and lead were monitored at Jones Tract. Most of these have MCLs published by the EPA to maintain adequate drinking water standards.
2. Iron and manganese levels were recorded above the MCL at the Jones Tract. This may have been brought about by the anaerobic conditions near the bottom during the pump-out. In organic wetland soils, anaerobic conditions and temperatures higher than 5 °C transform insoluble ferric and manganic compounds to soluble ferrous and manganous compounds.
3. Average concentrations of iron and manganese at Lower Jones were about 7 times the amount found in the Middle River. The average concentration of iron and manganese at Upper Jones was about 3 to 4 times the concentration at Middle River.
4. When the water receded during the pump-out, red and orange mottling was seen on the exposed soil. This may be due to re-oxidation of ion and manganous compounds on the soil.
5. Zinc, aluminum, nickel, arsenic, barium, chromium, copper, molybdunum, and vanadium concentrations did not exceed the MCL.
6. Cobalt, lithium, selenium, antimony, mercury, and lead were undetectable in the floodwater at Jones Tract.

3.7 Pesticides

3.7.1 Introduction

According to the California County Agricultural Commissioner Disaster Report, the crops planted at Jones Tract before the flooding were alfalfa, asparagus, grain corn, sweet corn, tomatoes, wheat, potatoes, turf grass, and blueberries. Crops were destroyed on approximately 12,671 acres, resulting in an estimated monetary loss of $14.4 million. The San Joaquin County Agriculture Commissioners Office lists potential pesticides used and/or stored on Upper and Lower Jones Tracts. Floodwater at the site was tested for potential pesticide residues during the pump-out period (Table 3.7.1, Table 3.7.2). The majority of pesticides listed were not found in the water at detectable levels. A summary of the findings by pesticide type are listed below.

Table 3.7.1 Metolachlor pesticide concentrations

Table 3.7.2 Diazinon concentrations

3.7.2 Metolachlor

Metolachlor is applied to the soil before plant growth (pre-emergent). It is used primarily in corn fields to control the growth of different grasses. It is readily absorbed by muck and is less mobile in organic soils. Metolachlor is relatively non-persistent in soil and rapidly deteriorates in fields.

Figure 3.7.1a Metolachlor (herbicide) at Jones Tract (Bryte Lab), June–Nov 2004

The data collected from the San Joaquin County Agricultural Commissioner’s Office indicate that s-Metolachlor, a pesticide, was used and stored at Upper and Lower Jones Tracts.

Metolachlor was repeatedly detected in both Upper and Lower Jones throughout the monitoring period. Most measurements indicated that concentrations of s-Metolachlor were greater at Upper Jones compared to Lower Jones (Figure 3.7.1a-b). Concentrations, however, did not exceed the MCL. Metolachlor concentrations in the Middle River were undetectable.

Figure 3.7.1b Average metolachlor (herbicide) at Jones Tract (Bryte Lab), June–Nov 2004

3.7.3 Diazinon

The product Diazinon was taken off the market in 1983. Before it was removed from the market, it was used as a pesticide to kill insects and worms otherwise harmful to vegetation. On Jones Tract, it was used to protect planted corn seed.

Diazinon levels were monitored at Upper Jones and Lower Jones from June 4 to September 2. On June 11 a sample collected from Lower Jones East side measured 0.01 µg/L of Diazinon (Figure 3.7.2). Other samples did not measure detectable levels of Diazinon. Diazinon was not detected in water samples taken from Middle River.

Figure 3.7.2 Diazinon (pesticide) at Jones Tract, June–Sep 2004

3.7.4 Molinate

Molinate is toxic to germinating broad-leaf and grassy weeds. Molinate was present at Upper and Lower Jones Tracts just after the levee break. Levels of Molinate detected at Upper Jones Tract were higher than measurements taken at Lower Jones. These levels were far below the MCL set by the California Drinking Water Standards for treated water. Molinate became undetectable after July.

Figure 3.7.3 Molinate (pesticide) in Jones Tract (Bryte Lab), June–Sep 2004

Water samples taken from Middle River in June show Molinate concentrations equal to or more than those measured at the Upper Jones breach during the same sampling period (Figure 3.7.3).

3.7.5 Atrazine

Atrazine is used to control broad-leaf and grassy weeds in corn fields. It breaks down over time by microbial activity in normal soil and water. It is applied to soils before and after planting. Atrazine is on the list of pesticides used and stored at Upper and Lower Jones Tracts at the time the flooding occurred.

Samples of water taken from Upper Jones and Lower Jones Tract through the monitoring period showed detectable levels of Atrazine (Figure 3.7.4a-b). Concentrations of Atrazine were higher at Lower Jones than at Upper Jones. All samples had concentrations below the MCL of 3 parts per billion (µg/L). Water samples taken from Middle River on June 23 and June 30 contained Atrazine concentrations of 0.03 µg/L and 0.02 µg/L levels, respectively (Figure 3.7.3). The higher concentrations within the island relative to the Middle River may imply that Atrazine detected at the Upper Jones and Lower Jones sampling locations came from storage and application sites in the tracts.

Figure 3.7.4a Atrazine in the Jones Tract (Bryte Lab), June–Nov 2004

Figure 3.7.4b Atrazine in the Jones Tract (Bryte Lab), June–Nov 2004

Table 3.7.3 Molinate concentrations at Jones Tract

3.7.6 Diuron

Diuron was used as a pesticide and stored at Upper and Lower Jones Tracts. Diuron levels were below detectable limits in water samples taken from Middle River in June and July. There is no sampling data available from Middle River for the remainder of the monitoring period.

Diuron was detected consistently at both the Upper and Lower Jones Tract discharge sites throughout the monitoring period. As the island was drained off, the levels of detectable Diuron decreased to around or below the detectable limit (Figure 3.7.5a).

Figure 3.7.5a Diuron (herbicide) at Jones Tract (Bryte Lab), June–Nov 2004

Figure 3.7.5b Average Diuron (herbicide) at Jones Tract (Bryte Lab), June–Nov 2004

3.7.7 Simazine

Simazine is a pre-emergence herbicide used to control broad-leaf and grassy weeds in corn fields. It was applied at the Jones Tract fields between January and May of 2004. The EPA MCL for Simazine in drinking water is 4 parts per billion.

Simazine levels were below detectable limits in samples taken from Middle River (Figure 3.7.6). The Lower Jones Tract discharge site measured levels of Simazine near the detection limit in the beginning of the monitoring period, but levels fell below the detection limit after August 5. Samples from Upper Jones discharge site never measured amounts of Simazine above the detection limit. All the samples from the Jones Tract contained Simazine at levels below the MCL.

Figure 3.7.6 Simazine (pesticide) at Jones Tract (Bryte Lab), June–Nov 2004

3.7.8 Trifluralin

Trifluralin is an herbicide used to control annual grasses and weeds in fields growing fruits and vegetables. It was used and stored between January and May of 2004 at Jones Tract. Trifluralin does not have an established MCL defined by the EPA.

Trifluralin was not detected in Middle River during the period samples were taken (Figure 3.7.7). Upper and Lower Jones Tract discharge sites never measured at levels above the detectable limit of 0.01µg/L.

Figure 3.7.7 Trifluralin (pesticide) in Jones Tract (Bryte Lab), June–Sep 2004

3.8 Organic Compounds

On the morning of June 3, 2004, when the Jones Tract breach occurred, fields were inundated with water from the Middle River. As a result of this unexpected inundation, equipment used for daily farming operations was submerged. Most farm equipment remained in the flooded fields until enough water was pumped off the island and it could be safely and properly removed. The equipment used for daily farming operations used petroleum-based organic compounds in the form of diesel, oil, and gasoline for fuel and lubrication. A consequence of the farming equipment being submerged for such an extended period is the possibility that leaking organics may have contaminated the water.

To determine the extent of contamination caused by leaked petroleum products, water samples were taken at several locations and different depths throughout the flooded Jones Tract. The water samples were tested for more than 100 compounds including diesel and gasoline range organics, volatile and semi-volatile organics, and different types of oils and greases described in the methodology section in Chapter 2. Most of the test results were returned with amounts well below the reporting limit or no detection at all. The only constituent detected in significant amounts were the diesel range organic compounds.

The reportable limits for diesel range organic compounds in the samples taken were anything above 50 micrograms per liter. The testing for these compounds was carried out by an independent lab. The sampling period for these diesel range organics extended from mid-June to the beginning of September 2004. Test results for diesel range organic compounds are displayed in Figure 3.8.1a and Figure 3.8.1b. The data indicate that as water was pumped out of Upper Jones Tract and flowed naturally into Lower Jones Tract the levels of diesel range organic compounds had a slight increase. It is assumed this increase is attributed to a stratification effect caused by the non-homogenous mixing of water and diesel. As water was pumped from the island, it is assumed that diesel remained at or near the surface of the water. This stratification caused higher amounts of diesel range organic compounds to show up near the end of the sampling period.

Figure 3.8.1a Diesel range organics at Jones Tract (Contract Lab), June–Sep 2004

Figure 3.8.1b Average diesel range organics at Jones Tract (Contract Lab), July 28–Sep 2, 2004

Lower Jones Tract did not exhibit the same increase in diesel range organic compounds at sampling sites. The data gathered show a slight decrease in the levels of diesel compounds through the reporting period. This decrease may have been attributed to a combination of pumping of water and a constant inflow of water draining from the Upper Jones Tract area.

The data evaluated were gathered at the Upper and Lower Jones Tract drainage locations. While data for samples at other locations were available, they became unobtainable as the island was drained.

3.9 Bacteria

3.9.1 Introduction

For a period after the levee breach on June 3, the bacterial concentrations on Jones Tract were not monitored. State and federal agencies were trying to get the public away from the flood zone. The water exports from the Delta were cut by about 80% to minimize the amount of salt water that might be pulled into the Delta from San Francisco Bay. Reservoir releases into the Sacramento River were increased in an attempt to maintain fresh water in the Delta. As the work of restoring and stabilizing the Jones Tract levees progressed, the bacterial count in the water was monitored in response to health and safety concerns for the workers doing levee work in the Jones Tract waters. From June 16 to August 30, water samples were tested for bacteria.

The group of bacteria that was monitored belongs to the coliform group in the family Enterobacteriaceae. The bacterial concentration was monitored with Standard Method 9222 and Standard Method 9221 as described in the methodology section of this report. Fermentation technique (Standard Method 9221) identified facultative anaerobic, gram-negative, non-spore forming, rod-shaped bacteria that fermented lactose with gas and acid formation within 48 hours at 35 °C. Membrane Filter (MF) technique (Standard Method 9222) identified facultative anaerobic, gram-negative, non-spore forming, rod-shaped bacteria that developed red colonies with metallic sheen within 24 hours at 35 °C. The MF technique is faster than the fermentation technique. Both methods were used in June of 2004 to find the concentration of the coliform bacteria. These methods measured the total coliforms, fecal coliform, and *E. coli*. The presence of fecal coliforms and *E. coli* bacteria would indicate that the water inside Jones Tract was contaminated with livestock and/or human wastes. The pathogens found in these wastes can cause diarrhea, cramps, nausea, headaches, or other symptoms and serious diseases.

MF = Membrane Filter

The Central Valley Regional Water Quality Control Board has a water quality objective in the Sacramento-San Joaquin River Basin Plan for bacteria (fecal coliform). The objective is for contact recreation. The objective calls for a 30-day average of 200/100 mL (MPN) with no more than 10% of measurements above 400/100ml (MPN).

MPN = most probably number (estimate)

3.9.2 Monitoring for Total Coliforms, Fecal Coliforms, and E.coli

On June 16, the initial bacterial monitoring was done when workers were shoring up the levee and were exposed to obviously contaminated water because dead animals were seen floating along the shoreline. Initial monitoring showed that the total coliforms, fecal coliforms, and *E.coli* were high in the Upper Jones bottom water (UJB) and the Lower Jones East Side (LJES) water (Table 3.9.1 – Table 3.9.6). At that time the bacterial count in the Middle River was relatively low compared to inside Jones Tract. These measurements indicated that sources inside Jones Tract contributed to the initial increase in coliform bacteria inside Jones Tract.

UJB = Upper Jones bottom water

LJES = Lower Jones East Side

Table 3.9.1 Total coliforms at Jones Tract by multiple tube fermentation technique (MPN/100ml)

Table 3.9.2 Fecal coliforms at Jones Tract by multiple tube fermentation technique (MPN/100ml)

The relatively high initial bacterial counts measured inside Jones Tract delayed work while workers were kept away from the water. Workers were allowed to return to work, and by June 23, the fecal coliforms and *E.coli* counts were very low or nondetectable at UJB and LJES (Table 3.9.2 – Table 3.9.3). As the work progressed in July and August, the pump-off discharge areas (Upper Jones discharge-UJD), Lower Jones discharge-LJD) were periodically monitored for bacteria. The fecal coliforms count at UJD and LJD remained low—from 4 to 8 MPN/100ml in July and August, with one unexplained spike at one site (UJD), only to return to very low levels afterwards. The bacterial monitoring stopped after the last sample taken on August 23.

Table 3.9.3 E.coli at Jones Tract by multiple tube fermentation technique (MPN/100ml)

Table 3.9.4 Total coliforms at Jones Tract by Membrane Filter technique CFU/100ml

Table 3.9.5 Fecal coliforms at Jones Tract by Membrane Filter technique (CFU/100ml)

Table 3.9.6 E. coli at Jones Tract by Membrane Filter technique (CFU/100ml)

In summary, when MWQI monitoring results for fecal coliforms are compared to the Basin Plan contact recreation objective, the Jones Tract levels were well below the objective from June 23 on (Table 3.9.2), with the exception of one unexplained highly elevated measurement at one site.

UJD = Upper Jones Discharge

LJD = Lower Jones Discharge

3.10 Chlorophyll and Pheophytin

3.10.1. Introduction

Chlorophyll is the green pigment found in most plants, algae, and cyanobacteria. Chlorophyll can be used to estimate the amount of phytoplankton in the water. The concentration of chlorophyll indicates the amount of photosynthesis that can occur in the water. When the magnesium ion in a chlorophyll molecule is replaced by hydrogen ions, pheophytin is formed. Pheophytin is considered a degradation product of chlorophyll. Chlorophyll and pheophytin concentrations were analyzed from both grab samples and sonde instruments (continuous sampling) at numerous sites on the island and at the points of discharge off of the island (pumps).

3.10.2 Chlorophyll

Immediately after the levee breach, chlorophyll concentrations were measured at 3 sites on the island (LJES, UJB and Middle River-MR) on June 16, 23, and 30 (see Figure 2.1 showing MWQI sampling stations). These sites were not sampled after June 30 until discrete sample collection resumed on July 15 and continued through September 28 at several other sites on the island (LJI, LJMB, LJMT, LJD, UJB, UJI, UJMB, UJMT, and UJD). Chlorophyll concentration at LJES and UJB increased significantly over time, while MR remained constant (Figure 3.10.1).

LJI = Lower Jones Intake

LJMB = Lower Jones Middle-bottom

LJMT = Lower Jones Intake-top

LJD = Lower Jones Discharge

UJD = Upper Jones Discharge

UJI = Upper Jones Intake

UJMB = Upper Jones Middle – bottom

UJMT = Upper Jones Middle - top

Of the Lower Jones Tract sites sampled on the island (LJI, LJMB, and LJMT), chlorophyll concentration was highest at the LJMT and LJI sites and ranged from 24 to 68.4 mg/L and 21 to 66.6 mg/L, respectively. The LJMB site had the lowest concentration recorded (6.15 to 37.7 mg/L). At all 3 of these sites, peaks in chlorophyll concentration were detected on July 28 and again on September 2 (Figure 3.10.2). Chlorophyll concentration for these 3 sites followed a similar trend during the sampling period.

Figure 3.10.1 Chlorophyll concentration at LJES, UJB, and MR, June 16, 23, and 30 2004

Chlorophyll concentration from samples collected at the LJD site exhibited the most variability and resulted in the highest recorded concentration of chlorophyll for Lower Jones Tract (14.6 – 107 mg/L, Figure 3.10.2). The number of samples collected at this site exceeded those collected from other areas on Lower Jones Tract (11 vs 7 samples) most likely contributing to the greater variability and range. Peak chlorophyll concentration occurred at this site on August 16 and September 7 lagging behind peak dates from the 3 on-island monitoring sites.

Figure 3.10.2 Chlorophyll concentration at Lower Jones Tract (Bryte Lab data, July to Sep 2004)

Of the Upper Jones Tract sites sampled on the island (UJI, UJMB and UJMT), chlorophyll concentration was highest at the UJMT site, ranging from 42.2 to 102 mg/L. Chlorophyll concentration from the on-island sites was lowest at the UJMB site ranging from 33.1 to 48.1 mg/L. Peak values occurred at slightly different times, for the UJI site a peak concentration of 78.8 mg/L occurred on August 23 (Figure 3.10.3). For the UJMB site the highest concentration of 48.1 mg/L was recorded on September 7 (Figure 3.10.3) and for the UJMT site 2 peak values were measure on July 28 (91.5 mg/L) and September 7 (102 mg/L, Figure 3.10.3).

Figure 3.10.3 Chlorophyll concentration at Upper Jones Tract (Bryte Lab data, July to Sep 2004)

Chlorophyll concentration from samples collected at the UJD site ranged from 21.4 to 66.5 mg/L. Peak values occurred on August 23 (66.5 mg/L) and September 7 (64.1 mg/L).

Variation in chlorophyll concentration within and between Upper and Lower Jones Tracts was most likely influenced by variable distribution and concentration of algae, different light intensities, changes in water temperature and depth, time samples were taken and distribution of nutrients in the flooded area.

3.10.3 Pheophytin

Pheophytin concentration was measured at the LJES, UJB, and MR sites on June 16, 23 and 30. , and resumed on July 15 and continued through September 28 at several other sites on the island (LJI, LJMB, LJMT, LJD, UJB, UJI, UJMB, UJMT, and UJD; Figure 2.1). For all 3 sites pheophytin concentration increased over time with LJES and UJB having the highest concentrations on June 30 (Figure 3.10.4).

Figure 3.10.4 Pheophytin concentration in Jones Tract (Bryte Lab data), June 16, 23, and 30 2004

For Lower Jones Tract, pheophytin concentration ranged from 0.11 to 48.3 μg/L (Figure 3.10.5). Pheophytin concentration increased at all sites over time with the highest levels occurring at the end of the sampling period on September 21. An additional sample was taken at LJD on September 28, the concentration on this date was significantly lower (13.6 μg/L) than that taken on September 21 (48.3 μg/L).

Figure 3.10.5 Pheophytin concentration in Lower Jones Tract (Bryte Lab data), July–Nov 2004

Pheophytin concentration in Upper Jones Tract ranged from 5.3 to 56.6 μg/L (Figure 3.10.6). As with Lower Jones Tract, pheophytin concentration increased over time at all sites.

Figure 3.10.6 Pheophytin concentration in Upper Jones Tract (Bryte Lab data), July–Nov 2004

3.10.4 Average daily chlorophyll

The average daily chlorophyll concentration was plotted from sonde data. The sondes recorded the chlorophyll concentration in Upper Jones Tract (UJI and UJMT) starting on July 8 and at Lower Jones Tract (LJI and LJMT) starting on August 4. Data were collected at all 4 sites until November. Chlorophyll levels at both Upper and Lower Jones Tracts were similar until September 28 ranging from 5.91 to 62.5 mg/L (Figure 3.10.7). After September 28, concentration of chlorophyll at Upper Jones Tract was significantly higher than that of Lower Jones Tract (Figure 3.10.7). This may have been due to water levels lower in Upper Jones Tract than in Lower Jones Tract as water was continually pumped off of the island. Data collected with the sondes starting in November were difficult to interpret as the instruments came in contact with mud and soil as the water levels went down.

Figure 3.10.7 Average daily chlorophyll concentration at Jones Tract, July–Nov 2004

3.10.5 Chlorophyll on a typical day

Sonde data were used to record chlorophyll concentration changes over a 24-hour period for Upper and Lower Jones Tract sites from July through October. Chlorophyll concentration measurements for LJI and LJM did not begin until August. Initially, an hourly average was calculated for each day at each monitoring site. From these values, hourly averages for a month were calculated and graphed for the 4 different sites (Figures 3.10.8 through 3.10.11).

Figure 3.10.8 Chlorophyll concentration on a typical 24-hour day (LJI)

Figure 3.10.9 Chlorophyll concentration on a typical 24-hour day (LJM)

Figure 3.10.10 Chlorophyll concentration on a typical 24-hour day (UJI)

Figure 3.10.11 Chlorophyll concentration on a typical 24-hour day (UJM)

Chlorophyll concentrations of samples collected in July (UJI and UJM sites only) were highest between 9 a.m. and 2 p.m. (Figures 3.10.10 and 3.10.11). Chlorophyll concentration during August, September, and October were generally highest between 1 p.m. and 7 p.m. (Figures 3.10.8 through 3.10.11).

Additional discussion of daily chlorophyll concentration on Jones Tract as it relates to DO and temperature changes can be found in this chapter's section 3.1 (Physical Parameters).

3.11 Acute Toxicity Tests

The Central Valley Regional Water Quality Control Board discharge permit issued for the pump-off project required acute toxicity during dewatering of the island. Pacific EcoRisk (PER) did these tests between July 15, 2004, and September 14, 2004, using grab samples from various sites on Jones Tract and Middle River (UJI, UJD,LJD, MR, Figure 2.1). Eighty samples were analyzed (40 per study organism). EPA toxicity tests procedures were used and were as follows:

1. 96-hour acute toxicity tests with the crustacean *Ceridaphnia dubia*
2. 96-hour acute toxicity test with *Pimephales promelas* (fathead minnows)

3.11.1 Acute Toxicity Test Results

The percent survival for *Ceriodaphnia dubia* and *Pimephales promelas* was determined after 96 hours. Survival data from the grab samples were compared to control samples using CERTIS statistical software.

The percent survival results for each sample are listed in Tables 3.11.1 and 3.11.2. For *C. dubia,* samples taken at the MR site showed no signs of toxicity upon retesting. Initially the control sample resulted in a 55% survival rate, but after retesting the control 100% survival was achieved. Only one sample was taken at this site during the study period. Two sampling events were conducted at the UJI site on July 15 and July 21. As with the MR sample, the initial control results from July 15 were low (55%), but upon retesting, the survival rate was 100%. Samples taken at the actual field site on July 15 and 21 had survival rates of 90% or higher. Control and actual field samples were taken at the UJD site weekly over the entire study period. Survival rates at this site ranged from 90% to 100% with the exception of the August 30 sample that had a survival rate of 35%. Control and actual field samples were also collected weekly at the LJD site starting on July 28 and lasting through the study period. Survival rates for this site ranged from 80% to 100% with the exception of the August 30 sample that had a survival rate of 50%.

Table 3.11.1 *Ceriodaphnia dubia* acute toxicity percent survival

Table 3.11.2 Fathead minnow acute toxicity percent survival

For *P. promela*, the sample collected at the MR site on July 15 resulted in 100% survival, and the control sample resulted in 95% survival. Control and field samples collected at the UJI site on July 15 and July 21 had survival rates of 95% and 100%, respectively. Samples were collected at the UJD site weekly starting on July 21. Percent survival for the field samples ranged from 60% to 100% with the lowest survival rates occurring on August 16 (60%) and August 30 (75%). Control samples from this site had survival rates ranging from 90% to 100%. Samples were collected from the LJD site starting on July 28 weekly through the end of the study period. Field samples resulted in percent survival rates ranging from 80% to 100% with the lowest rates occurring on August 16 (80%) and August 30 (85%). This trend was similar to that seen at the UJD site. Control samples for the LJD site resulted in survival rates ranging from 90% to 100%.

Of the 80 samples analyzed (control and actual field) for each study organism only 6 had survival rates of less than 90%. Four of the 6 samples occurred on August 30 at both the UJD and LJD sites. Overall, only one of these 4 samples was significantly different from the controls (35%, Table 3.11.1).

Chapter 3 Results and Discussion

3.1 Physical Parameters, pH, DO, BOD, and Weather Data

Figures

Figure 3.1.1a Temperature at Jones Tract (Bryte Lab field data), June—Nov 2004

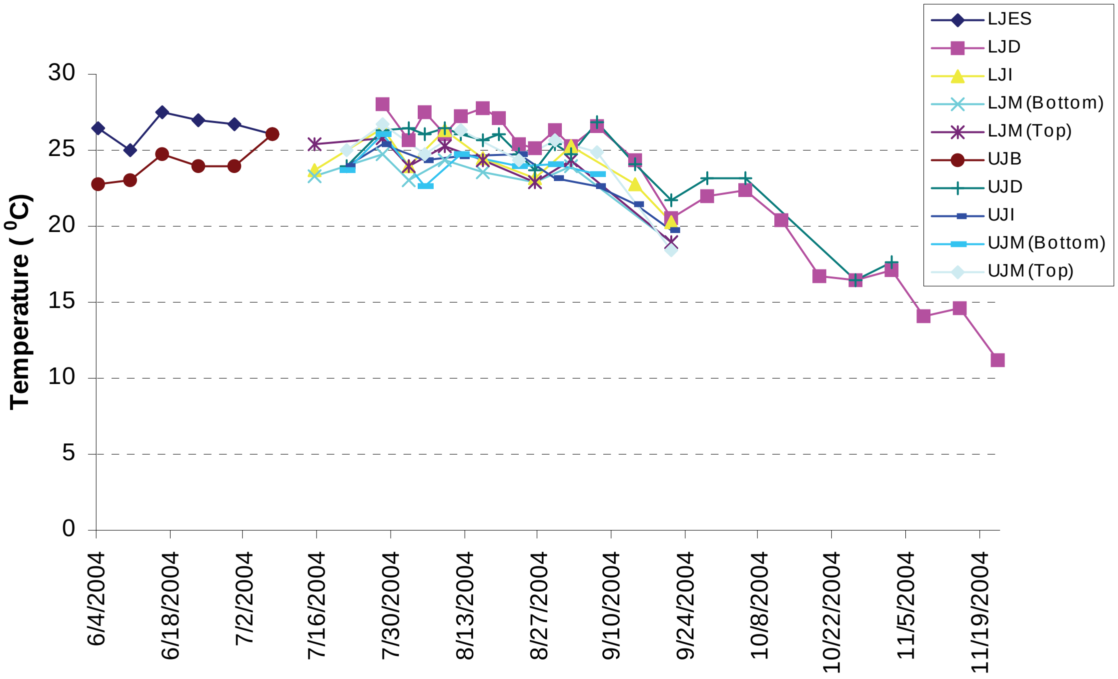


Figure 3.1.1b Average temperature at Upper and Lower Jones Tract (Bryte Lab field data), June—Nov 2004

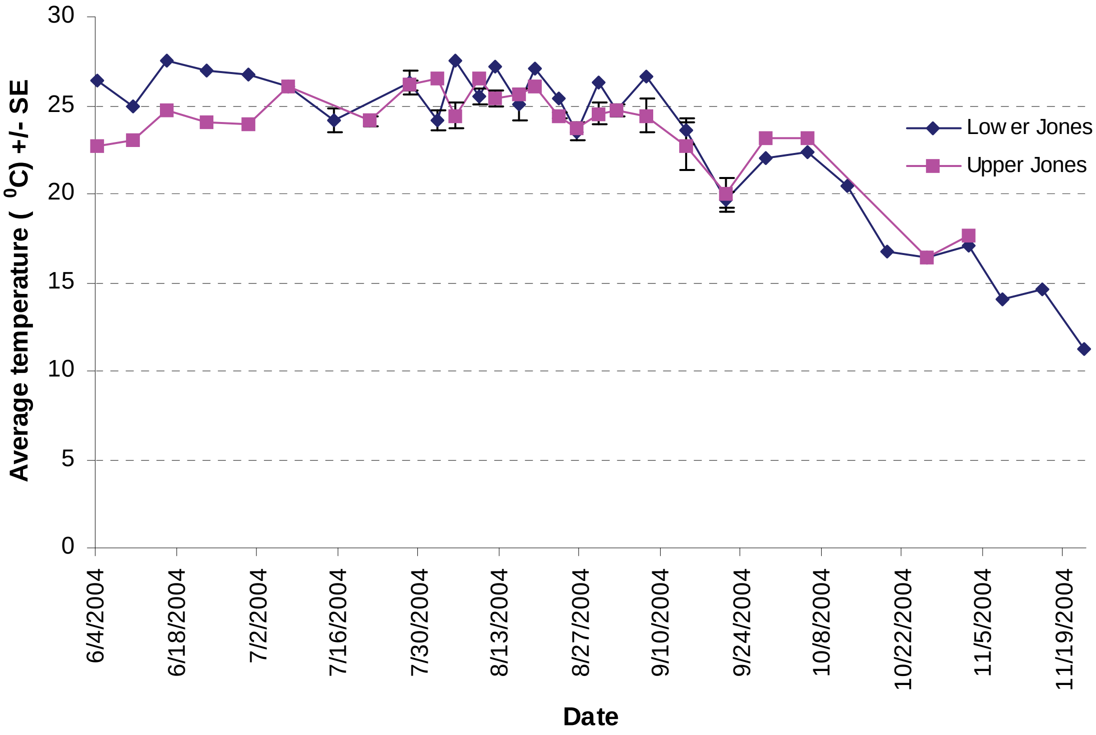


Figure 3.1.2 Average daily temperature at Upper Jones Discharge (Sonde data, n = 7,757), Aug—Oct 2004

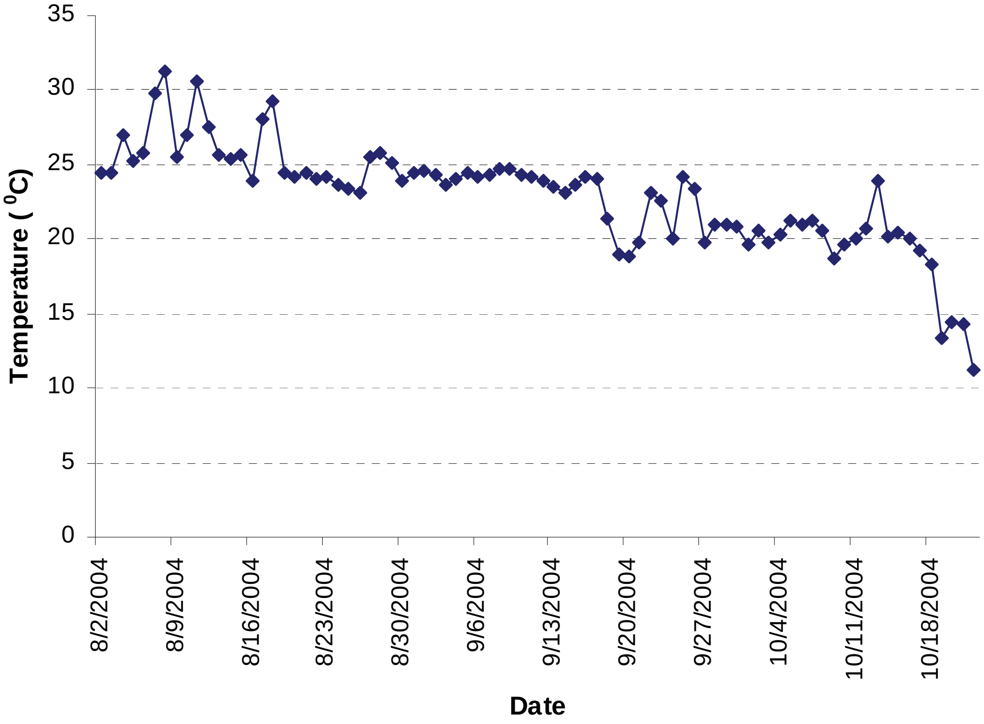


Figure 3.1.3 Water temperature at Upper Jones Intake, July—Nov 2004

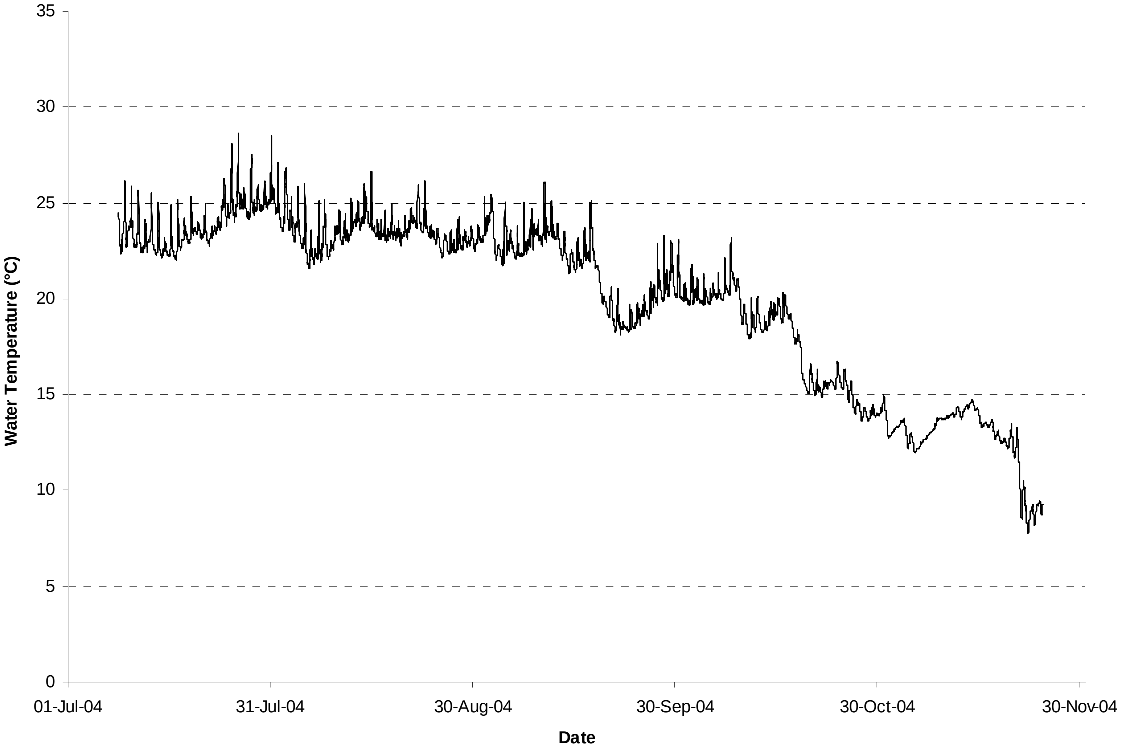


Figure 3.1.4 Typical daily water temperature pattern at Upper Jones Tract Intake, July—Nov 2004

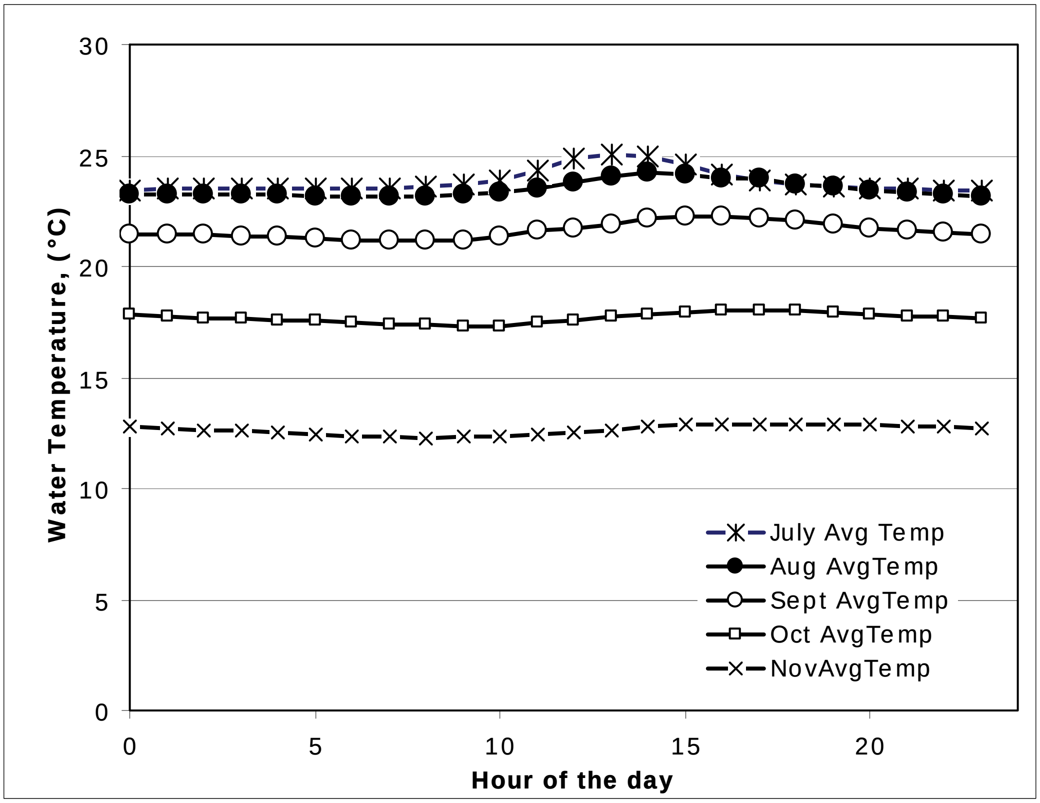


Figure 3.1.5 Typical daily water temperature pattern at Upper Jones Tract Middle Station, July—Nov 2004

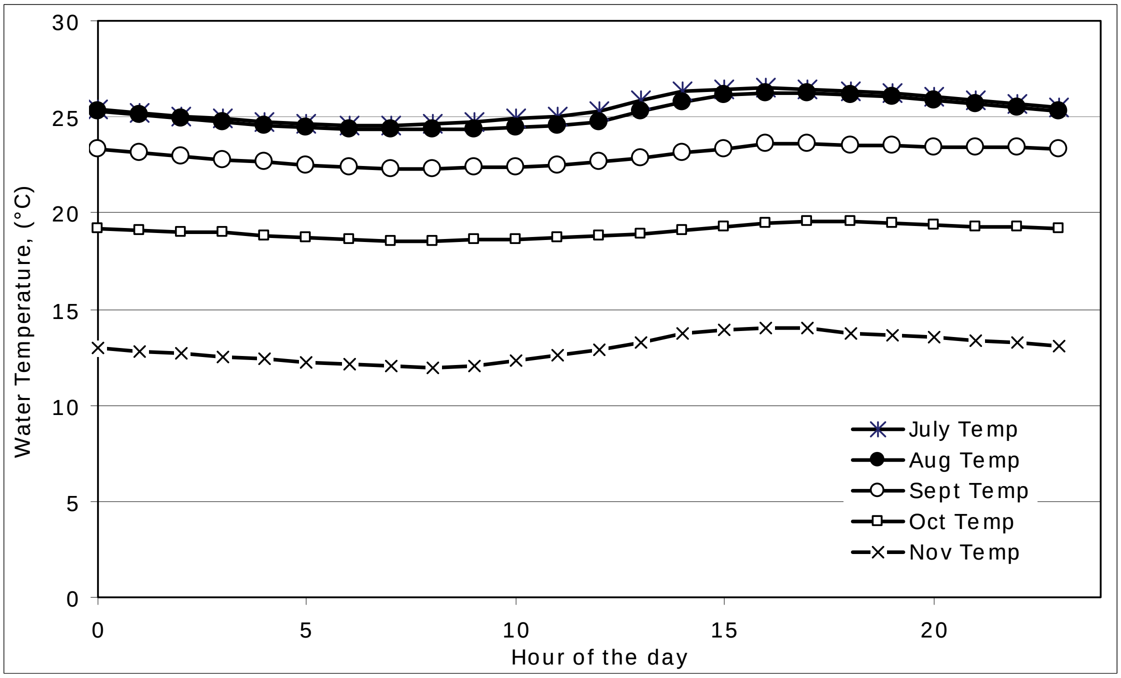


Figure 3.1.6 Daily average temperature, DO at Lower Jones Intake, Aug—Nov 2004

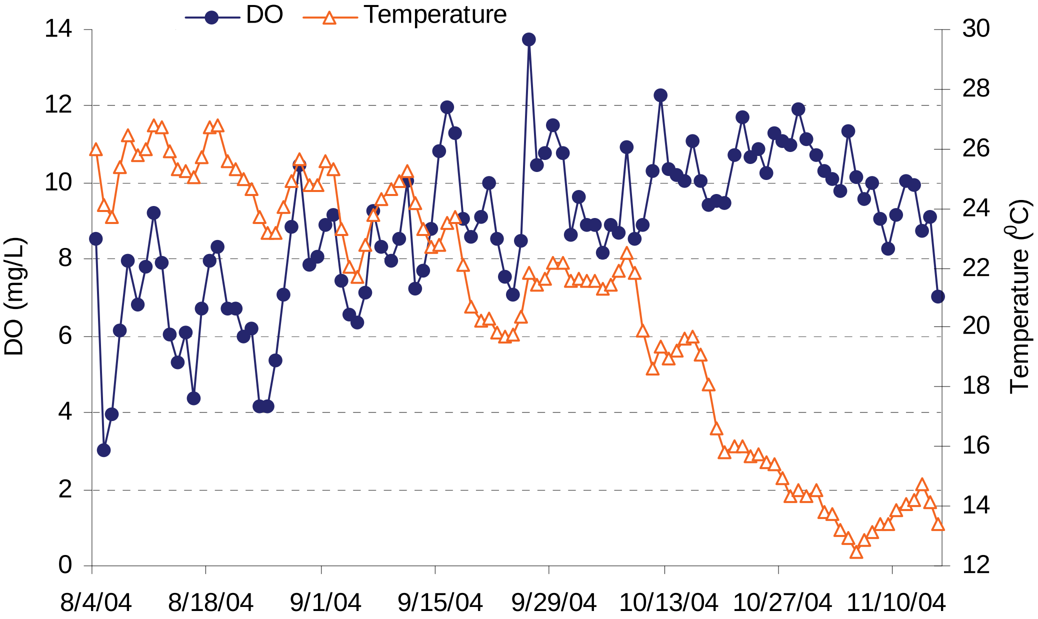


Figure 3.1.7 Average temperature, DO at Lower Jones Middle, Aug—Nov 2004

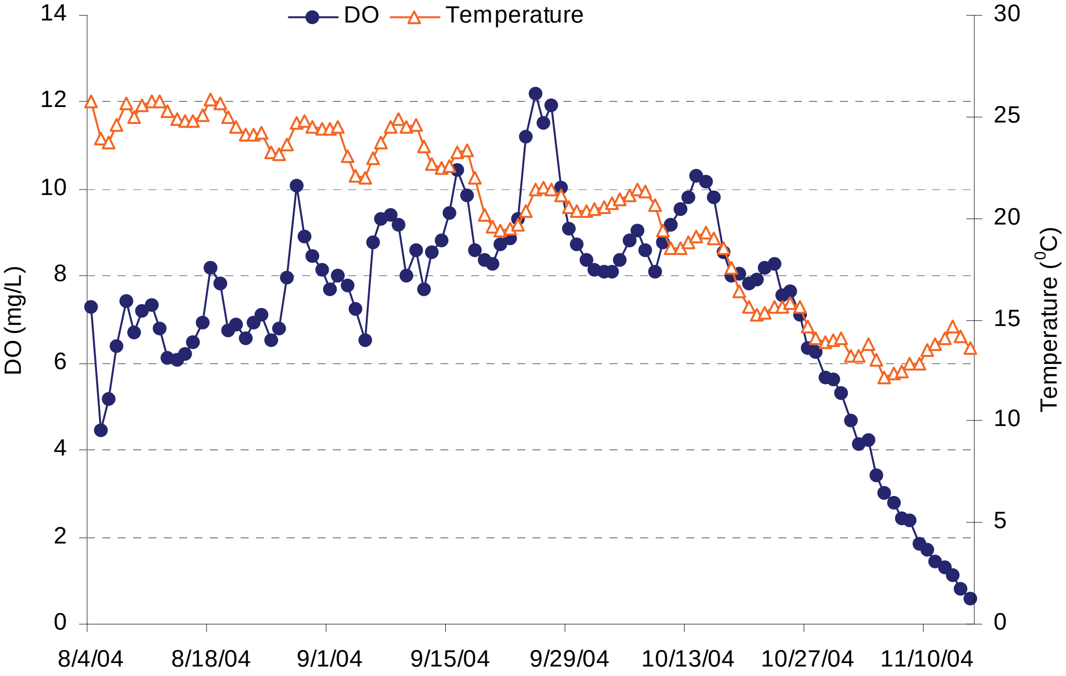


Figure 3.1.8 Average temperature, DO at Upper Jones Intake, July—Nov 2004

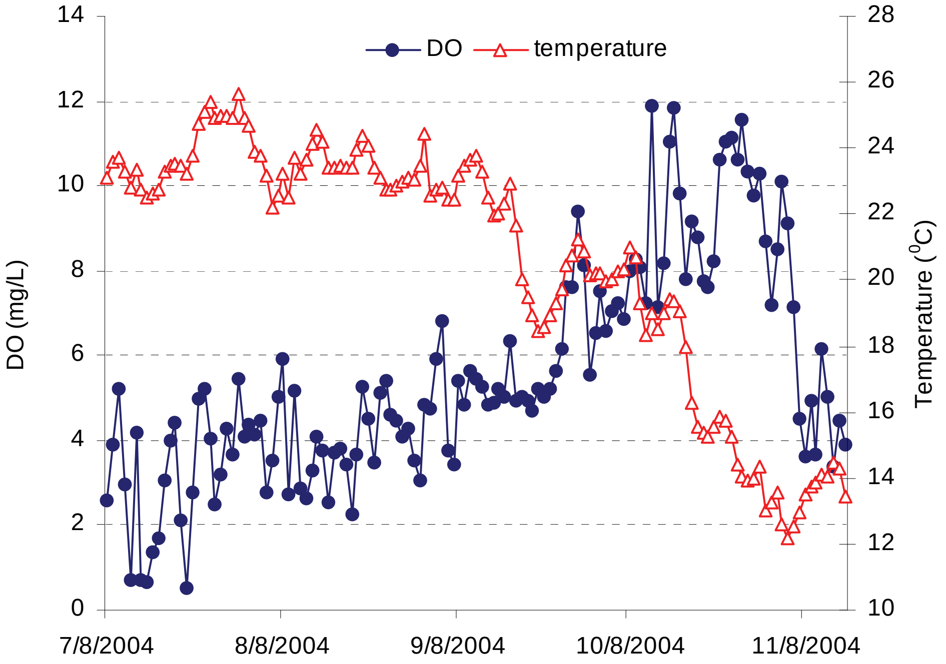


Figure 3.1.9 Average temperature, DO at Upper Jones Middle, July—Nov 2004

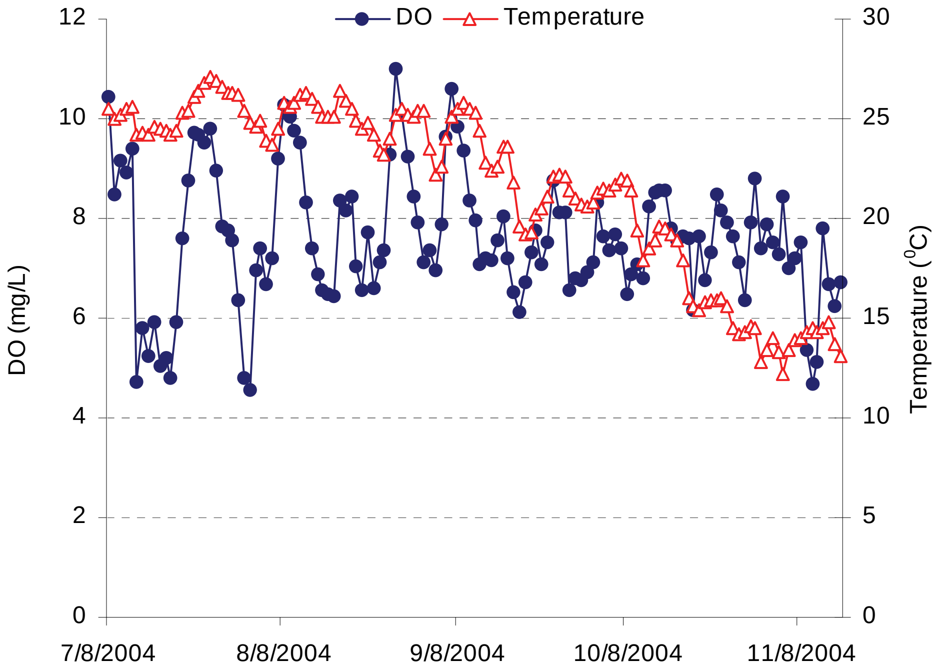


Figure 3.1.10a Dissolved oxygen in Jones Tract (Bryte lab), June—Nov 2004

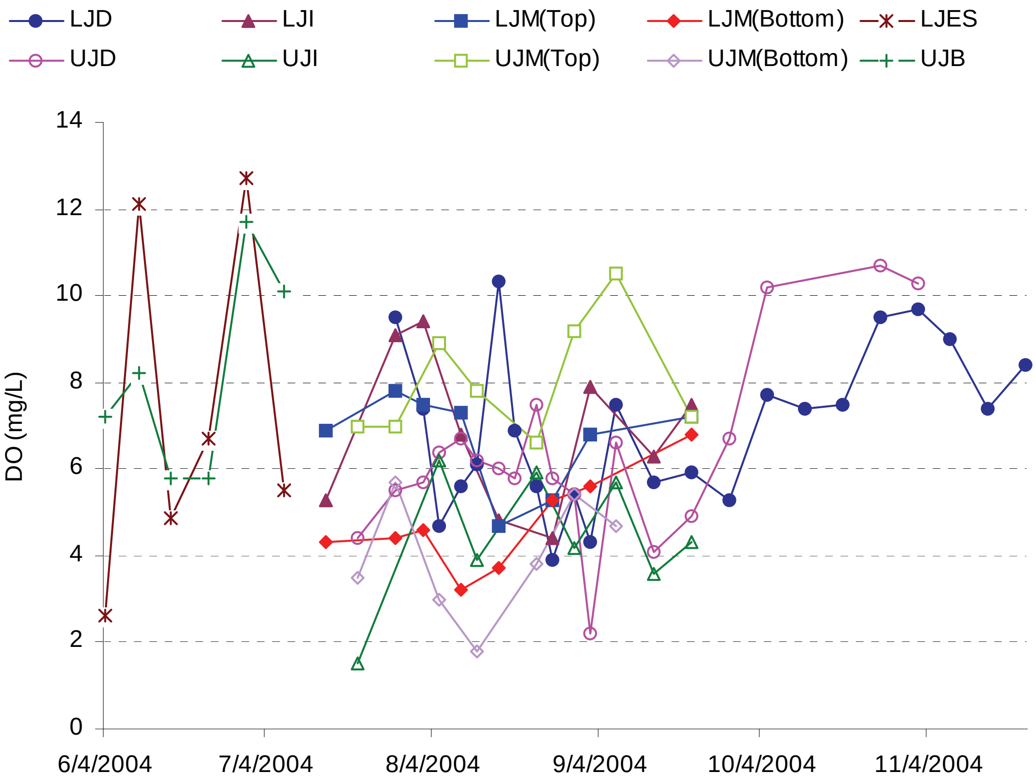


Figure 3.1.10b Average dissolved oxygen in Jones Tract, June—Nov 2004

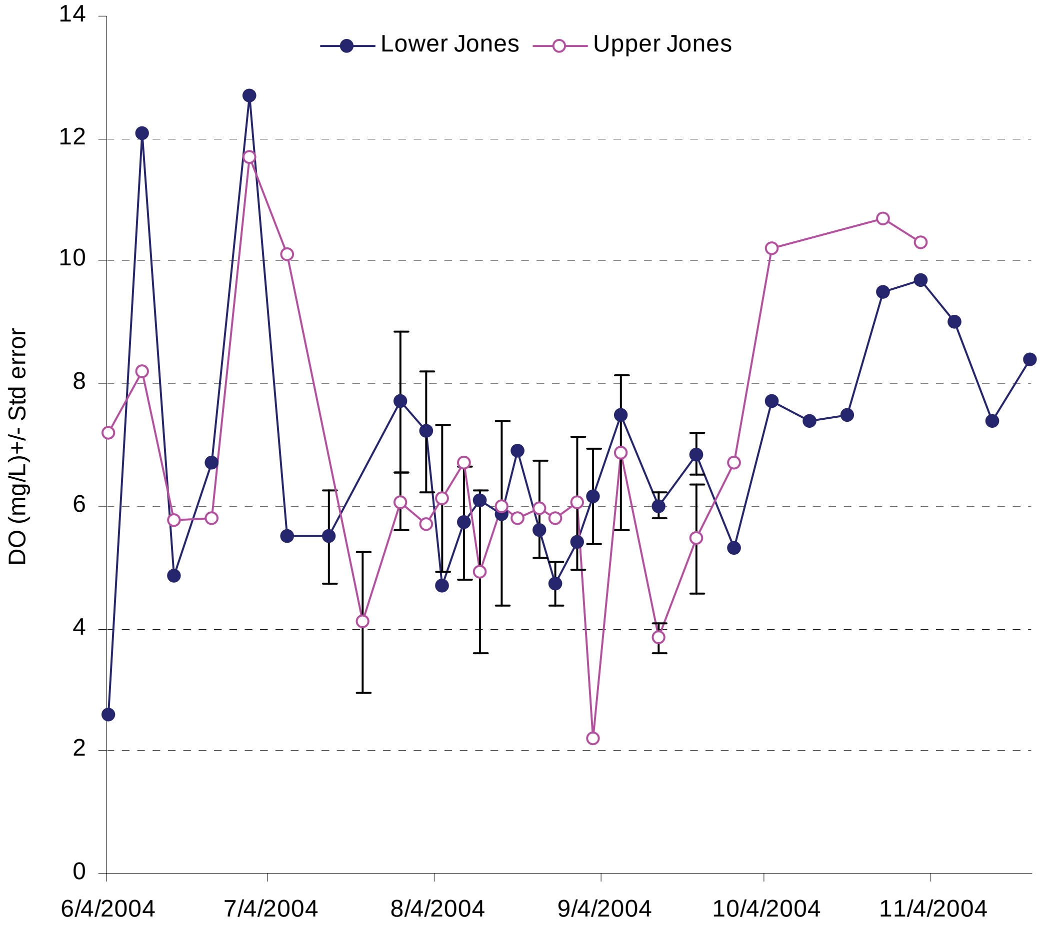


Figure 3.1.11 Average dissolved oxygen and chlorophyll at Lower Jones Middle, Aug—Nov 2004

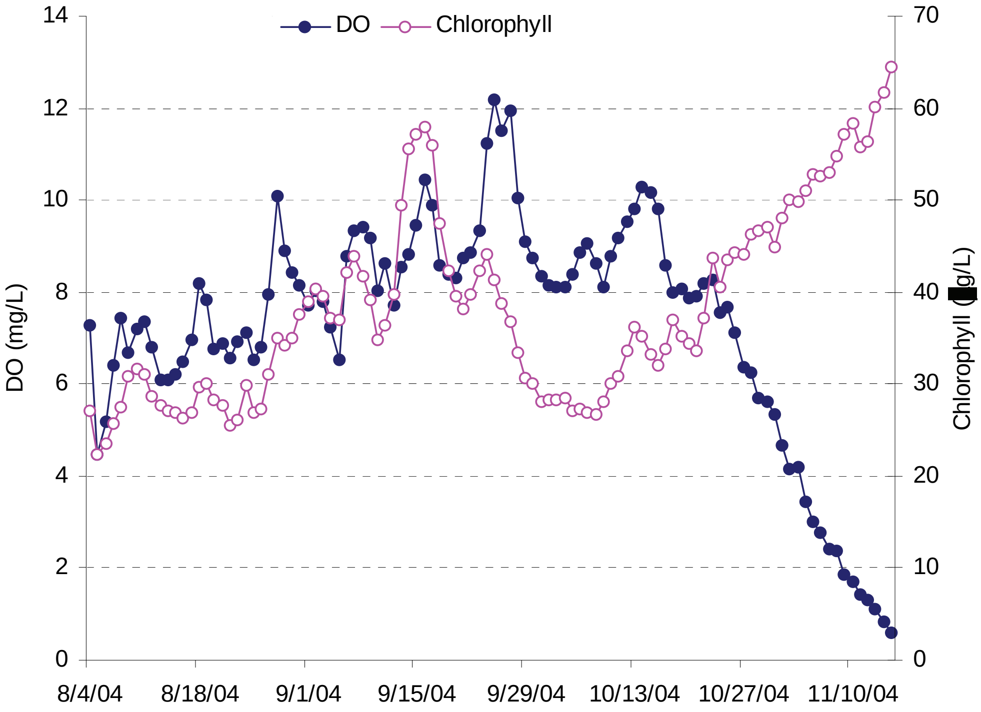


Figure 3.1.12 Average chlorophyll and DO at Lower Jones Intake, Aug—Sep 2004

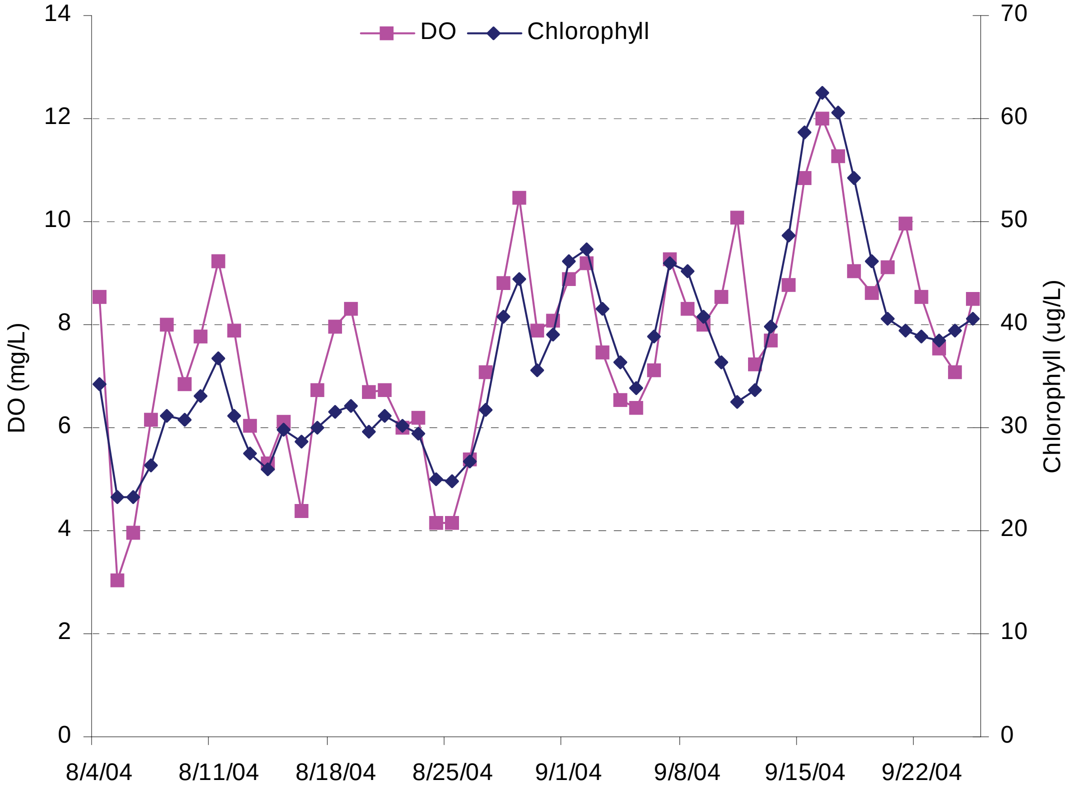
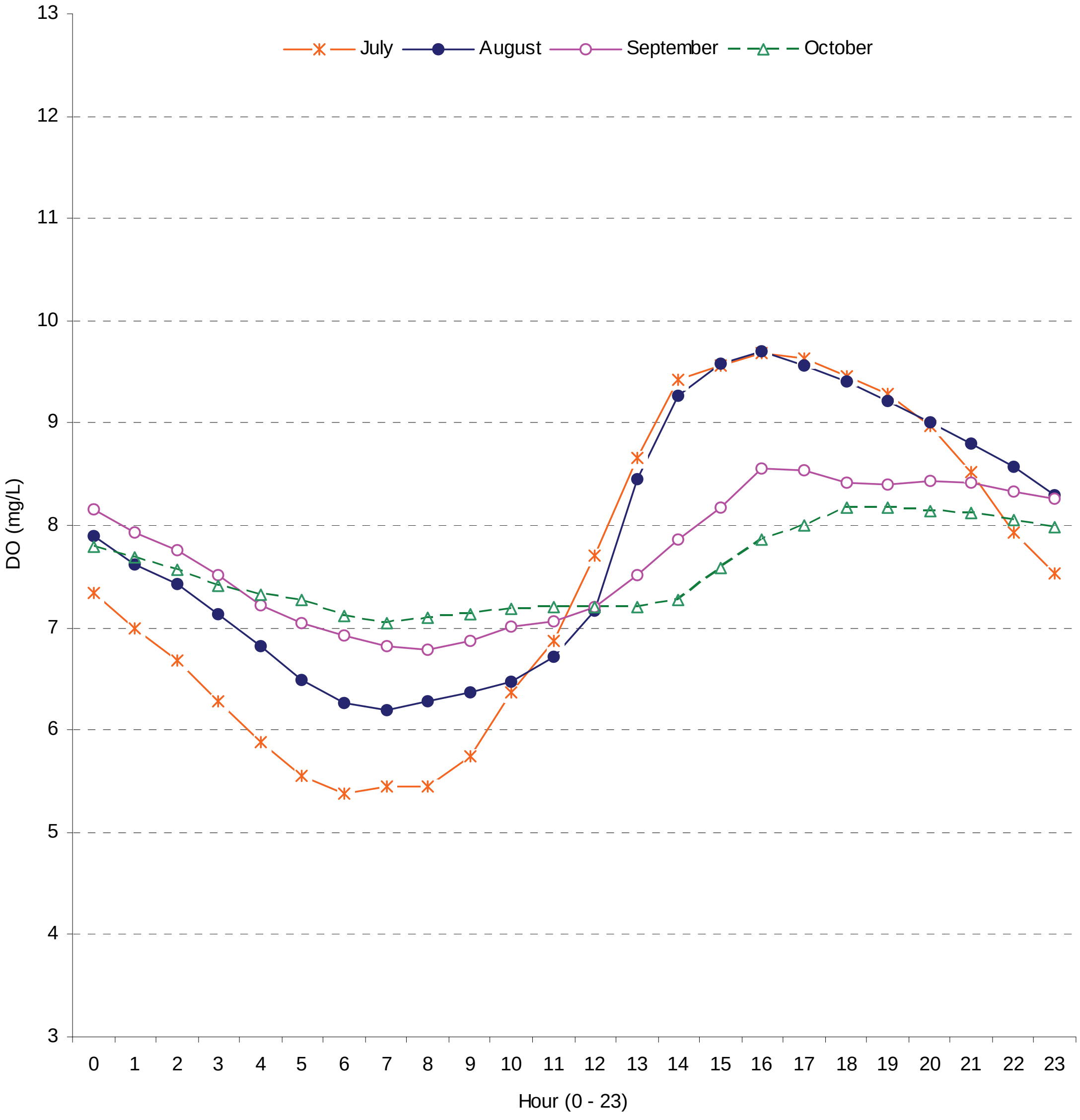
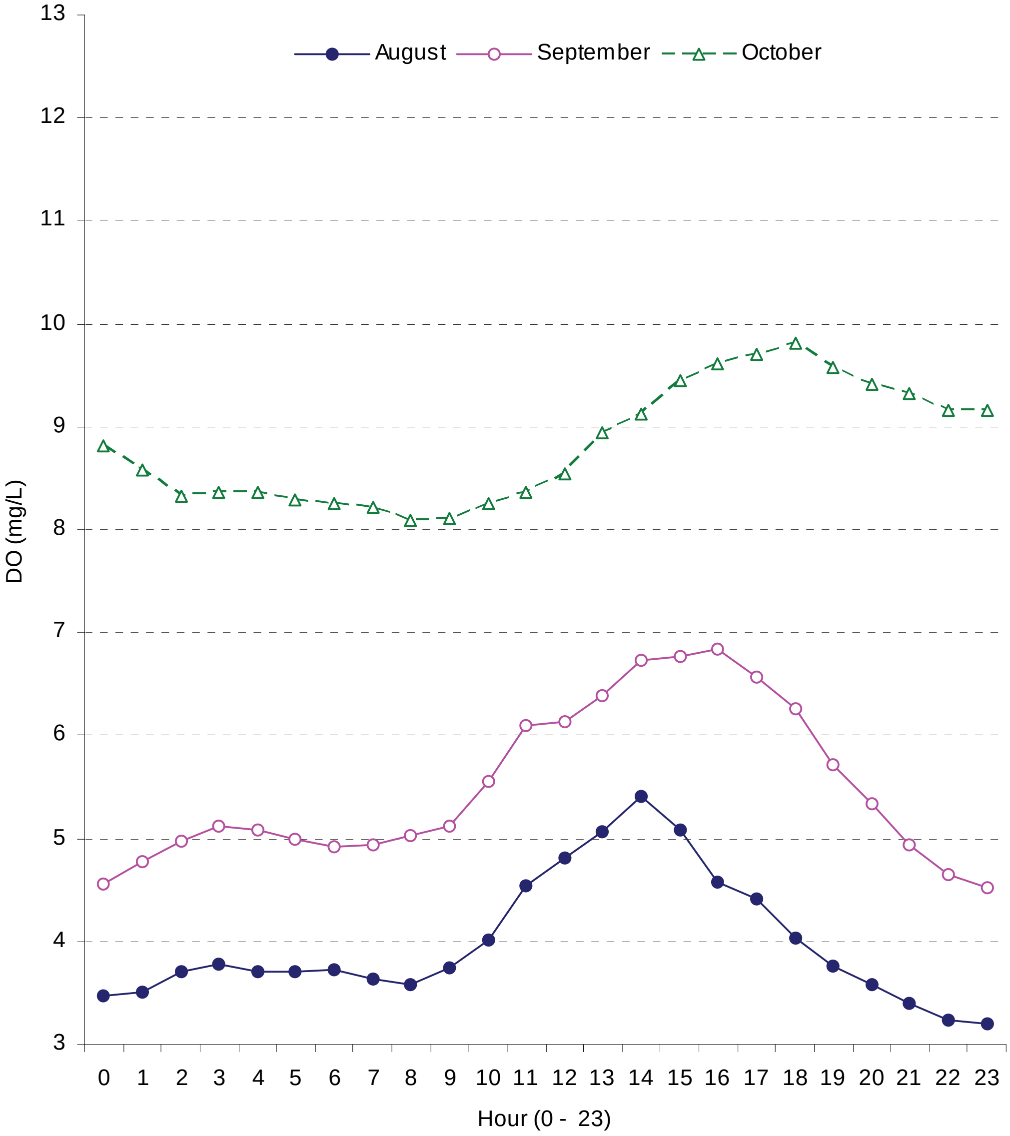


Figure 3.1.13 Typical daily dissolved oxygen pattern at Upper Jones Middle, July—Oct 2004



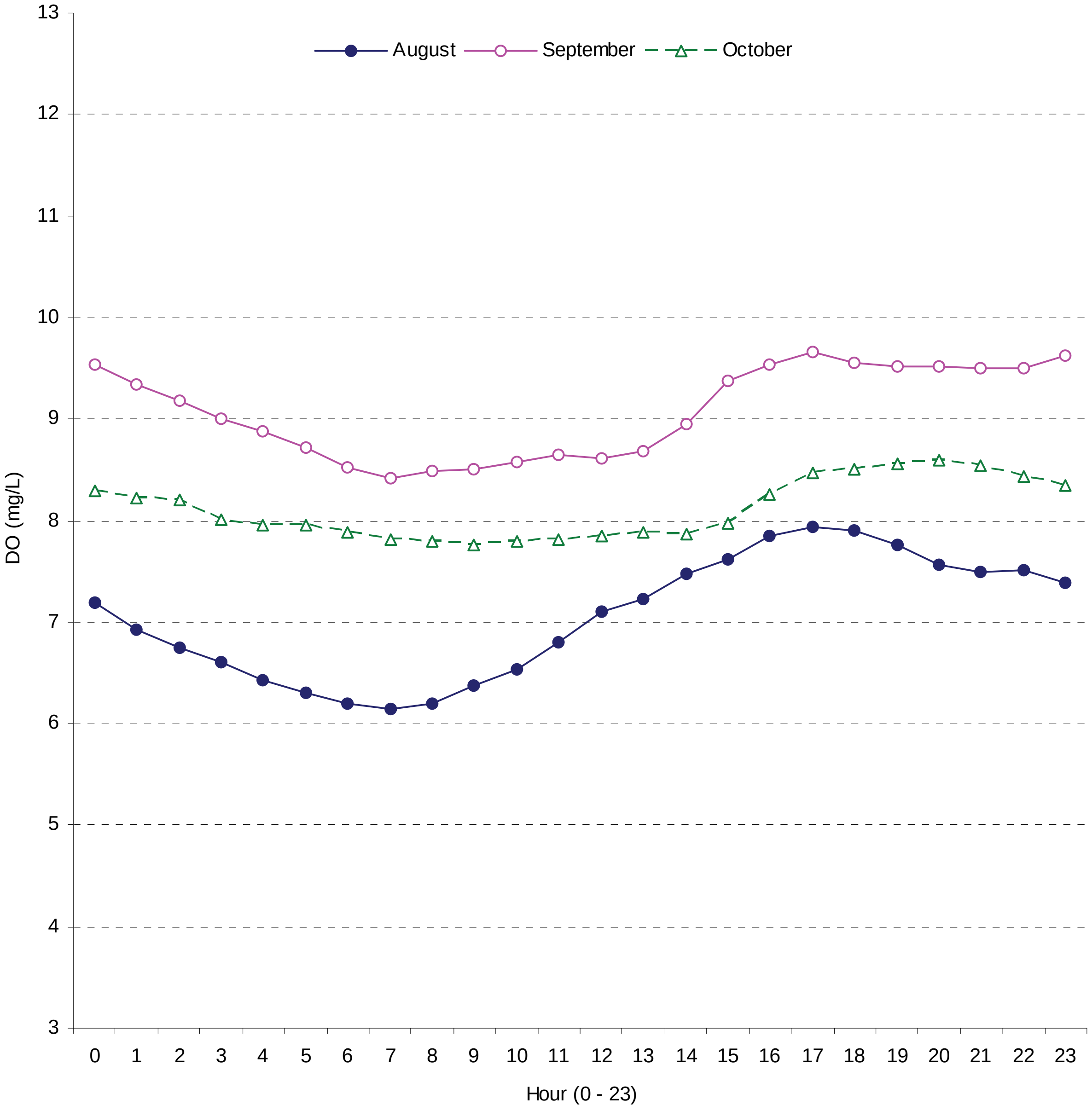
* samples collected 1 meter below surface

Figure 3.1.14 Typical daily dissolved oxygen pattern at Upper Jones Intake, Aug—Oct 2004



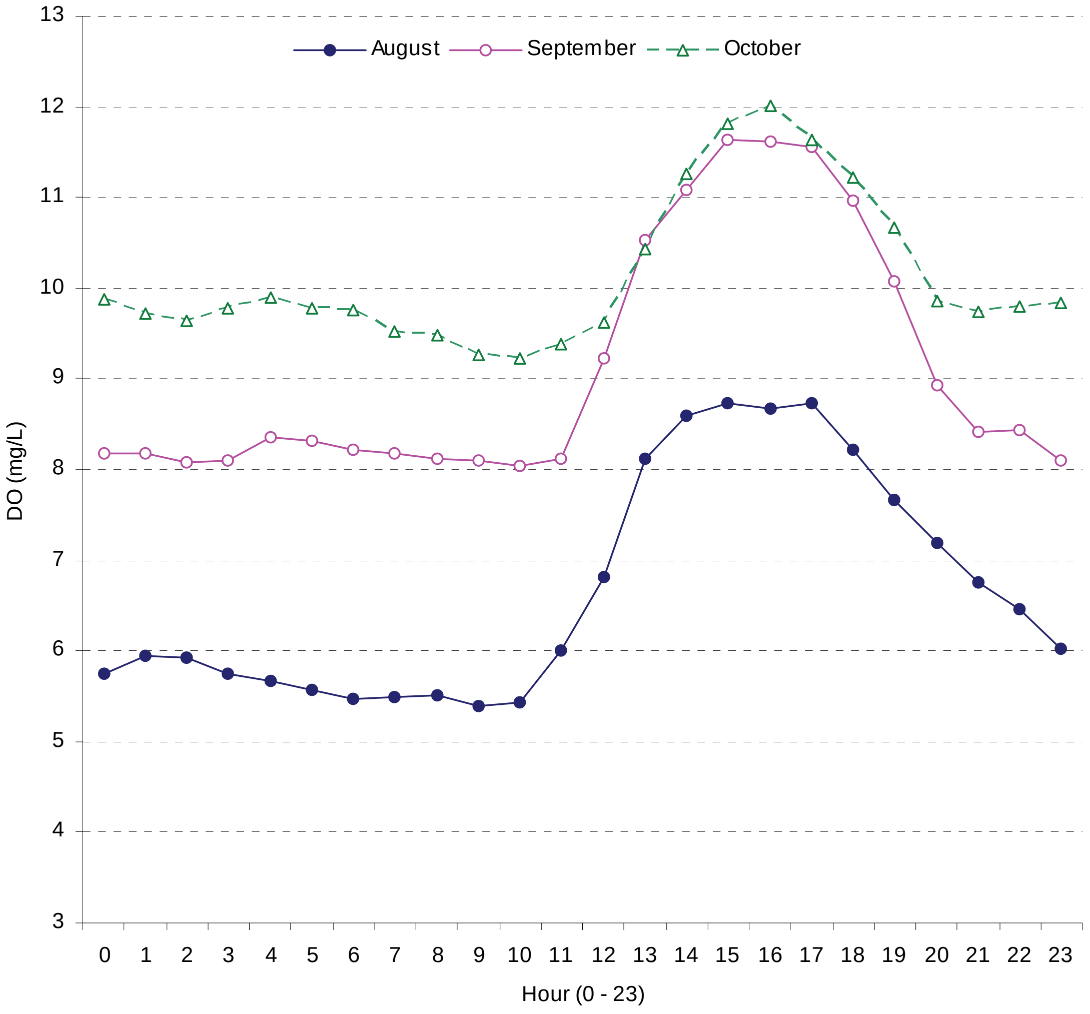
* samples collected 1 meter below surface

Figure 3.1.15 Typical daily dissolved oxygen pattern at Lower Jones Middle, Aug—Oct 2004



*samples collected 1 meter below surface

Figure 3.1.16 Typical daily dissolved oxygen pattern at Lower Jones Intake, Aug—Oct 2004



* samples collected 1 meter below surface

Figure 3.1.17a pH at Jones Tract (Bryte Lab-field), June—Nov 2004

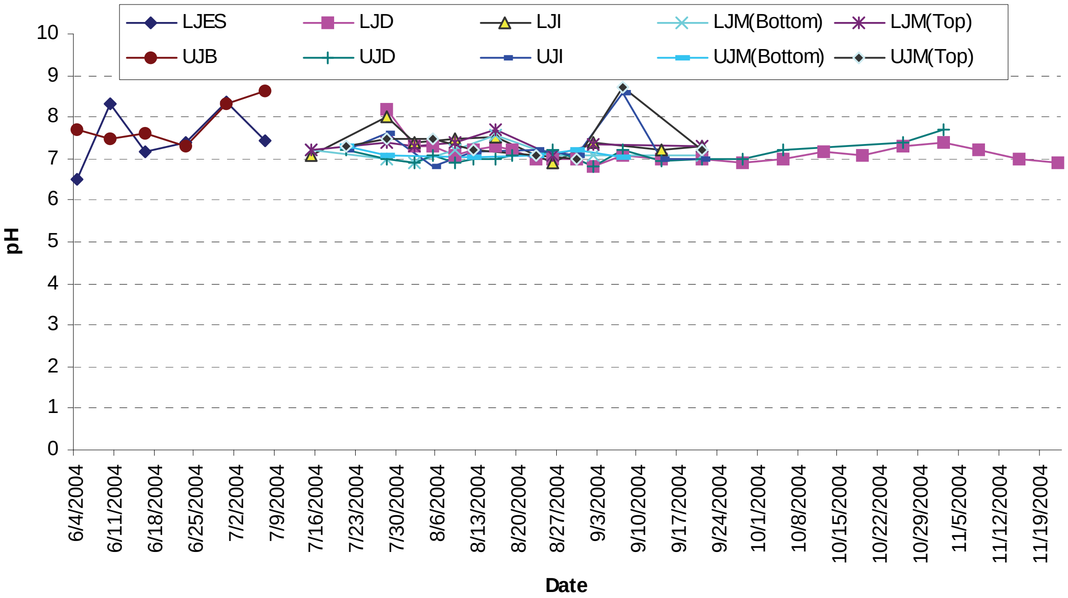


Figure 3.1.17b Average pH at Jones Tract (Bryte Lab-field), June—Nov 2004

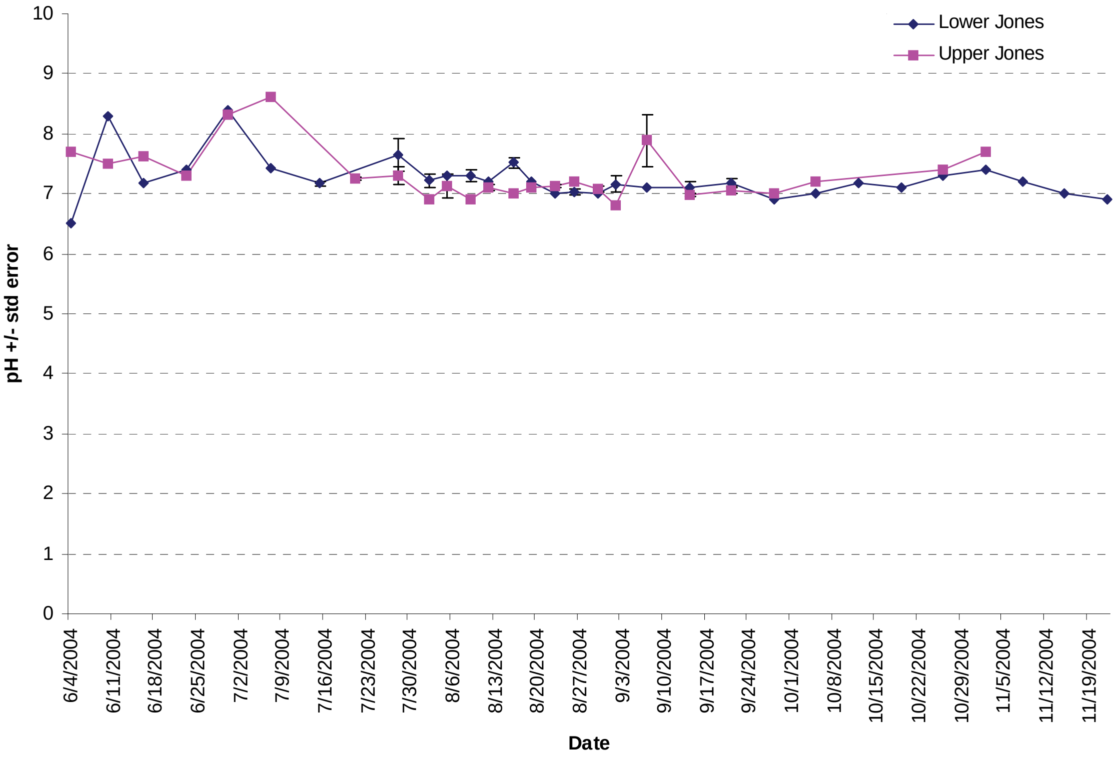


Figure 3.1.18 Average dissolved oxygen and pH at Lower Jones Intake, Aug—Nov 2004

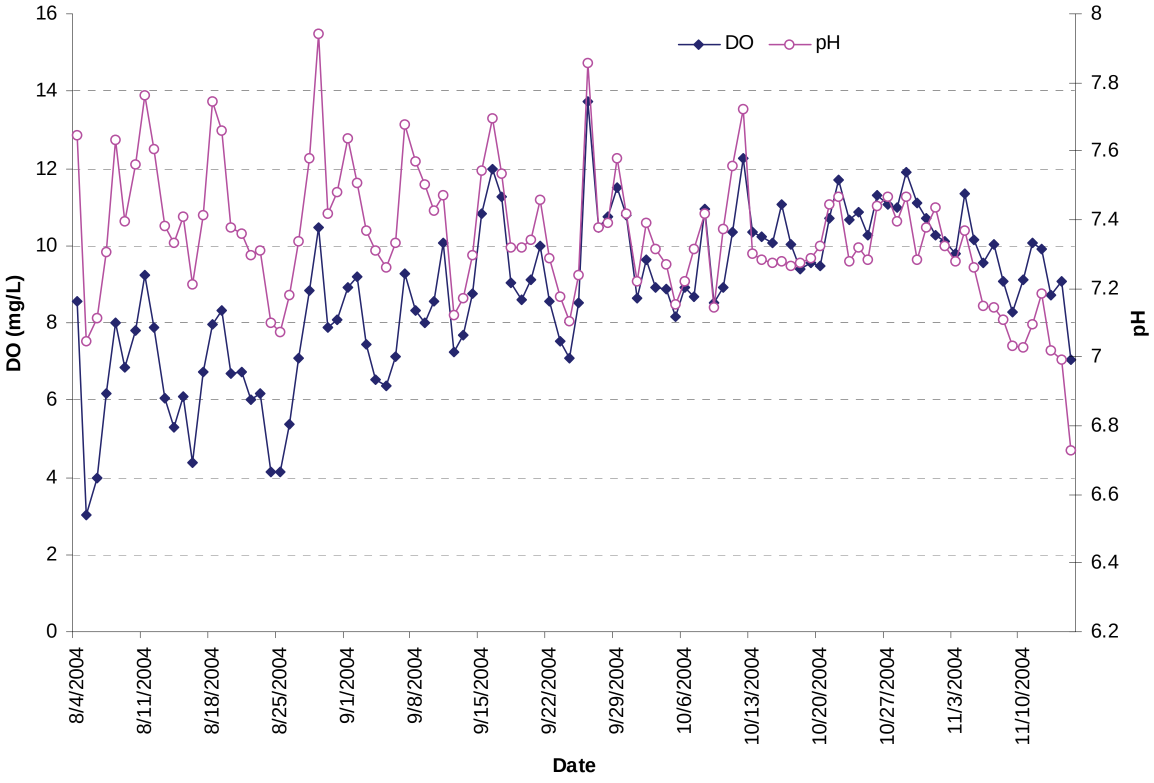


Figure 3.1.19 Average dissolved oxygen and pH at Lower Jones Middle, Aug—Nov 2005

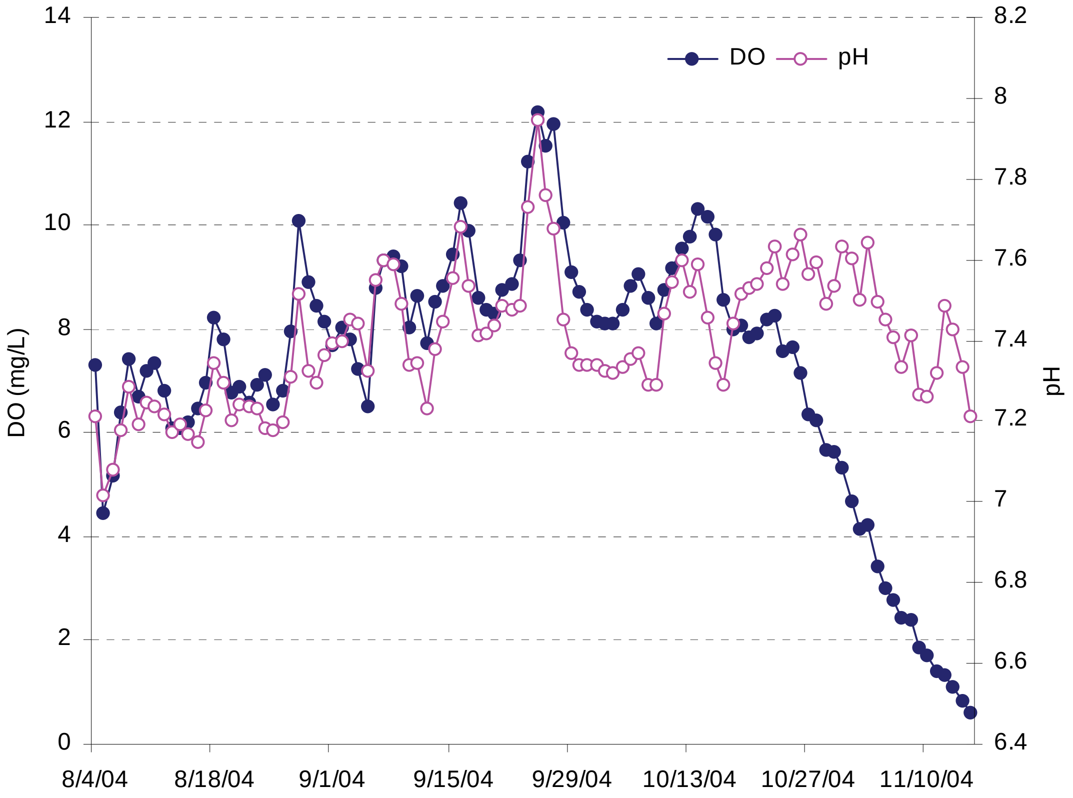


Figure 3.1.20 Average dissolved oxygen and pH at Upper Jones Intake, July—Nov 2004

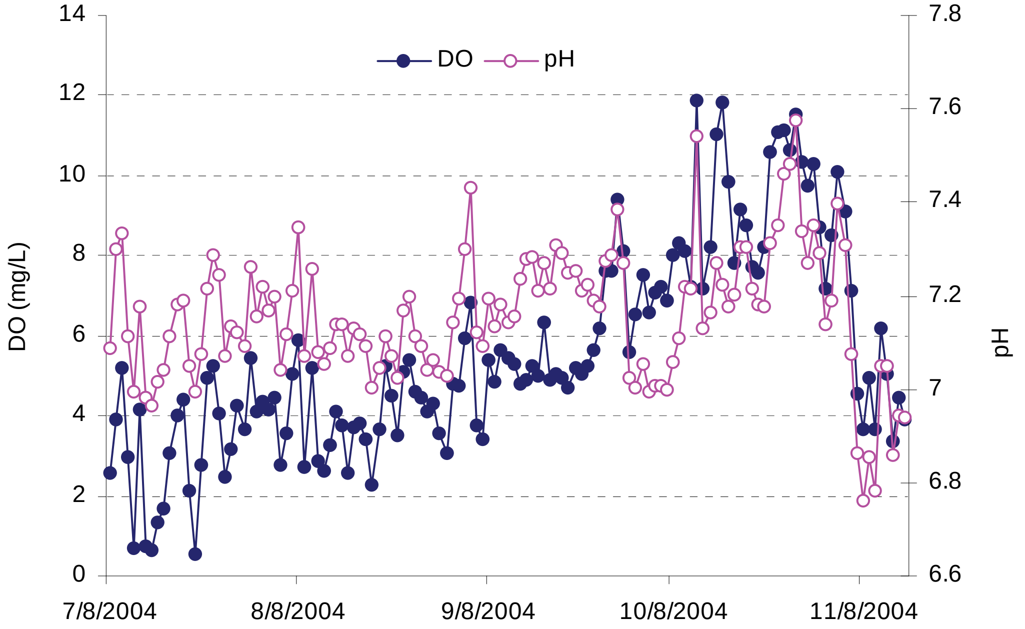
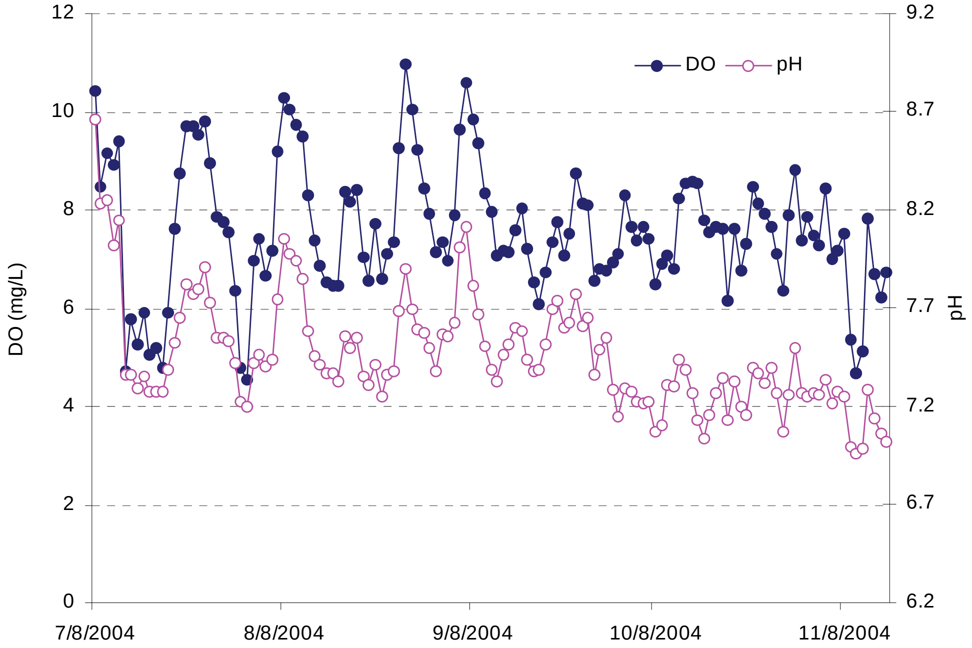


Figure 3.1.21 Average dissolved oxygen and pH at Upper Jones Middle, July—Nov 2004



7/8/04 to 11/15/04. Each data point is an average of 96 observations

Figure 3.1.22 Biochemical oxygen demand at Jones Tract, July—Nov 2004

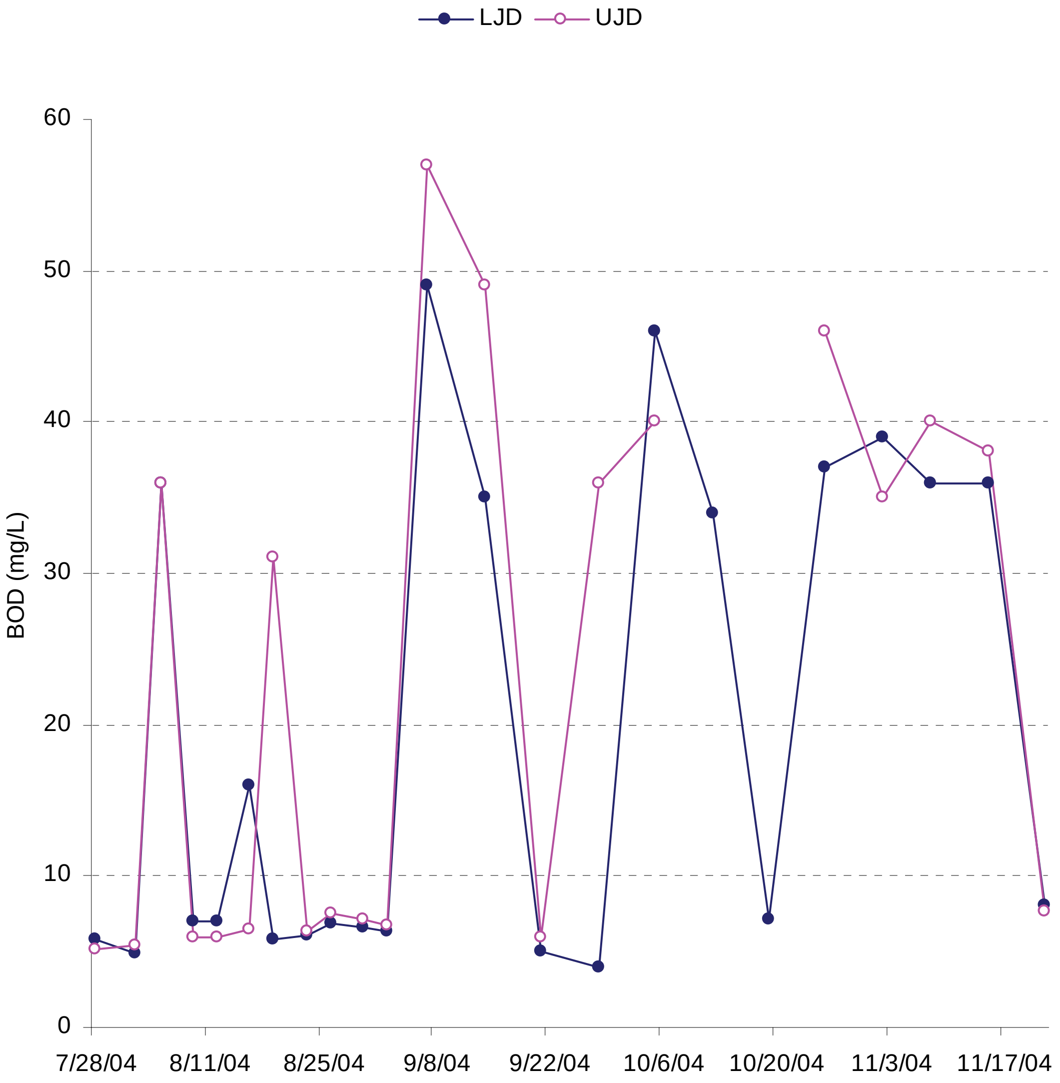


Figure 3.1.23a Turbidity in the Jones Tract (Bryte Lab), June to Nov 2004

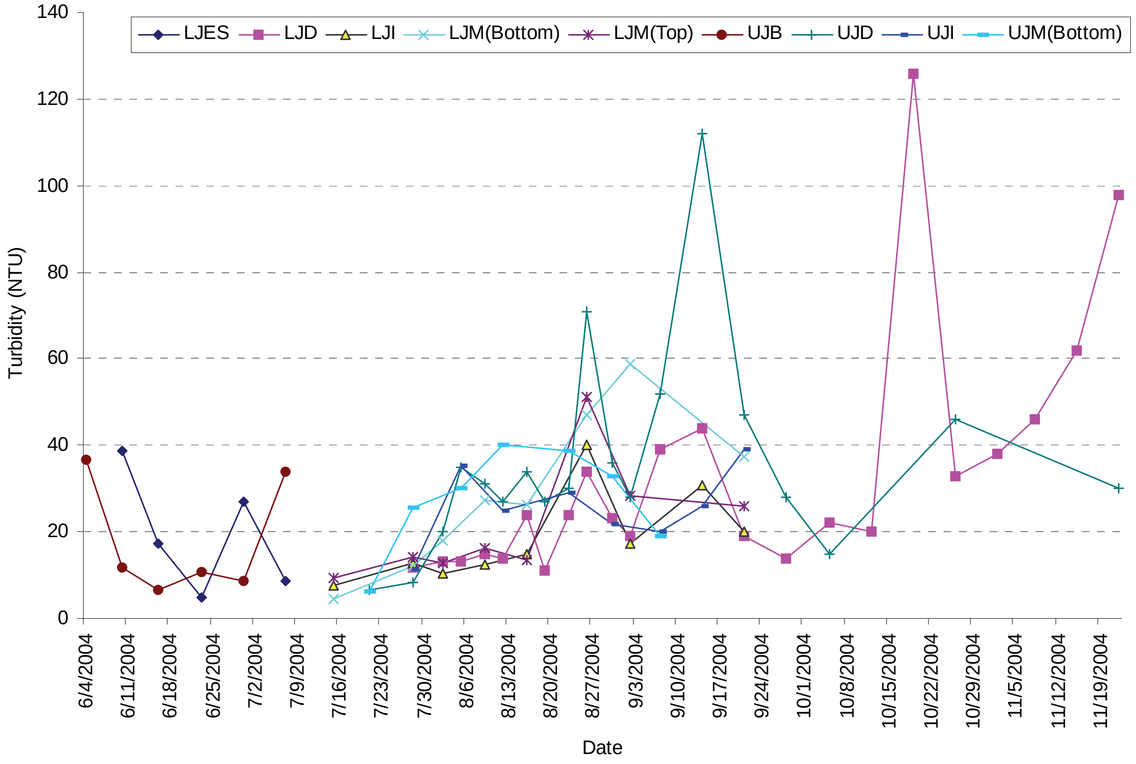


Figure 3.1.23b Average turbidity in the Jones Tract (Bryte Lab), June to Nov 2004

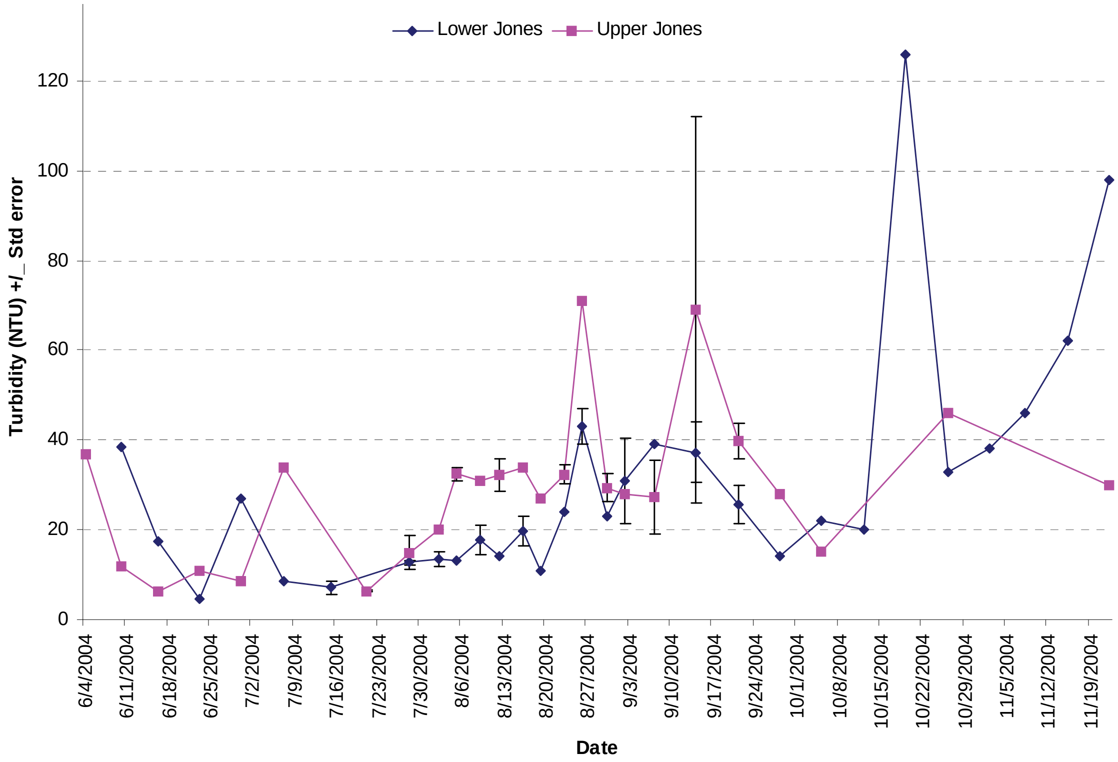


Figure 3.1.24 Total suspended solids at Jones Tract (Bryte Lab), July to Nov 2004

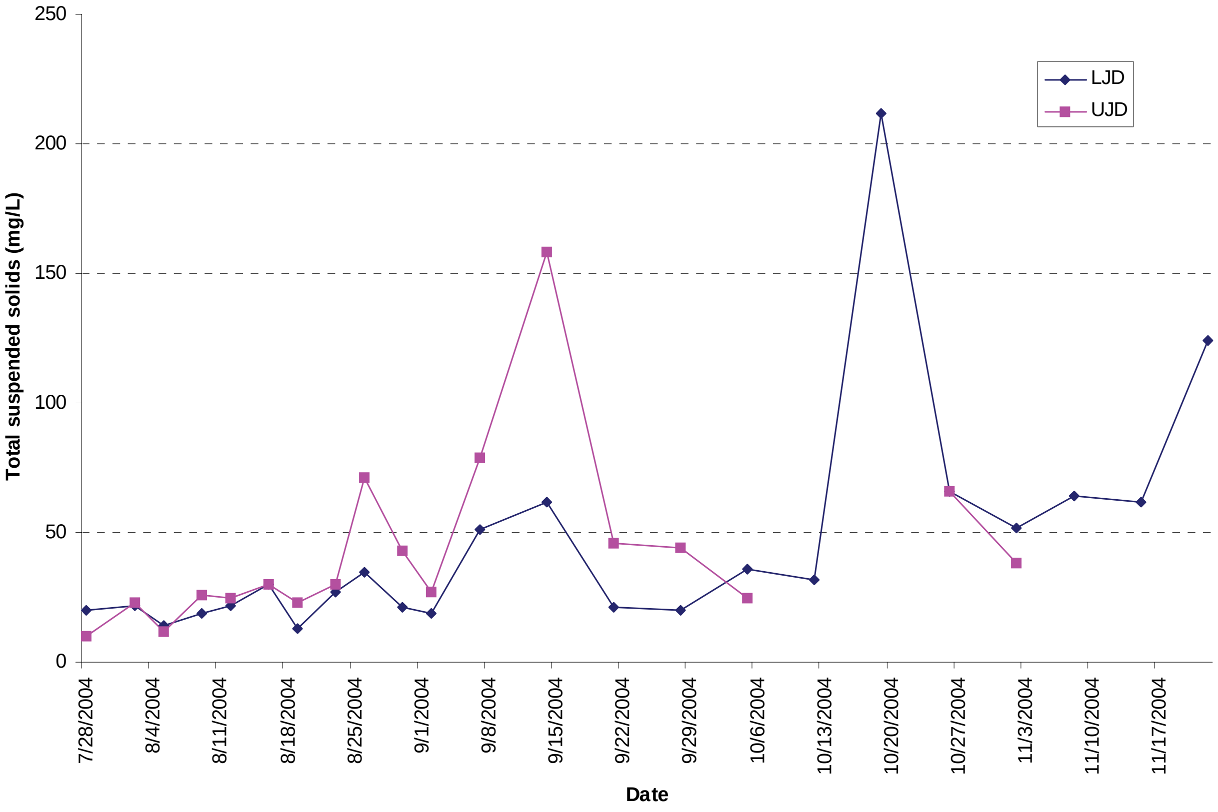


Figure 3.1.25a Turbidity and total suspended solids at Lower Jones Discharge, Jul—Nov 2004

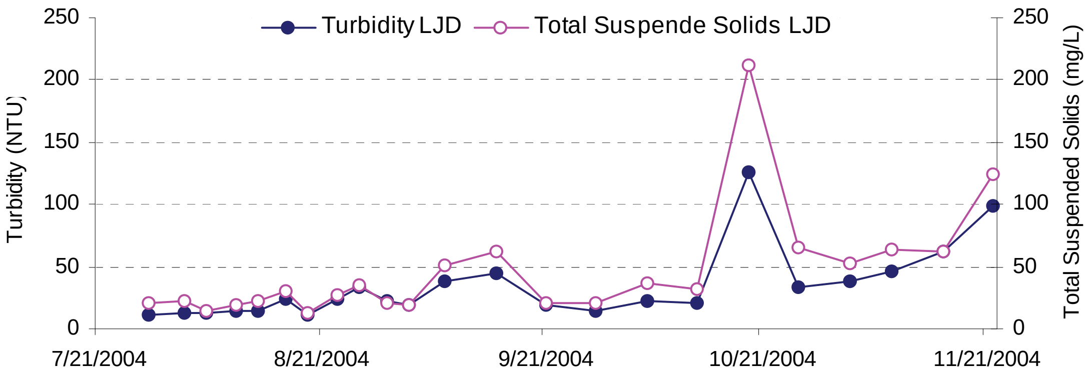


Figure 3.1.25b Turbidity and total suspended solids at Upper Jones Discharge, July—Nov 2004

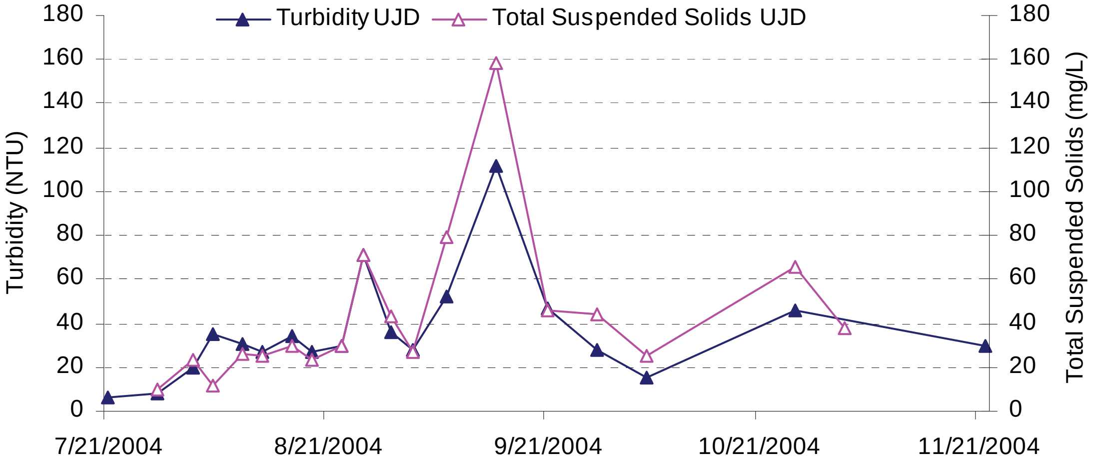


Figure 3.1.25c Turbidity vs total suspended solids at Lower Jones Discharge and Upper Jones Discharge

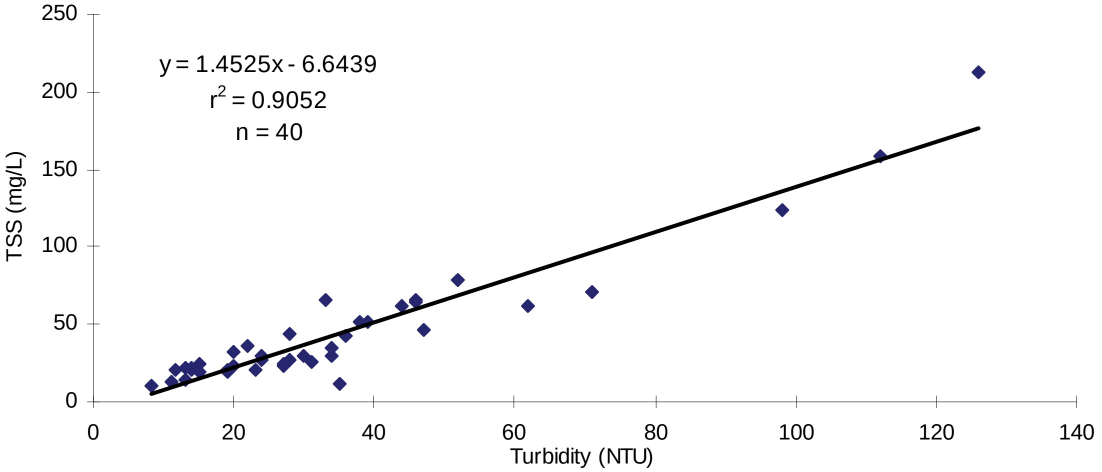
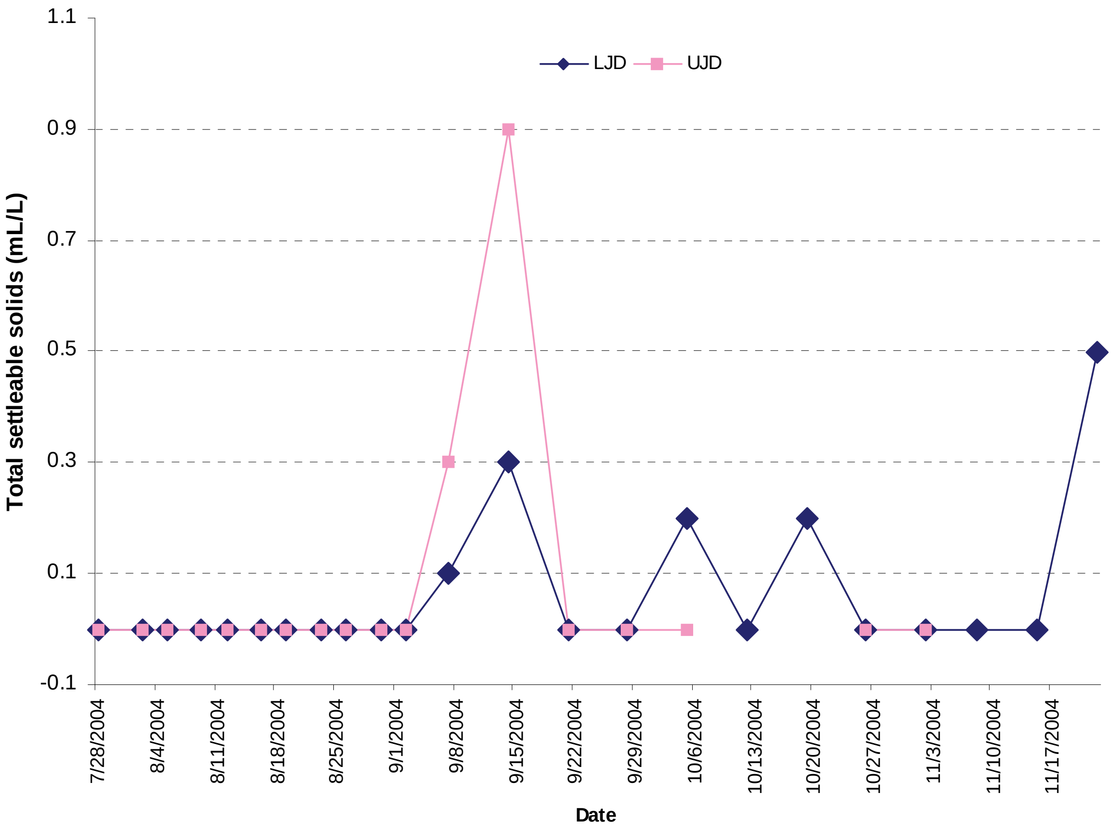
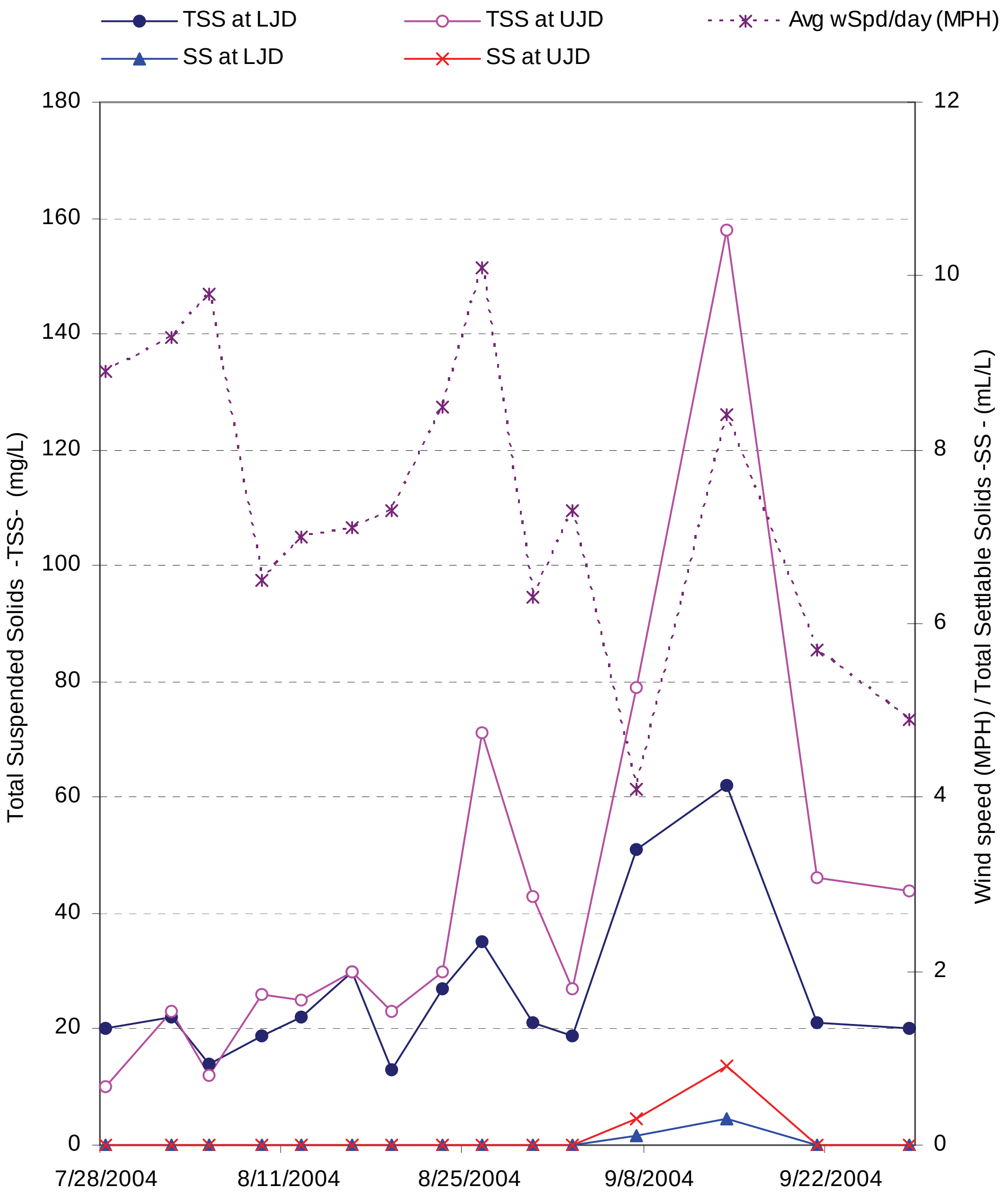


Figure 3.1.26 Total settleable solids in Jones Tract (Bryte Lab), July to Nov 2004



Nondetects are plotted as zeros

Figure 3.1.27 Average daily wind speed at Jones Tract and total suspended solids and total settlable solids at Upper Jones Discharge and Lower Jones Discharge



Non-detectables are plotted as zeros.
*CIMIS Jones Tract San Francisco Station 300 was used to recover wind-speed values on the days that grab sample data were collected from Jones Tract. Wind-speed values are not available for June and October.

Figure 3.1.28 Precipitation at Brentwood weather station, June—Dec 2004

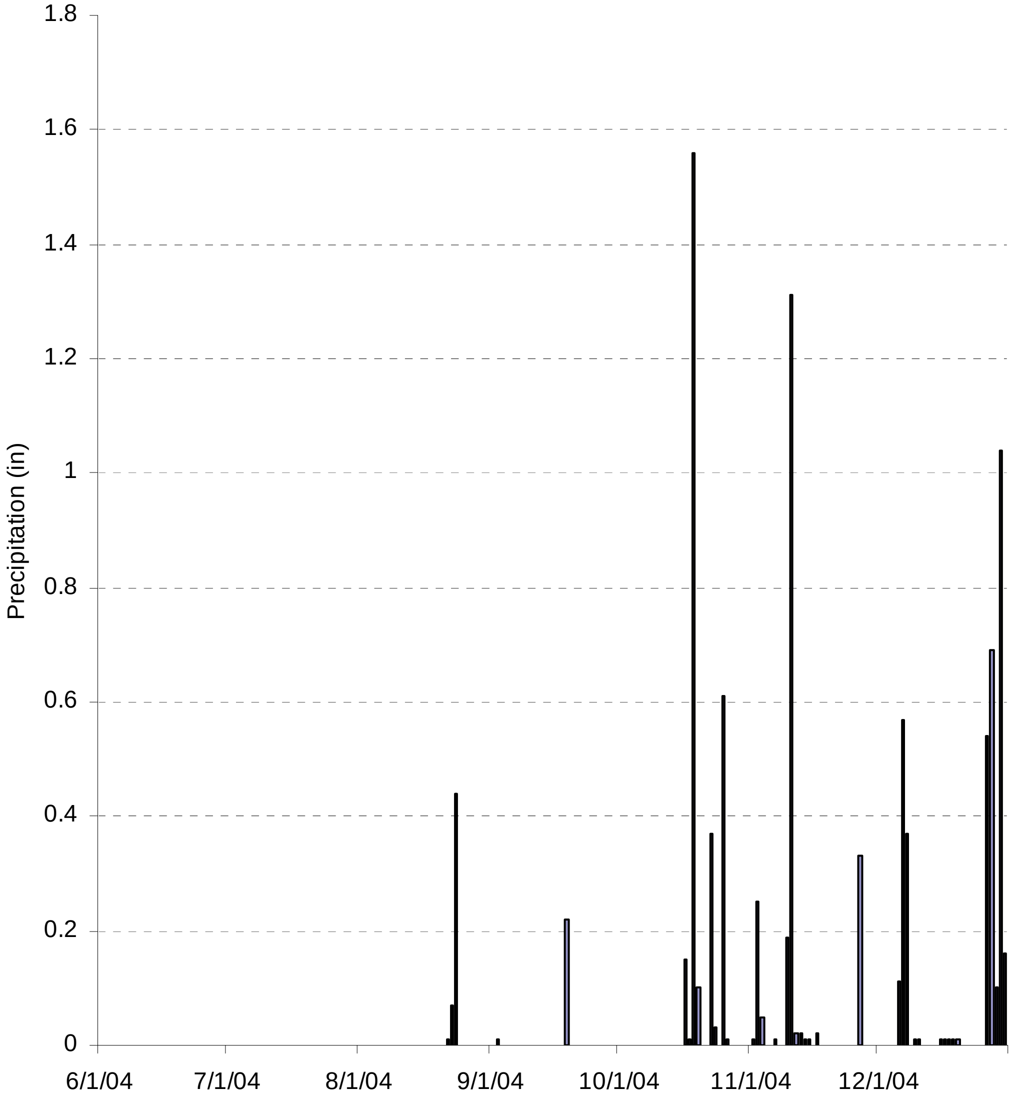


Figure 3.1.29a Evapotranspiration (ETo) in Jones Tract, July—Sep 2004

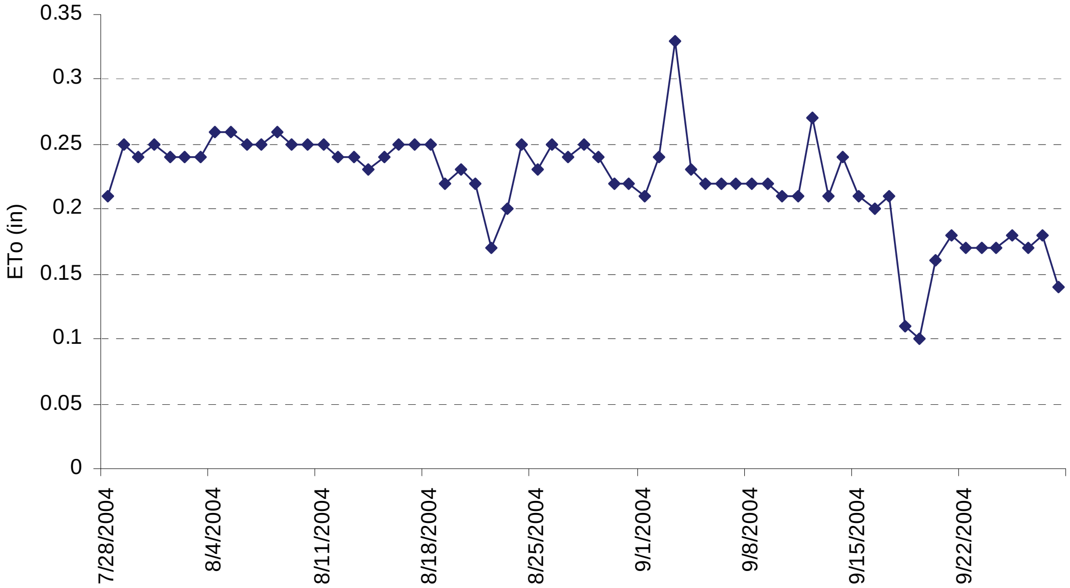


Figure 3.1.29b Solar radiation in Jones Tract, Jul—Sep 2004

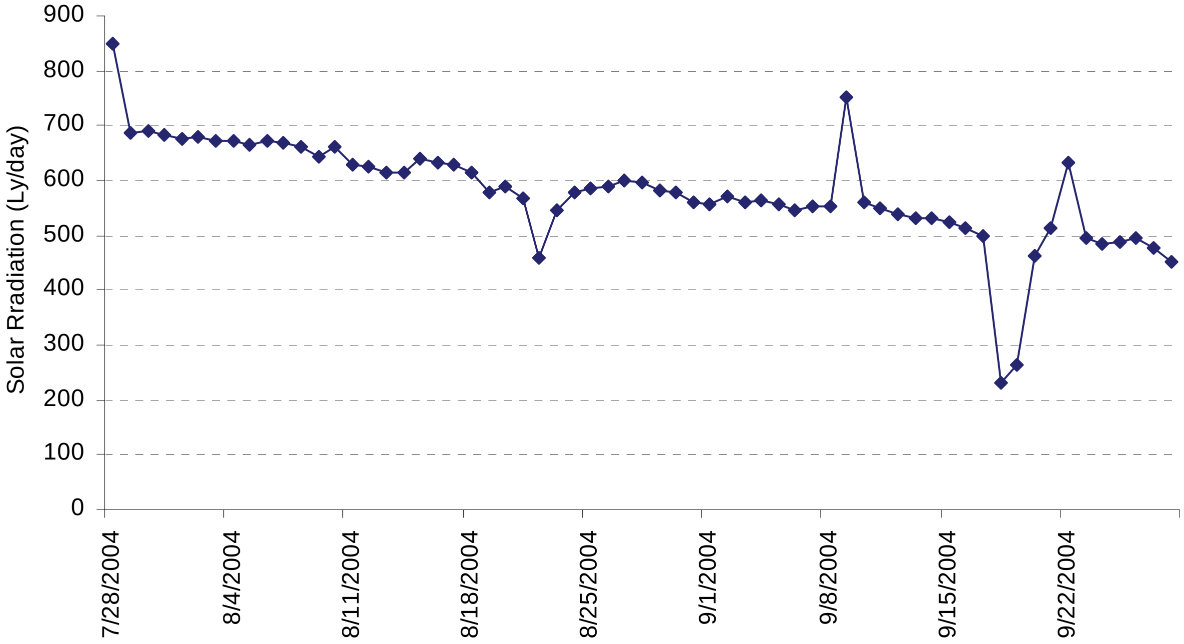


Figure 3.1.29c Relative humidity at Jones Tract, Jul—Dec 2004

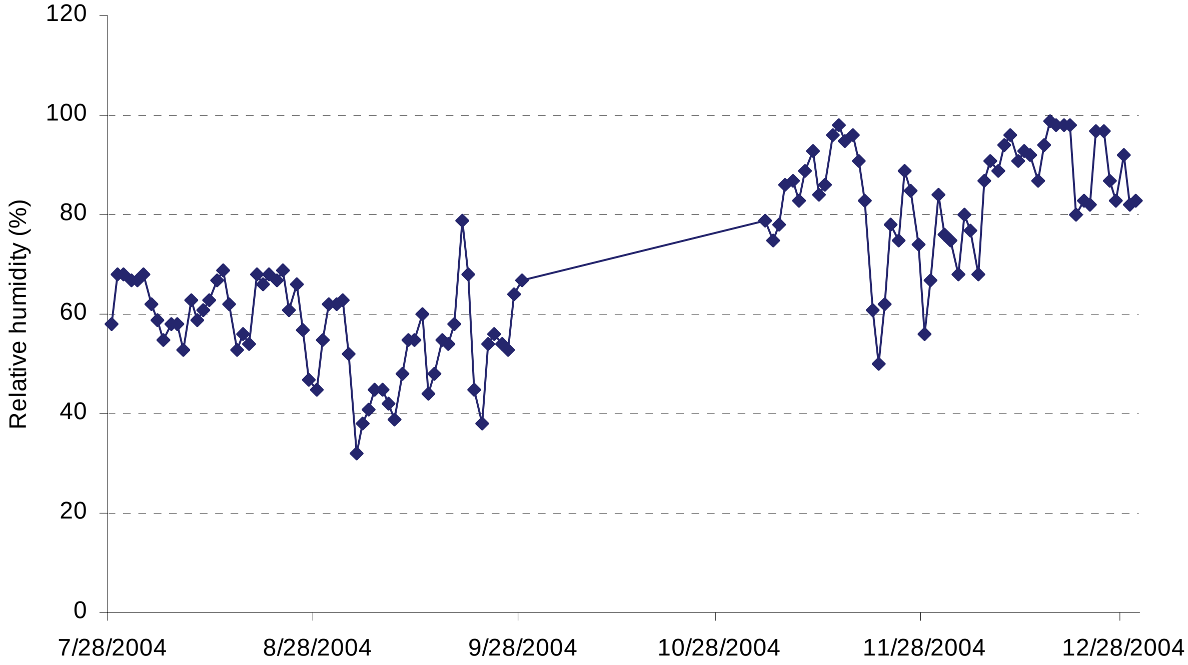


Figure 3.1.30 Relationship between solar radiation and evapotranspiration (ETo) at Jones Tract

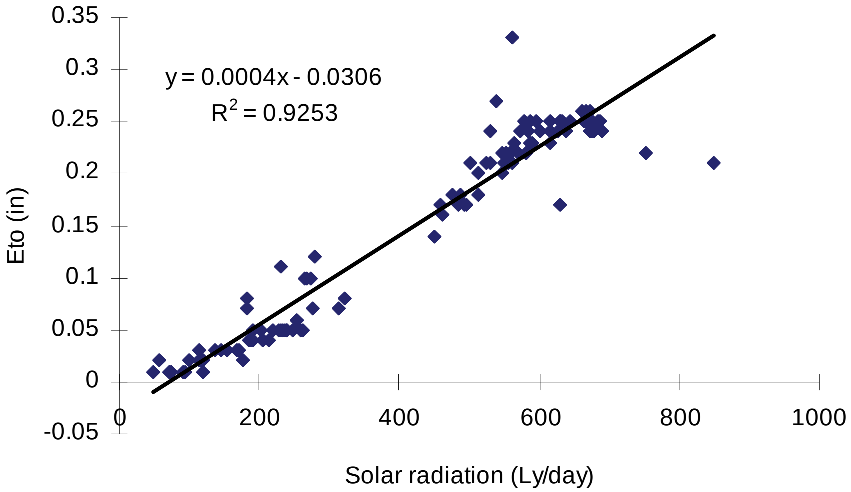


Figure 3.1.31 Relationship between evapotranspiration (Eto) and relative humidity at Jones Tract

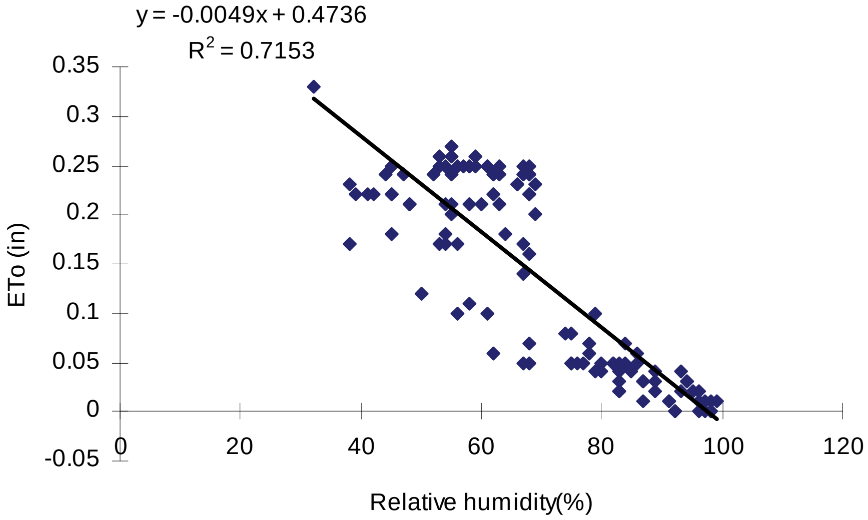


Figure 3.1.32 Evapotranspiration (ETo) at Jones Tract and Brentwood data on days that Jones Tract was not monitored, June—Dec 2004

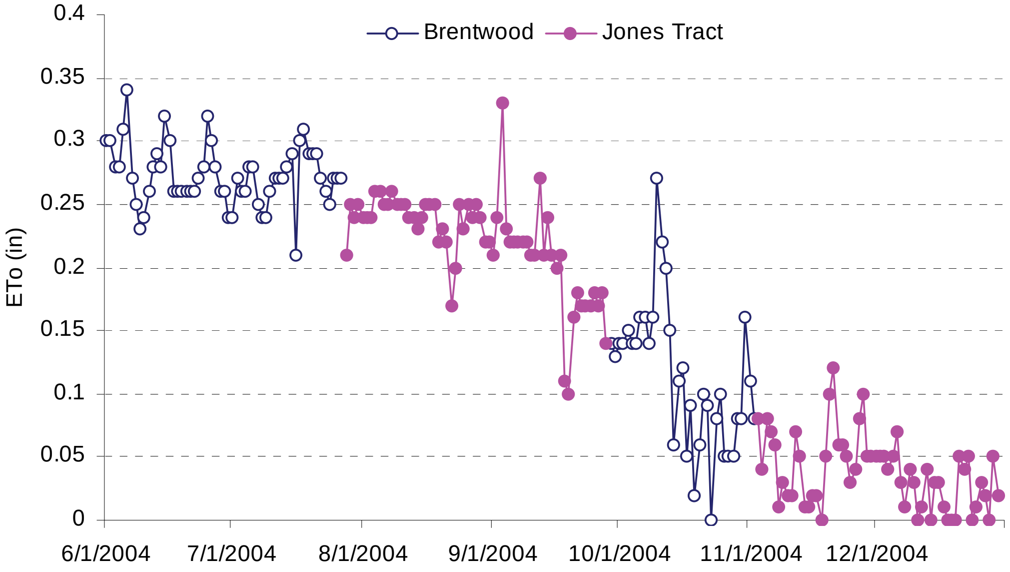


Figure 3.1.33 Evapotranspiration (ETo) at Jones Tract and Brentwood, June—Dec 2004

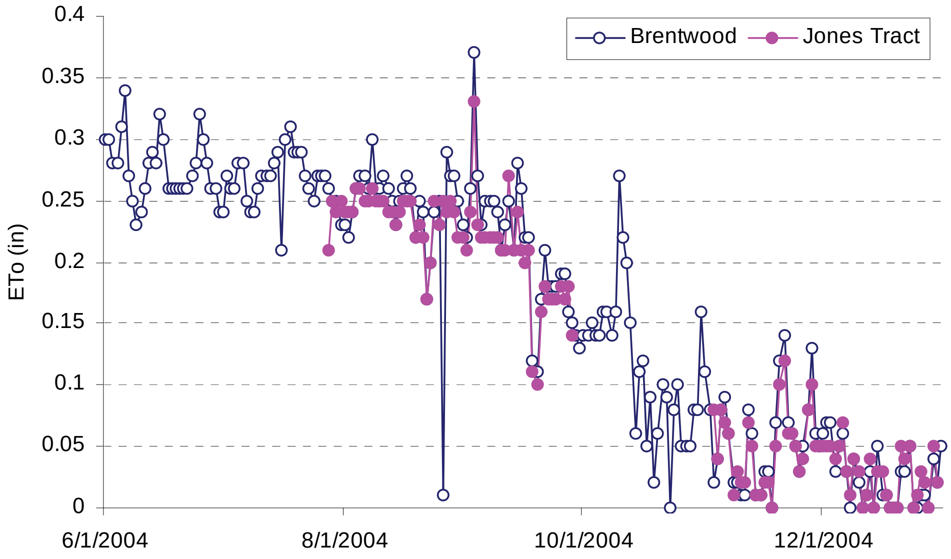


Figure 3.1.34 Average daily solar radiation at Jones Tract with Brentwood data when Jones Tract was not monitored, June—Dec 2004

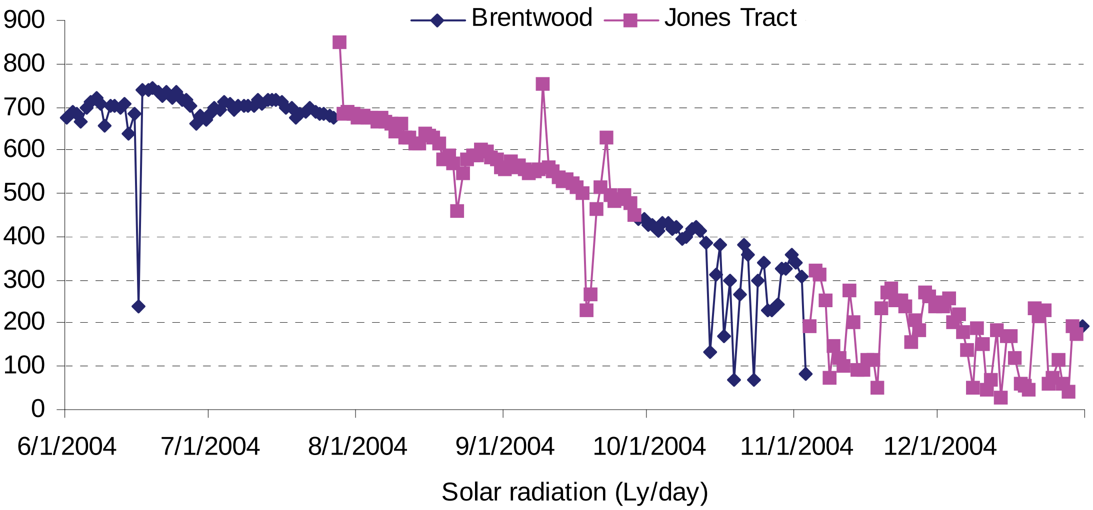


Figure 3.1.35 Relationship of solar radiation at Jones Tract and Brentwood

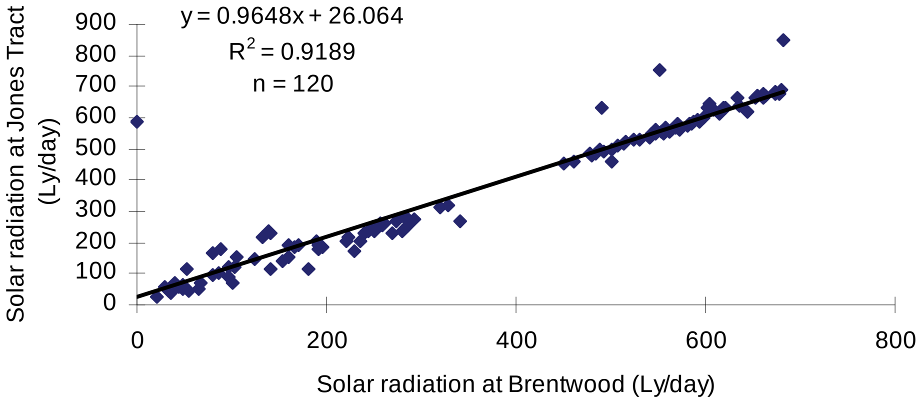


Figure 3.1.36 Estimated average daily relative humidity at Jones Tract using Brentwood data, Jun—Dec 2004

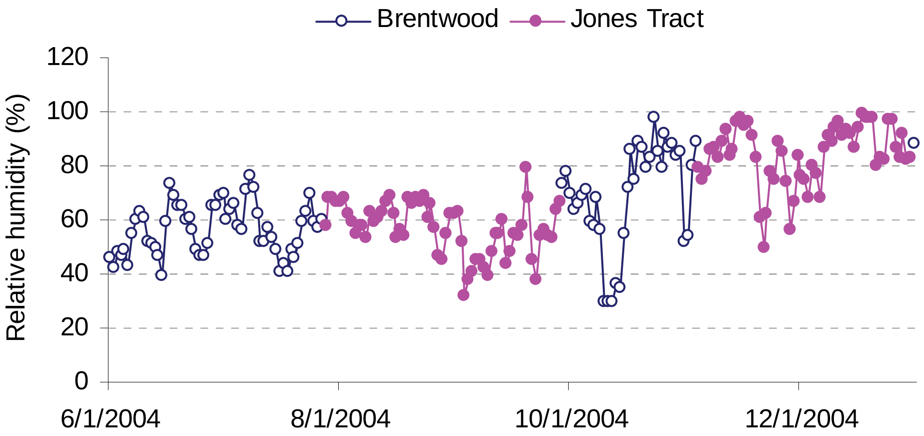


Figure 3.1.37 Average air temperature at Brentwood and Jones Tract, Jun—Dec 2004

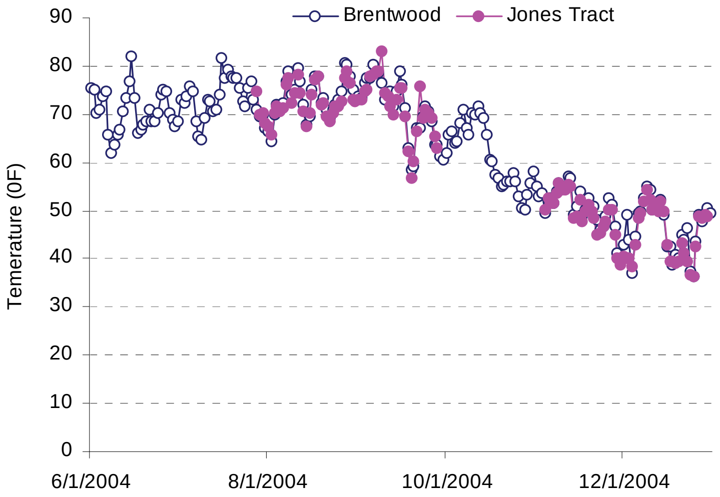


Figure 3.1.38 Average daily air temperature at Jones Tract with Brentwood data when Jones Tract was not monitored, June—Dec 2004

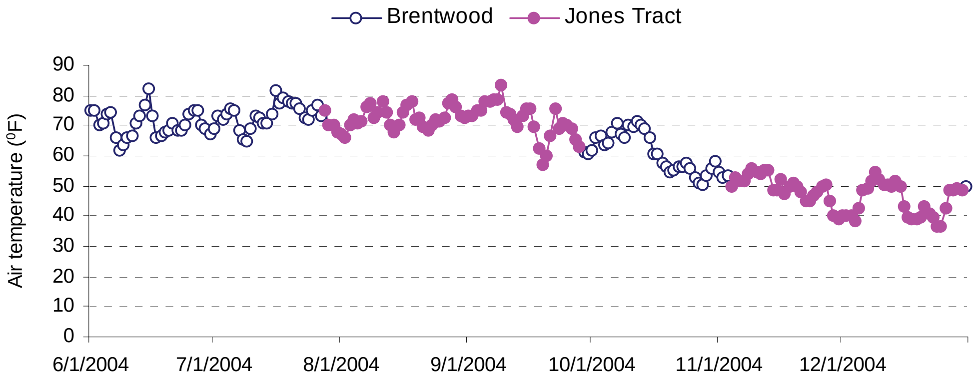


Figure 3.1.39 Average air temperature at Brentwood and Jones Tract, Jun—Dec 2004

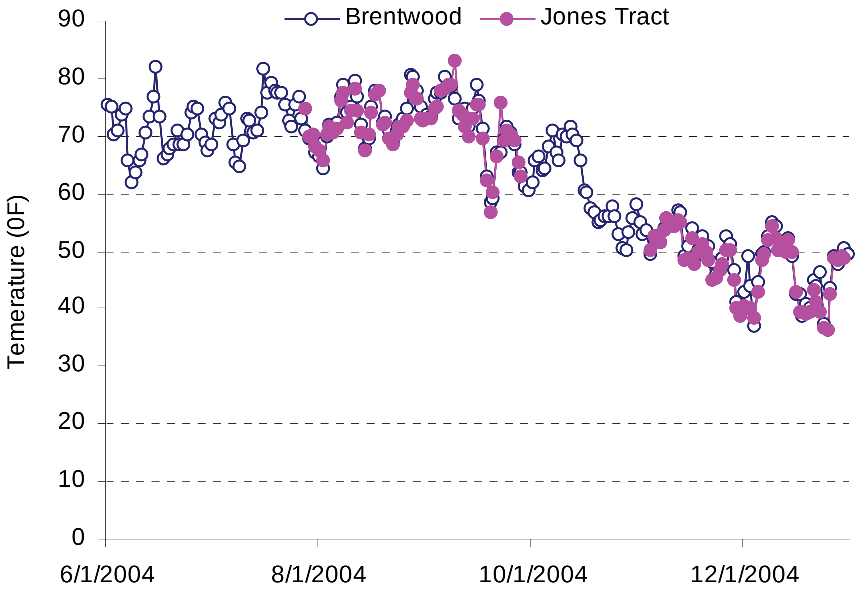


Figure 3.1.40 Average daily wind speed at Brentwood and Jones Tract, Jun—Dec 2004

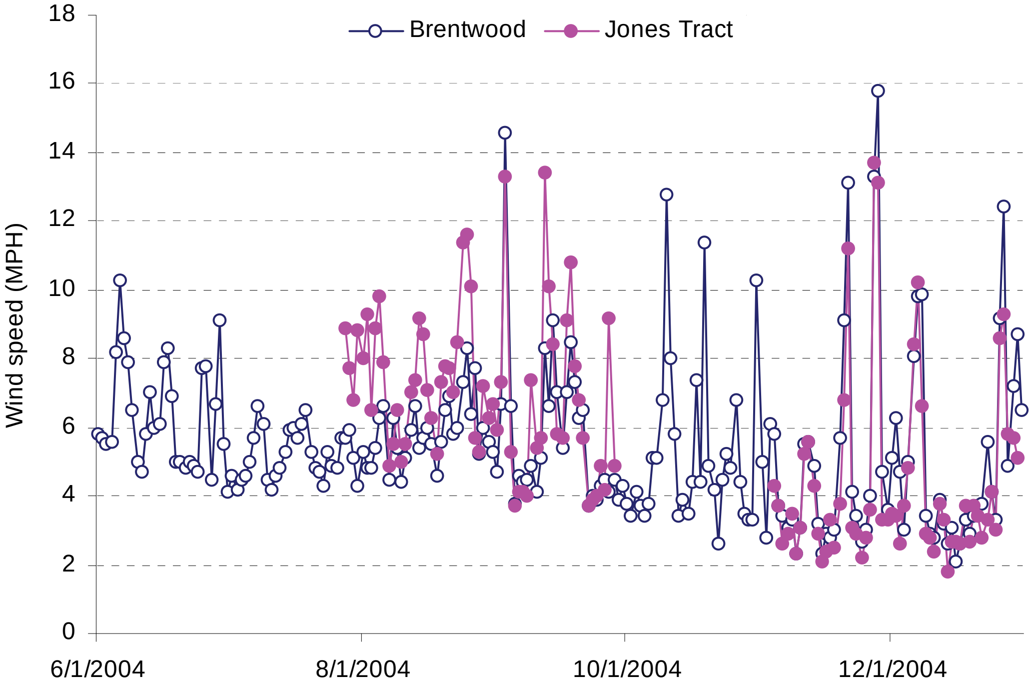
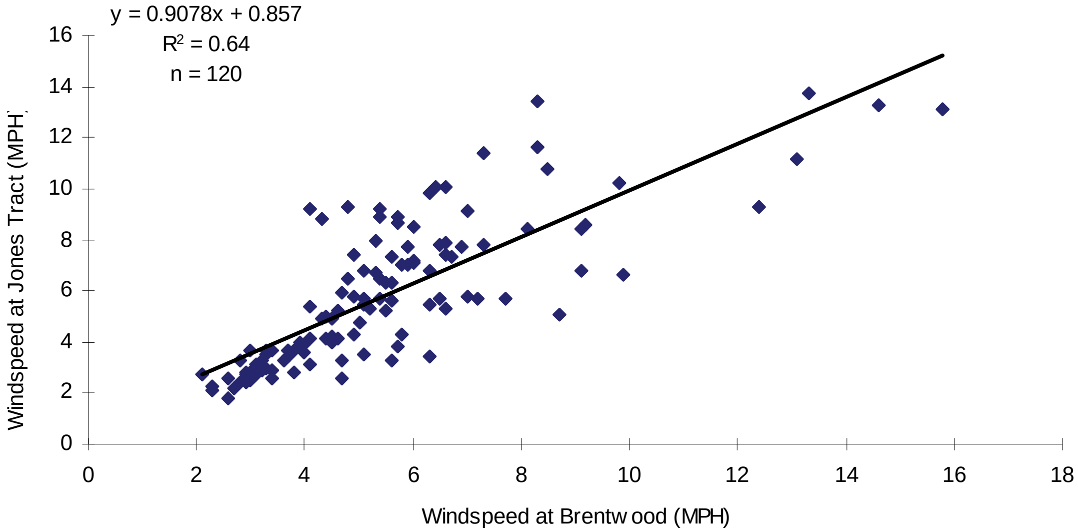


Figure 3.1.41 Relationship between average daily wind speed at Jones Tract and Brentwood



Chapter 3 Results and Discussion

3.2 Organic Carbon

Figures

Table

Figure 3.2.1a First year total organic carbon trends from SMARTS tanks, comparable to Jones Tract flood per square meter per day

The slope of the line is the rate of increase in TOC mass in grams.

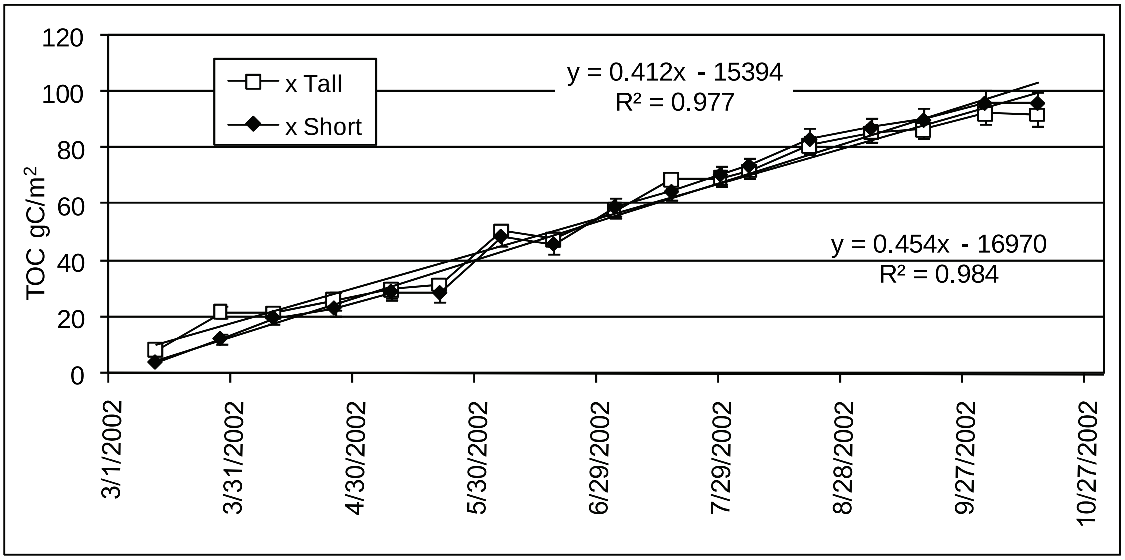


Figure 3.2.1b Long-term total organic carbon trends from SMARTS tanks

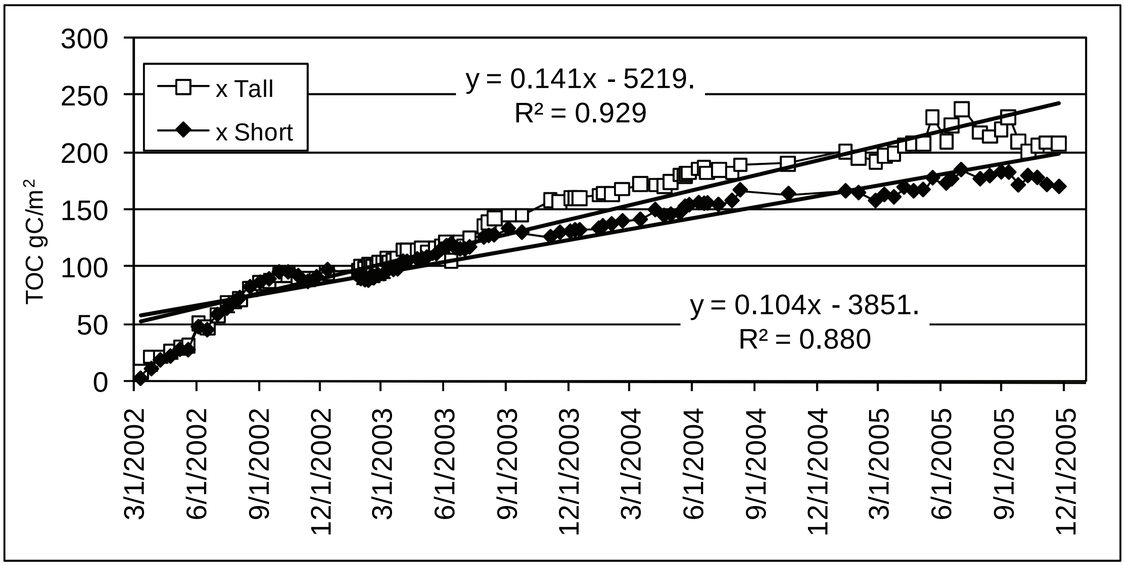


Figure 3.2.2 Total organic carbon and dissolved organic carbon on Jones Tract

The linear fit of 0.135 mg/L/day corresponds to an increase of about 1 mg/L per week.

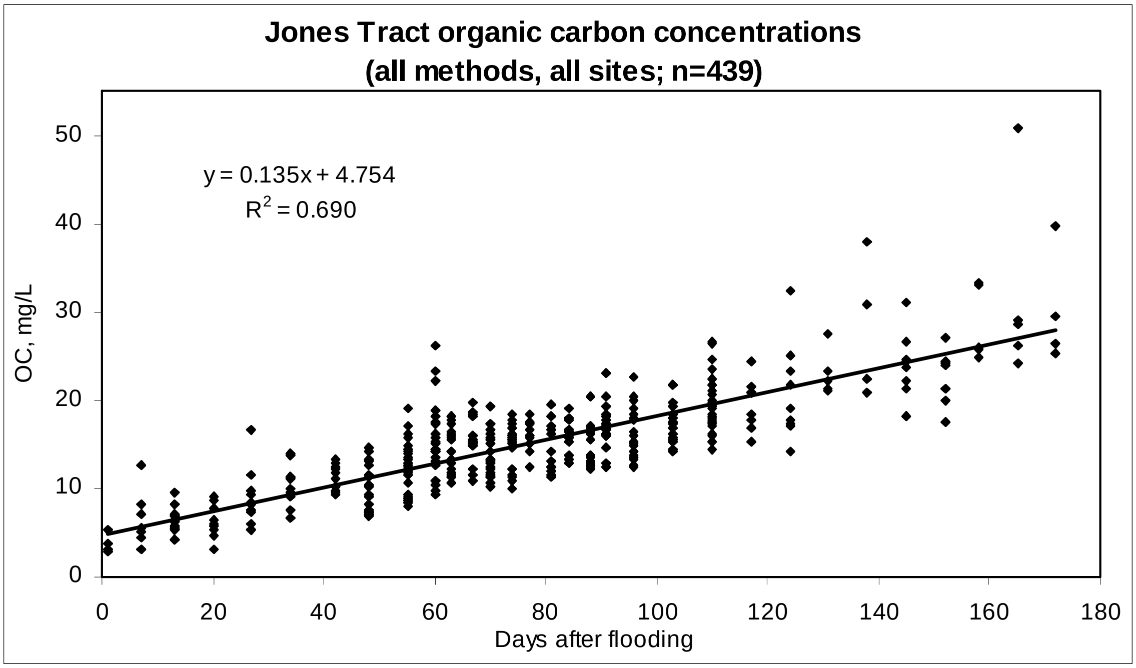


Figure 3.2.3 Lower Jones Tract dissolved organic carbon by wet oxidation

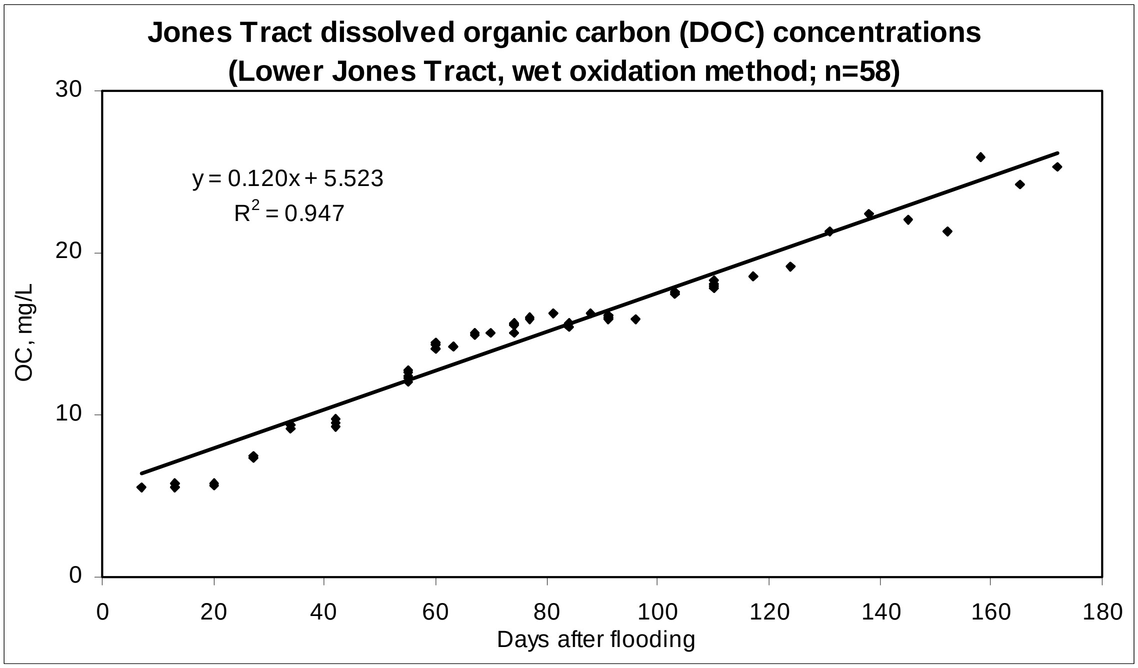


Figure 3.2.4 Comparison of Upper and Lower Jones Tract samples, showing larger initial dissolved organic carbon concentration in Upper Jones, and statistically identical rate of increase

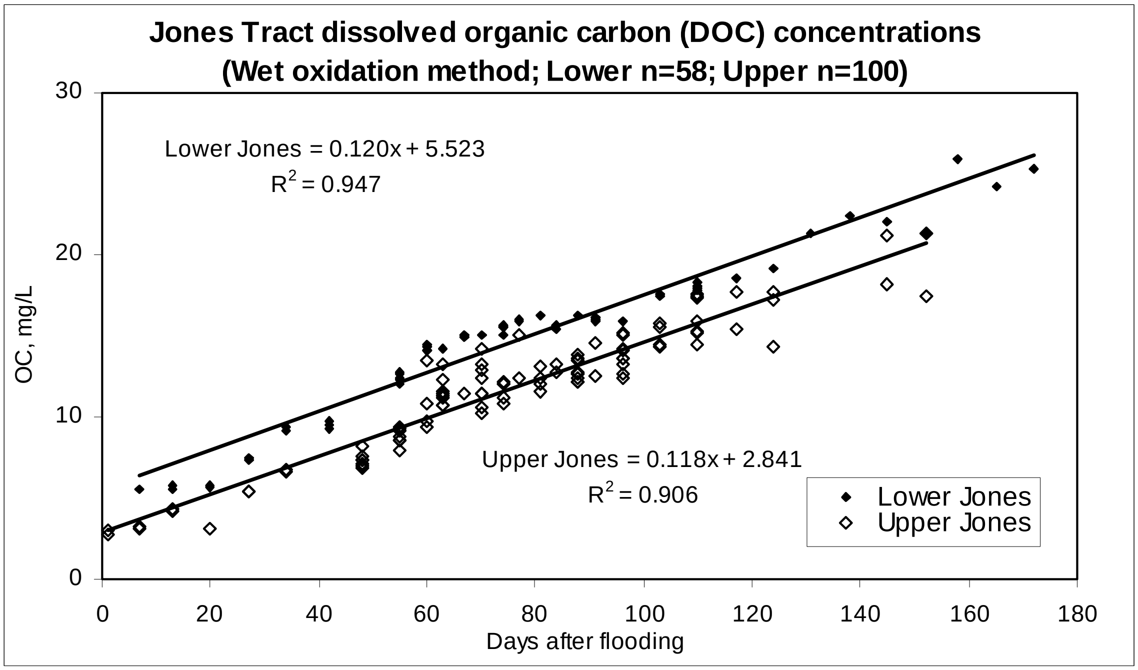


Figure 3.2.5 Average depth estimates for Jones Tract

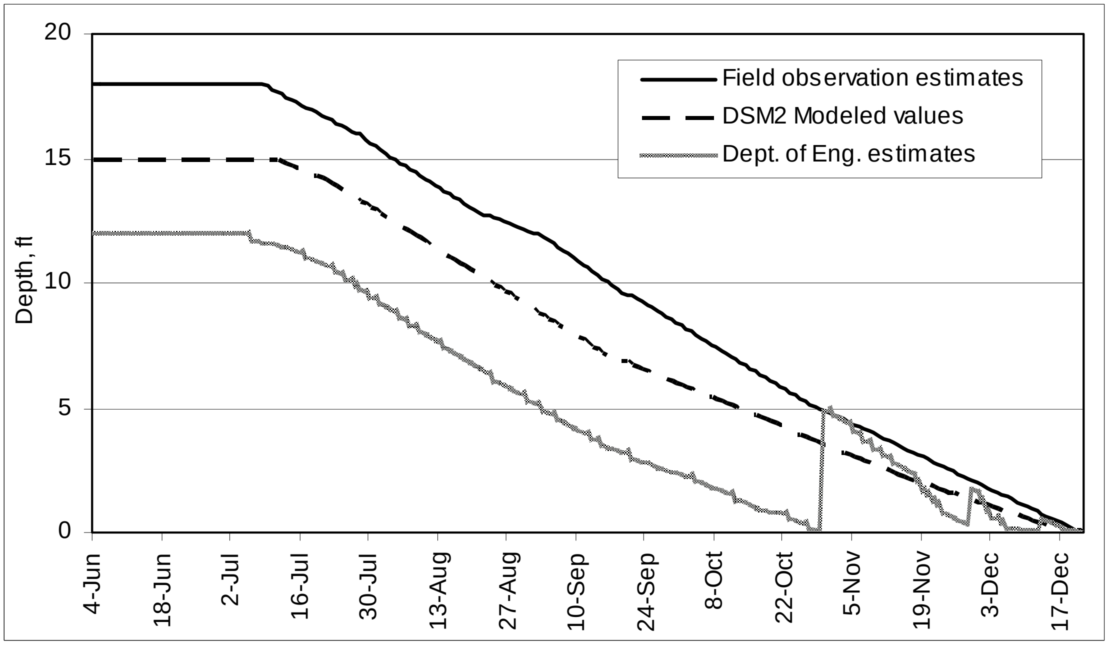


Figure 3.2.6 Topography or bathymetry (area vs elevation) on Webb Tract

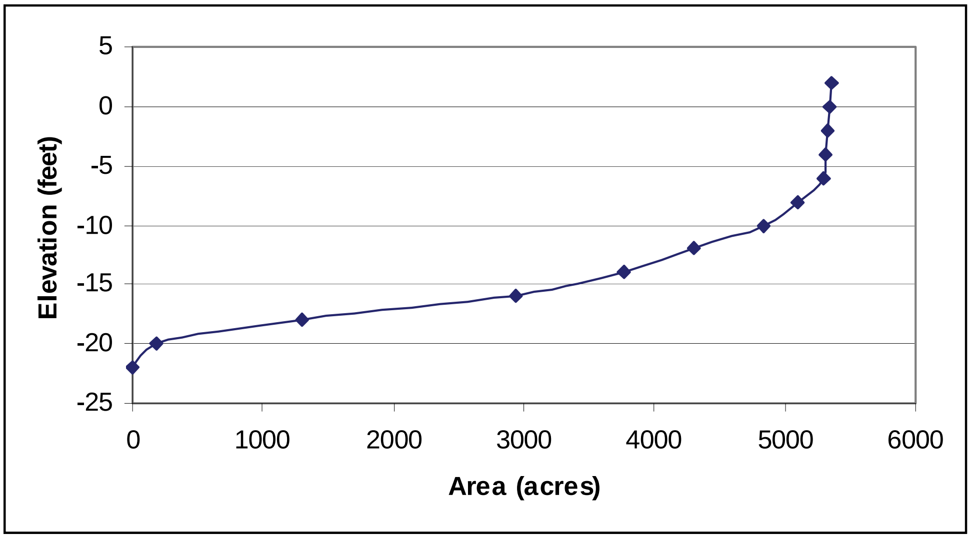


Figure 3.2.7 Topography or bathymetry (area vs elevation) on Bacon Island

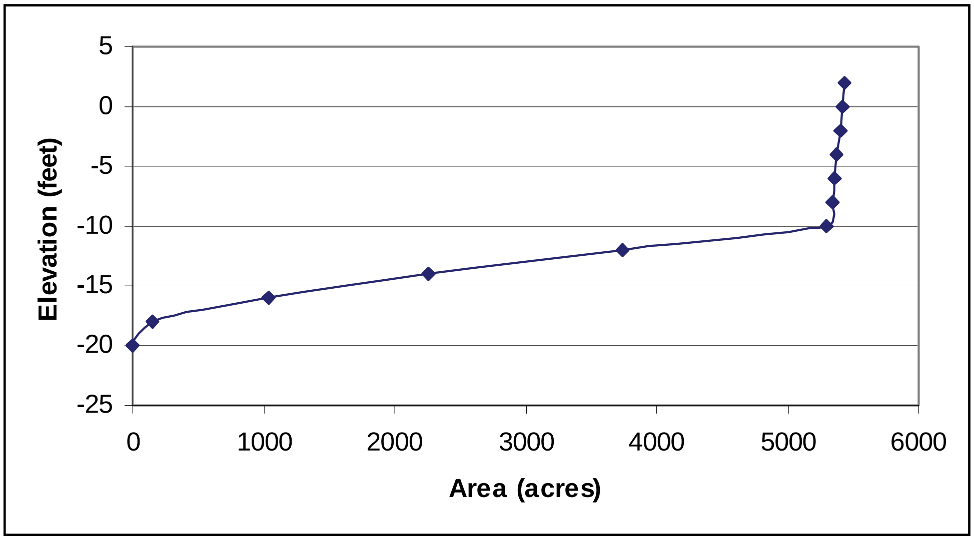


Figure 3.2.8 Lower Jones Tract DOC by wet oxidation, with predicted concentrations if volume decreased as observed and flux from peat were constant

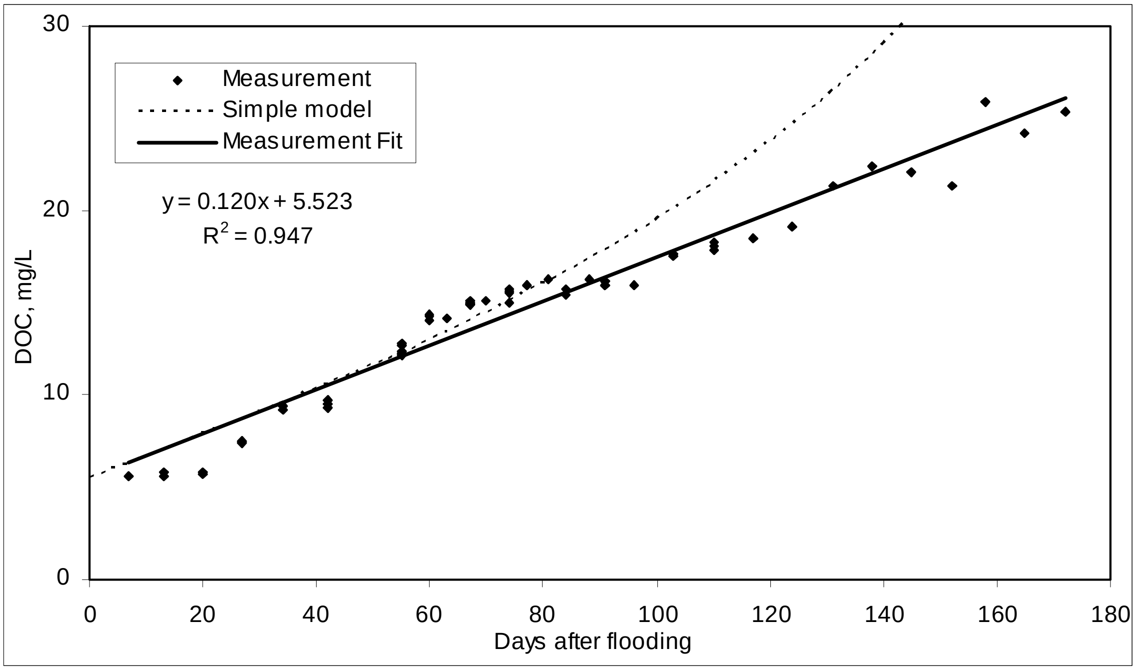


Figure 3.2.9 Water temperatures on Jones Tract

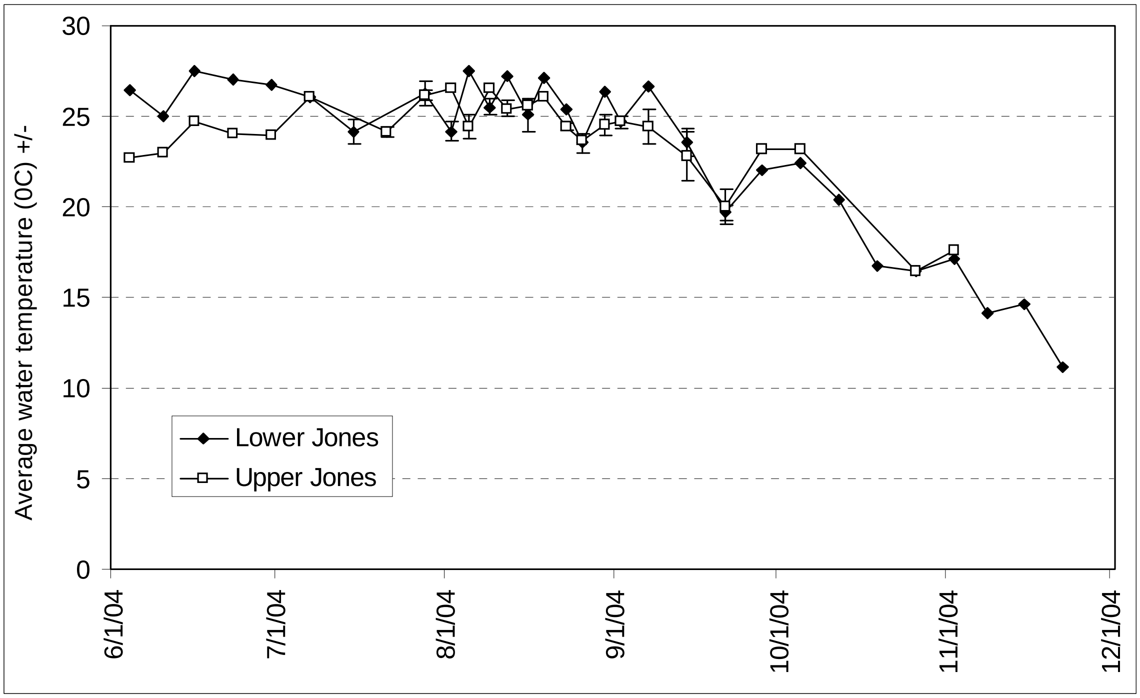


Figure 3.2.10 Monthly average water temperature at Clifton Court Forebay

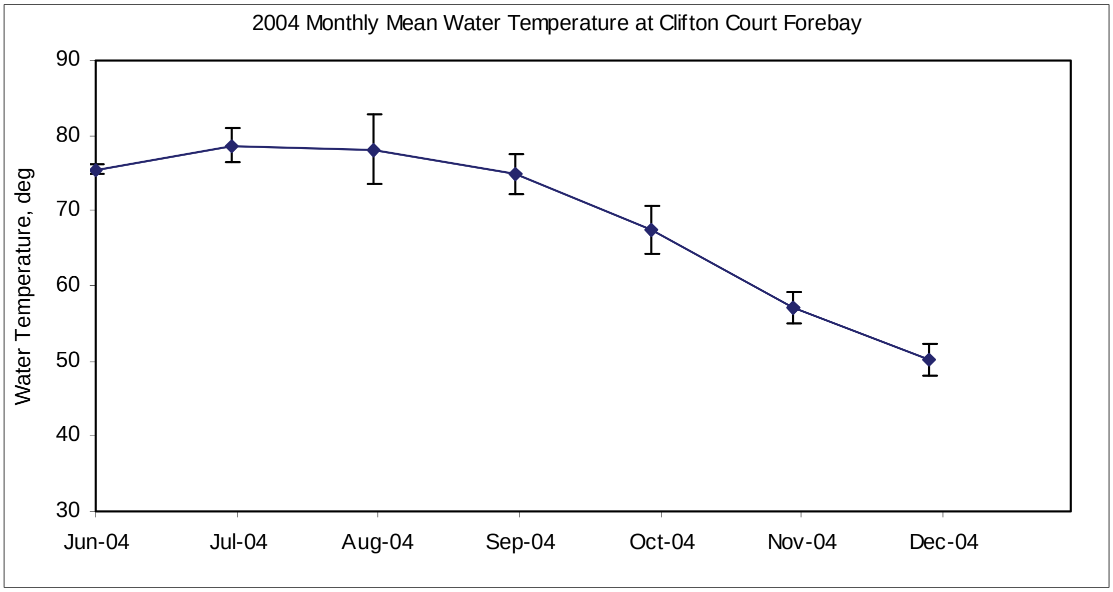


Figure 3.2.11 Monthly average carbon yield rates in g m2 d-1, monthly average water temperature, modeled yield rate, and In-Delta Storage estimated rate

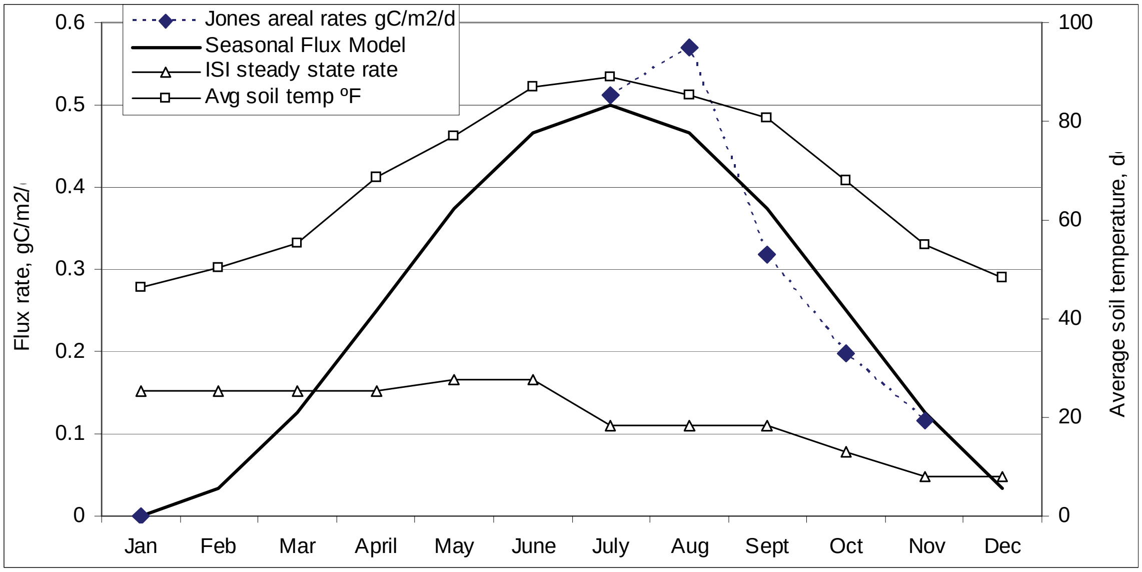


Figure 3.2.12 DSM2 fingerprint for DOC at Banks

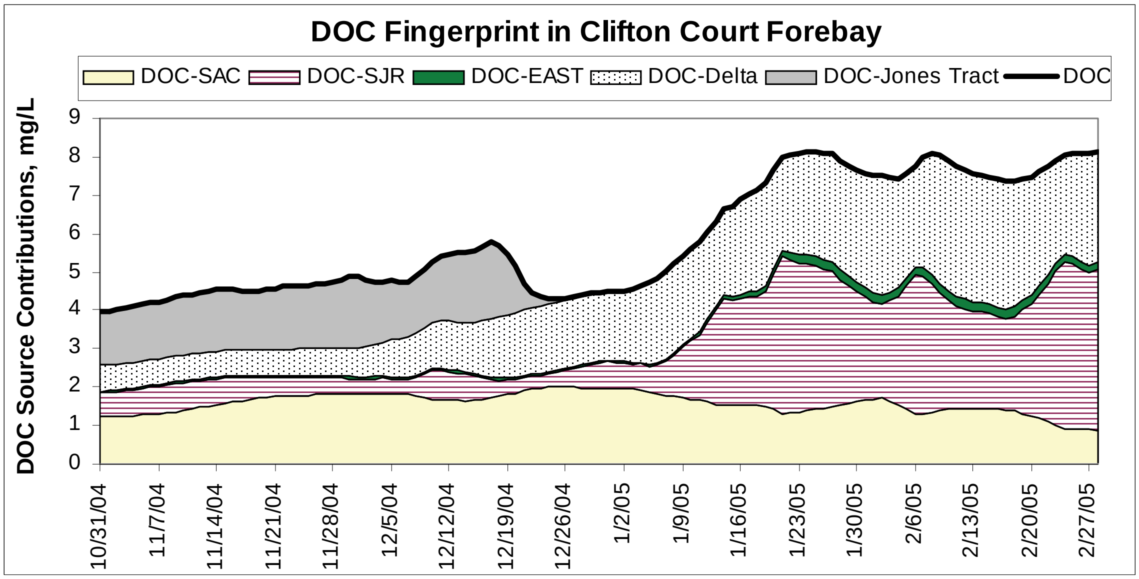


Figure 3.2.13 DOC concentrations at Banks Pumping Plant from 2004 grab samples and the historical mean from 1986 through 2003 (n=18)

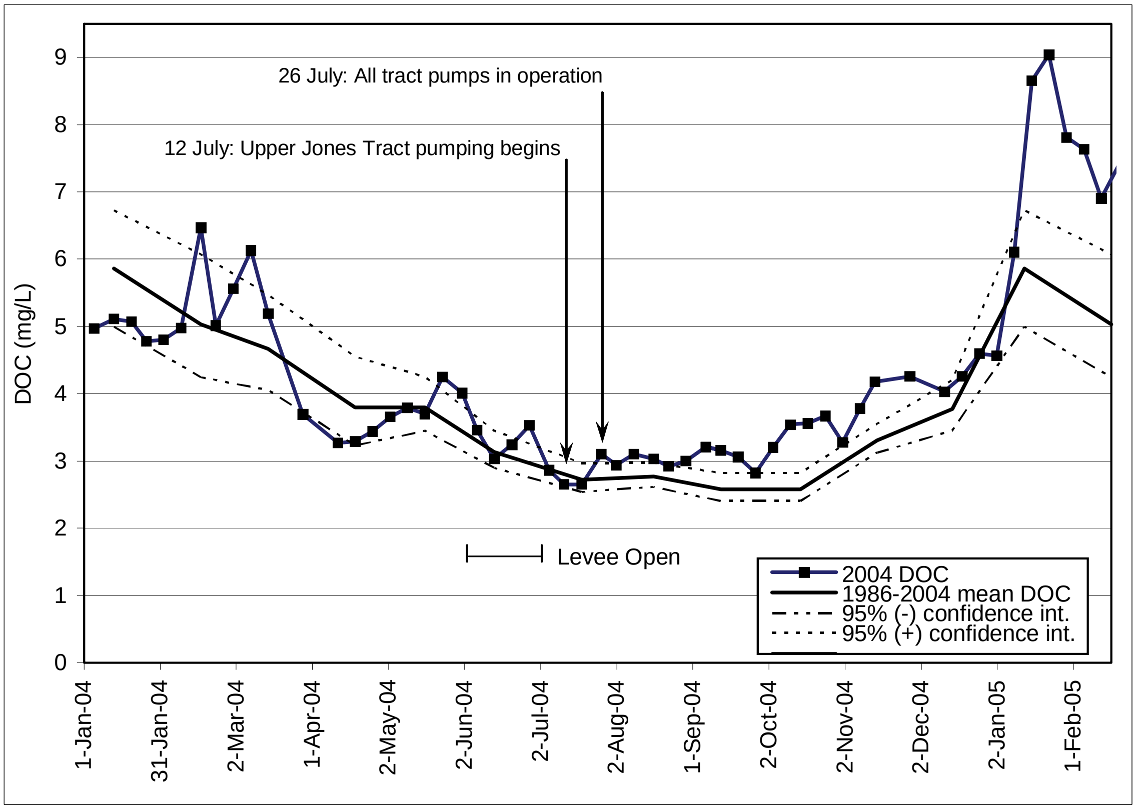


Figure 3.2.14 Carbon-14 fraction of modern carbon (fmc) of Jones Tract whole water samples

Larger values correspond to recently photosynthesized carbon; smaller values correspond to older material.

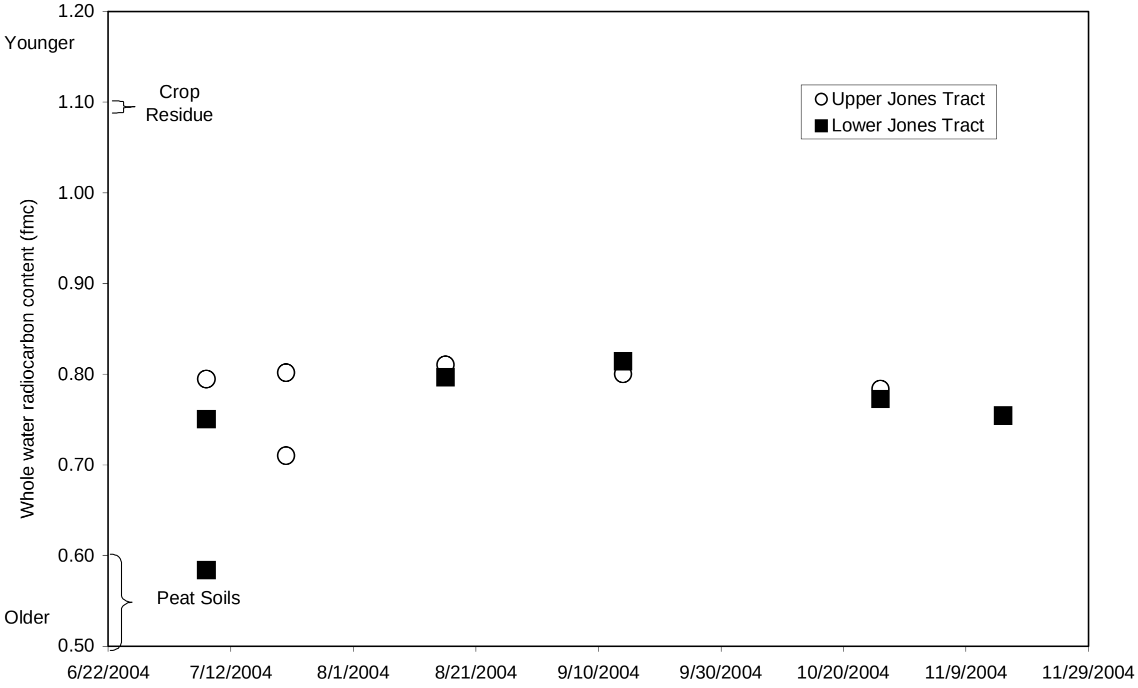


Table 3.2.1 Carbon isotope analysis of Jones Tract whole water samples

^{14}C is listed as fraction of modern carbon (fmc) accompanied by approximate age of the carbon in the sample.

Site	Date sampled	δ^{13}C, per mil	Δ^{14}C, fmc	Est. Age	C/N ratio
Lower Jones middle pre-pump off	7/8/2004	-26.3	0.75	2310	10.6
Upper Jones middle pre-pump off	7/8/2004	-26.5	0.79	1845	6.1
Lower Jones tract discharge	7/8/2004	-26.5	0.58	4320	7.1
Upper Jones Discharge	7/21/2004	-26.5	0.80	1775	2.5
Upper Jones tract - top	7/21/2004	-26.5	0.71	2750	6.1
Lower Jones tract discharge	8/16/2004	-26.3	0.80	1825	12.2
Upper Jones Discharge	8/16/2004	-26.8	0.81	1685	5.1
Lower Jones Discharge	9/14/2004	-25.2	0.81	1650	6.8
Upper Jones Discharge	9/14/2004	-25.9	0.80	1790	7.4
Lower Jones tract discharge	10/26/2004	-25.8	0.77	2070	5.4
Upper Jones discharge	10/26/2004	-26.3	0.78	1955	12.6
Lower Jones tract discharge	11/15/2004	-26.4	0.75	2265	10.1
	Average:	-26.2	0.76	2187	7.7
	Std. Dev.:	0.43	0.064	743	3.1
	n:	12	12.00	12	12

The average ^{14}C fraction of modern carbon (fmc), excluding the anomalously old sample collected July 8, 2004, was 0.871 ± 0.032. This corresponds to an approximate age of 1,993 ± 333 years.

Chapter 3 Results and Discussion

3.3 Trihalomethanes and Bromide

Figures

Table

Figure 3.3.1a Chloroform at Jones Tract (Bryte Lab), June–Nov 2004

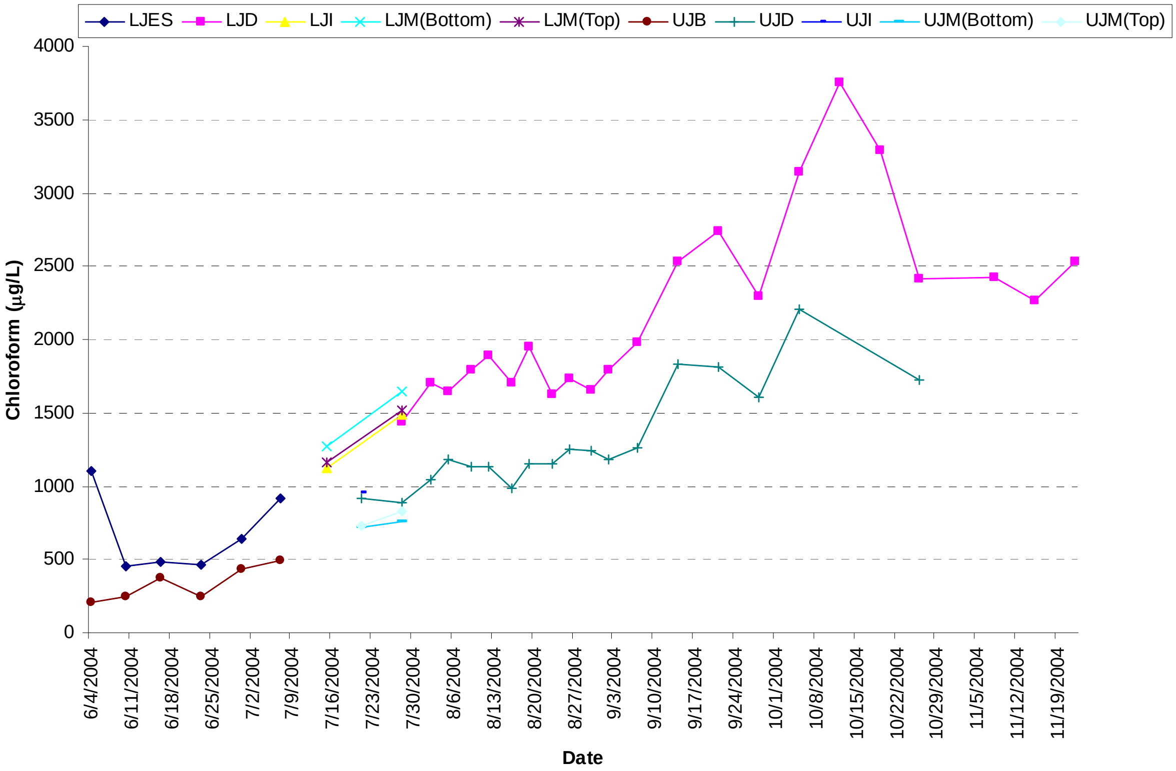


Figure 3.3.1b Average chloroform at Jones Tract (Bryte Lab), June–Nov 2004

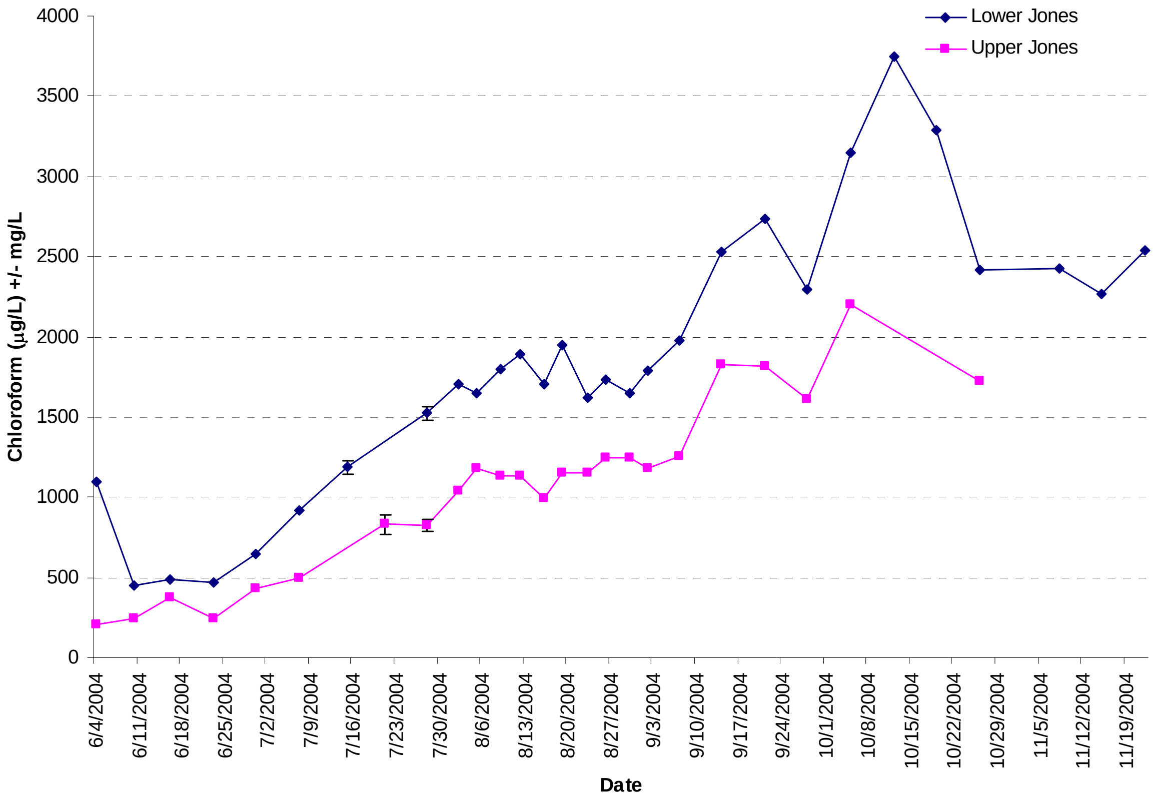


Figure 3.3.2a Bromodichloromethane in Jones Tract (Bryte Lab), June–Nov 2004

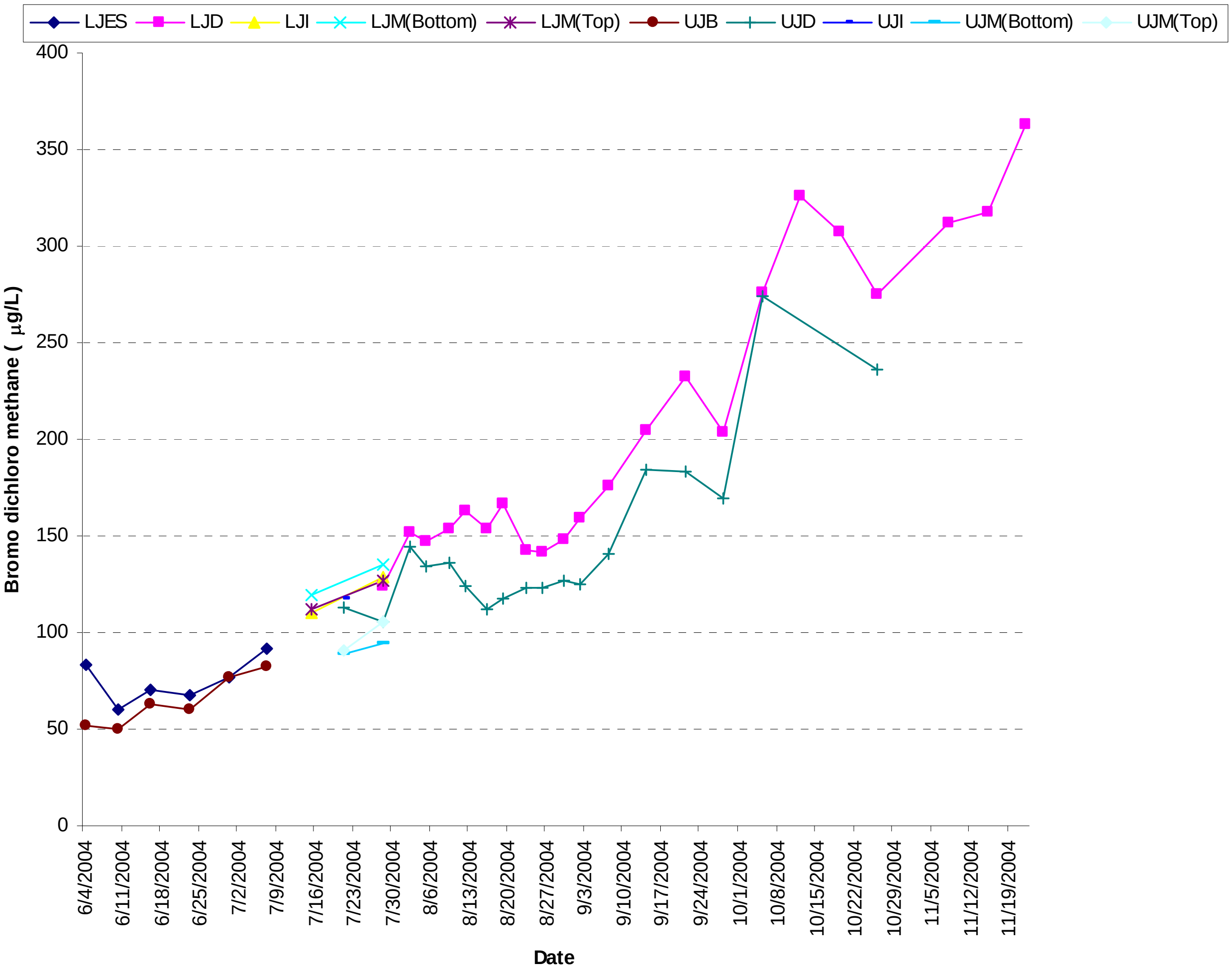


Figure 3.3.2b Average bromodichloromethane in Jones Tract (Bryte Lab), June–Nov 2004

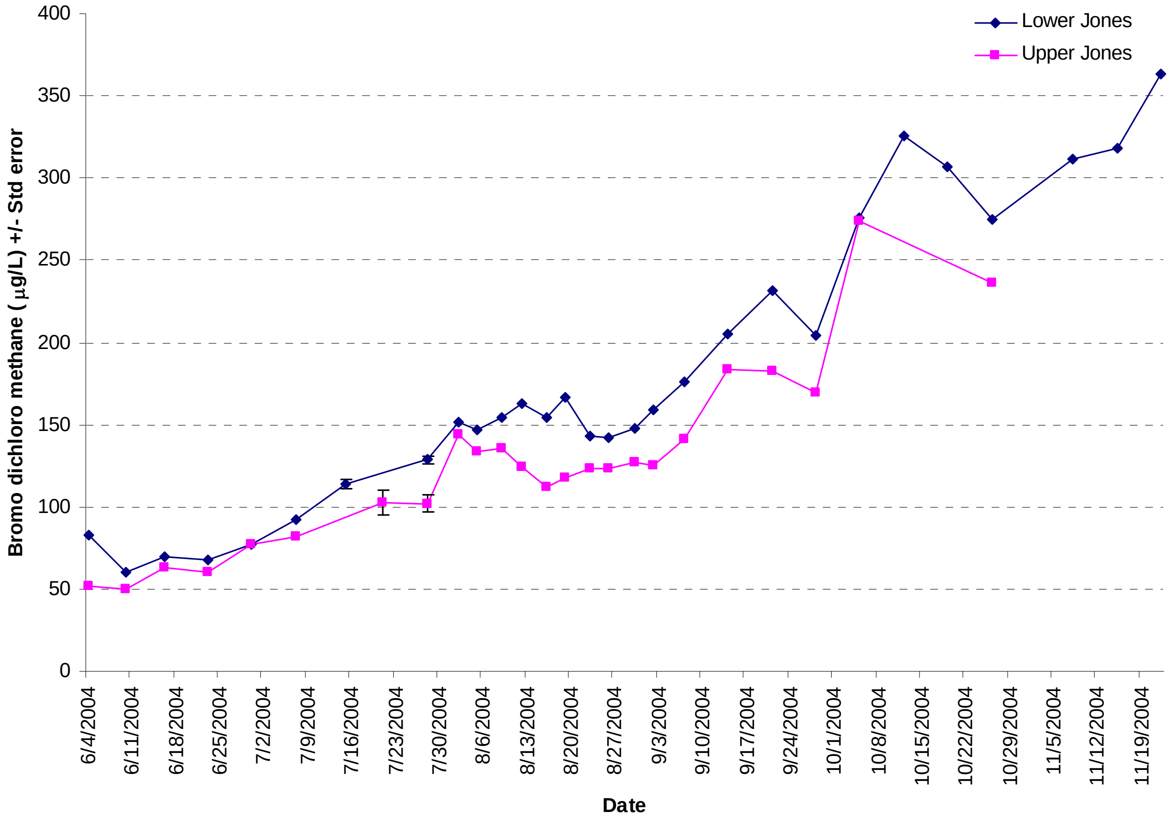


Figure 3.3.3 Average bromodichloromethane and bromide at Lower Jones and Upper Jones, June–Nov 2004

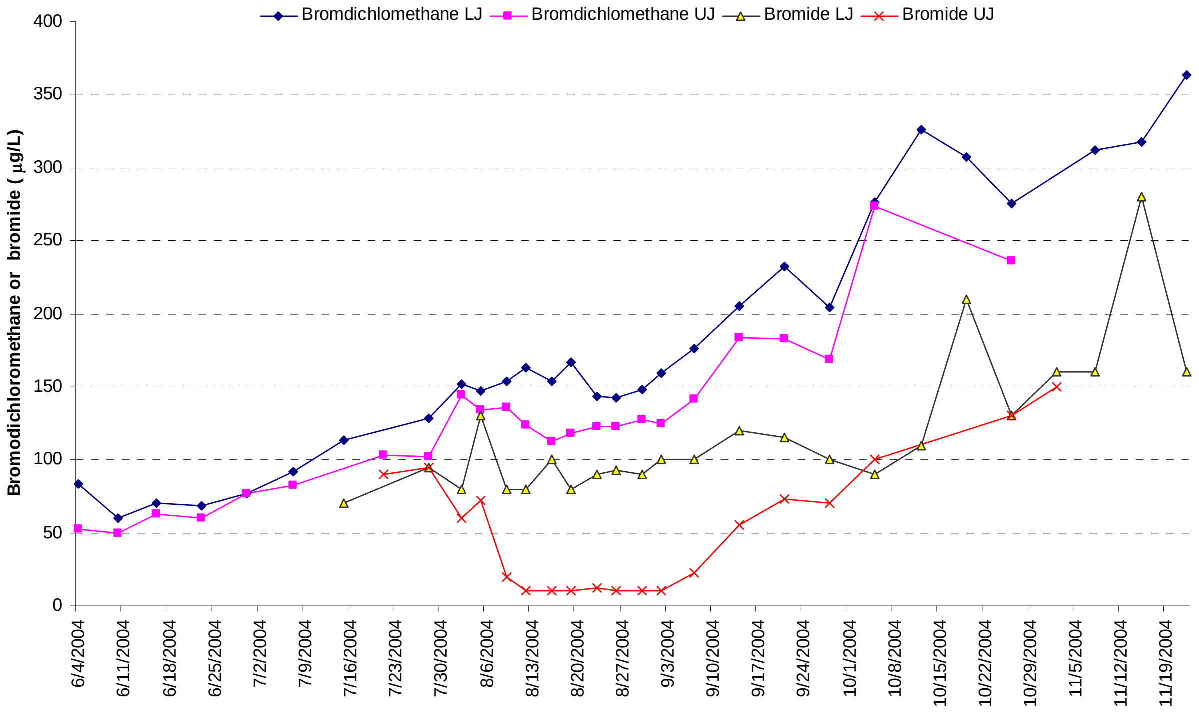


Figure 3.3.4 Average bromide and chloride in Jones Tract, June–Nov 2004

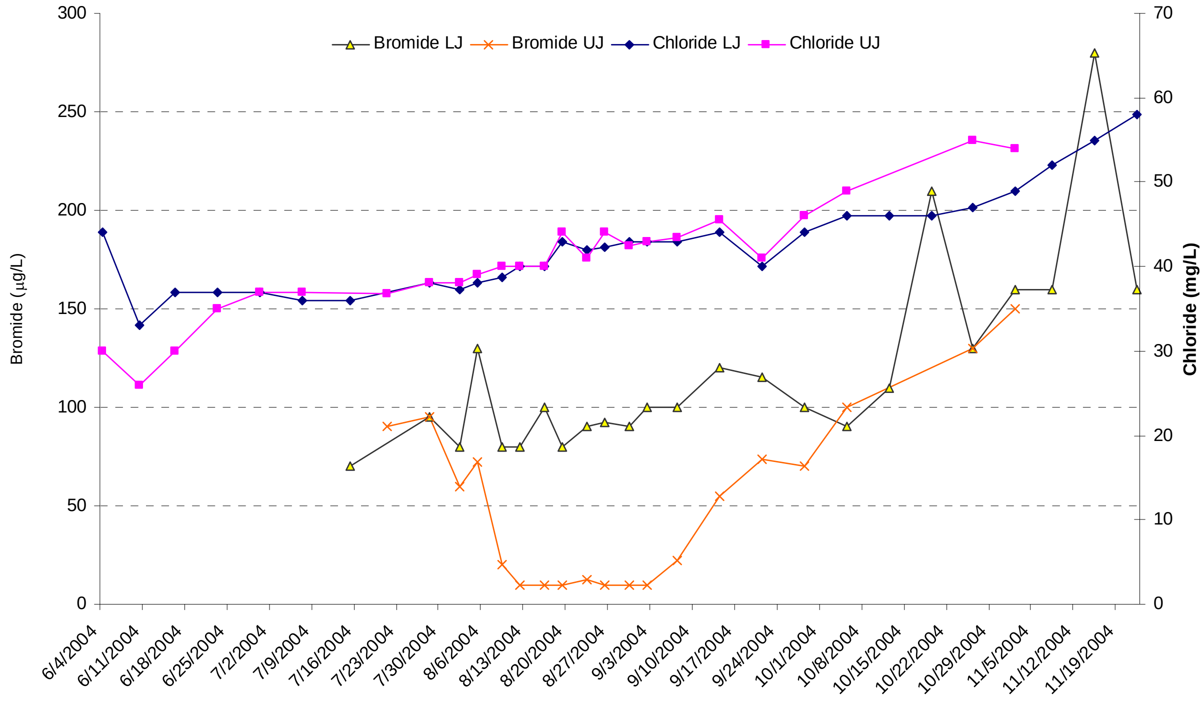


Figure 3.3.5 Average chloride and sodium at Jones Tract, June–Nov 2004

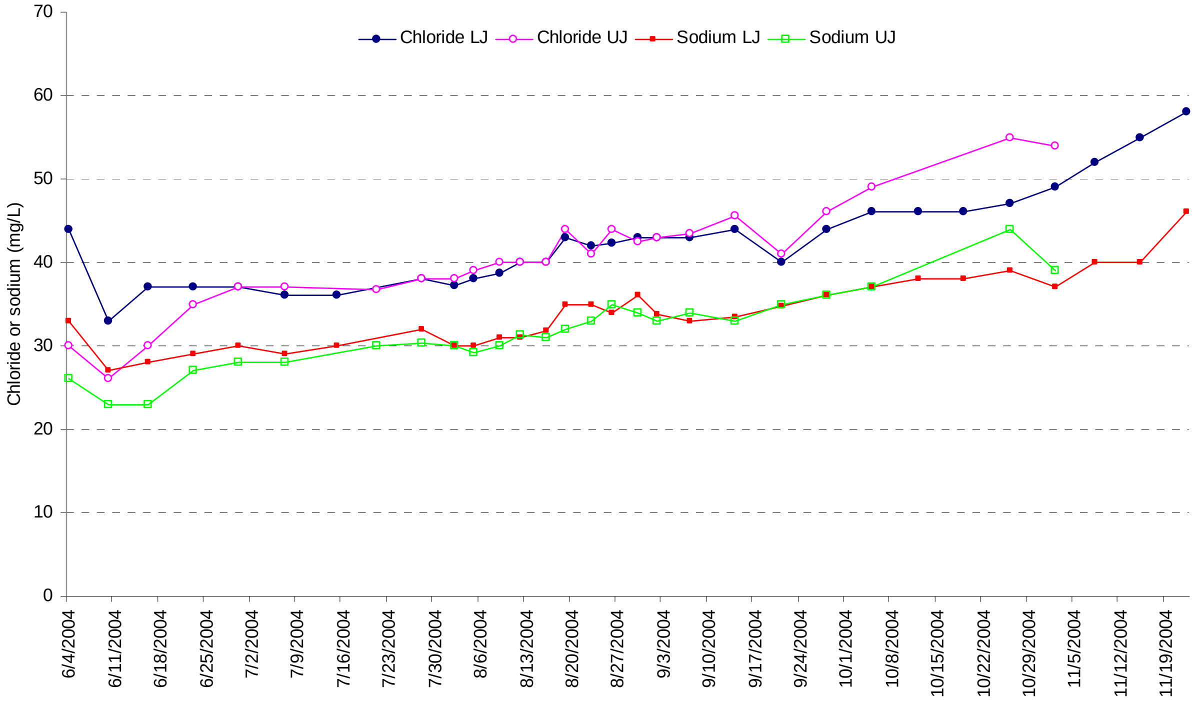


Figure 3.3.6a Relationship between bromide and chloride at Upper and Lower Jones

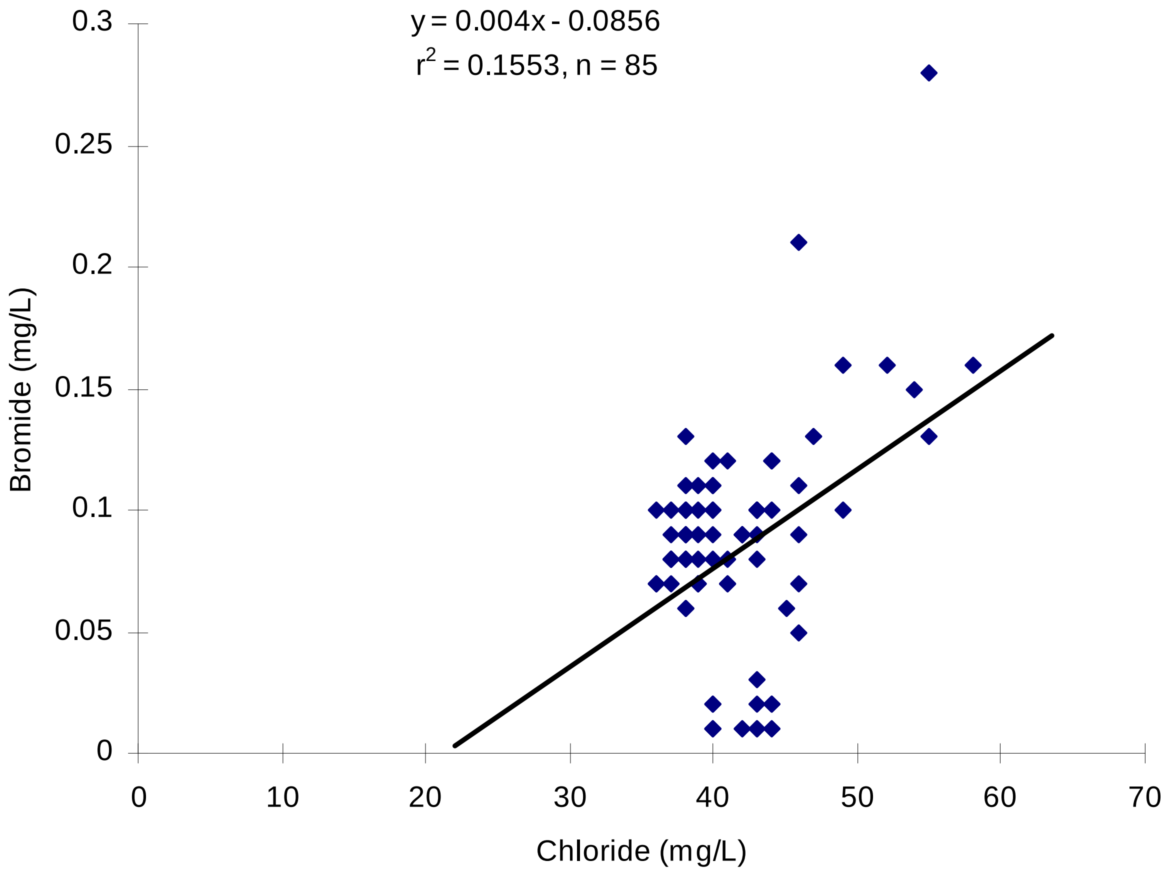


Figure 3.3.6b Relationship between chloride and bromide at Lower Jones Tract

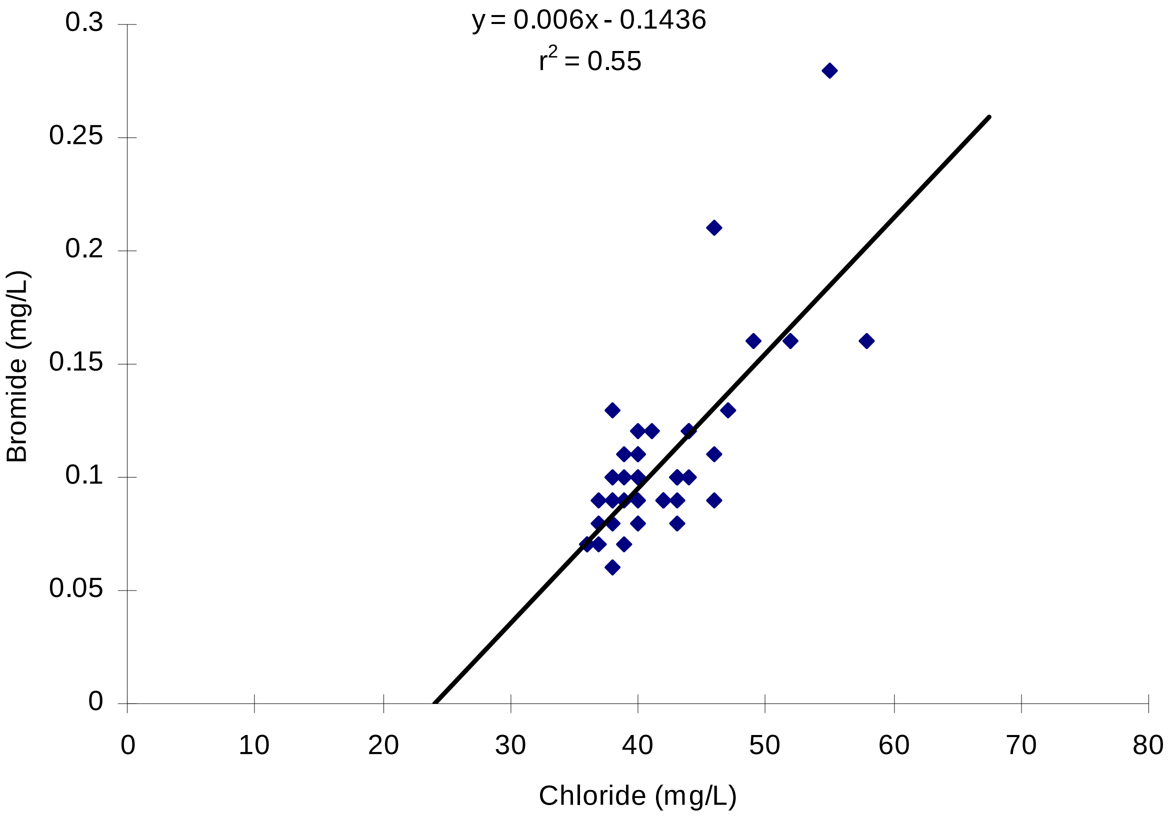


Figure 3.3.6c Relationship between bromide and chloride at Upper Jones Tract

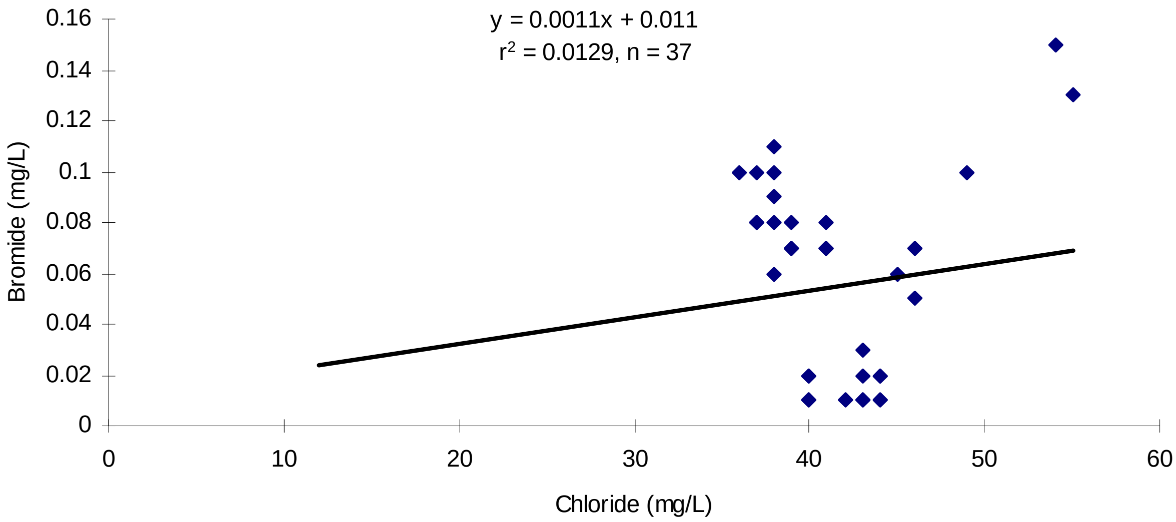


Figure 3.3.7a Dibromochloromethane at Jones Tract (Bryte Lab), June–Nov 2004

Nondetects are plotted as zeros

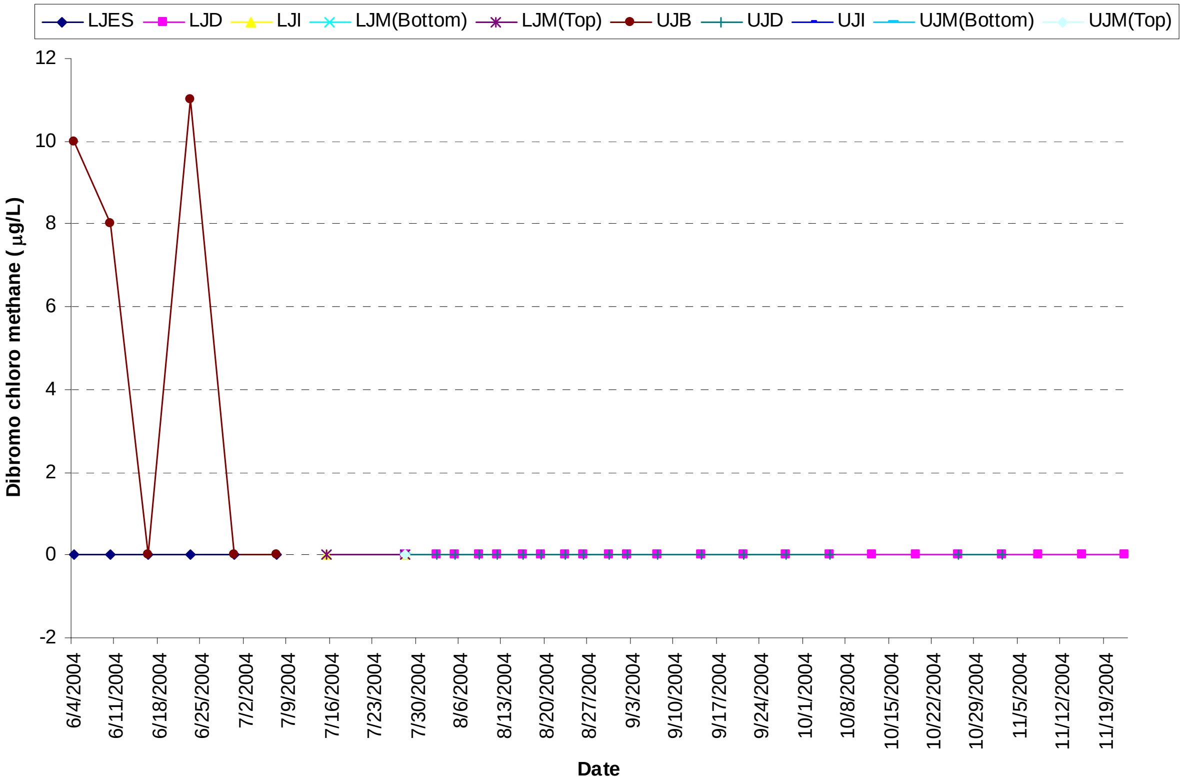


Figure 3.3.7b Averagedibromochloromethane at Jones Tract (Bryte Lab), June–Nov 2004

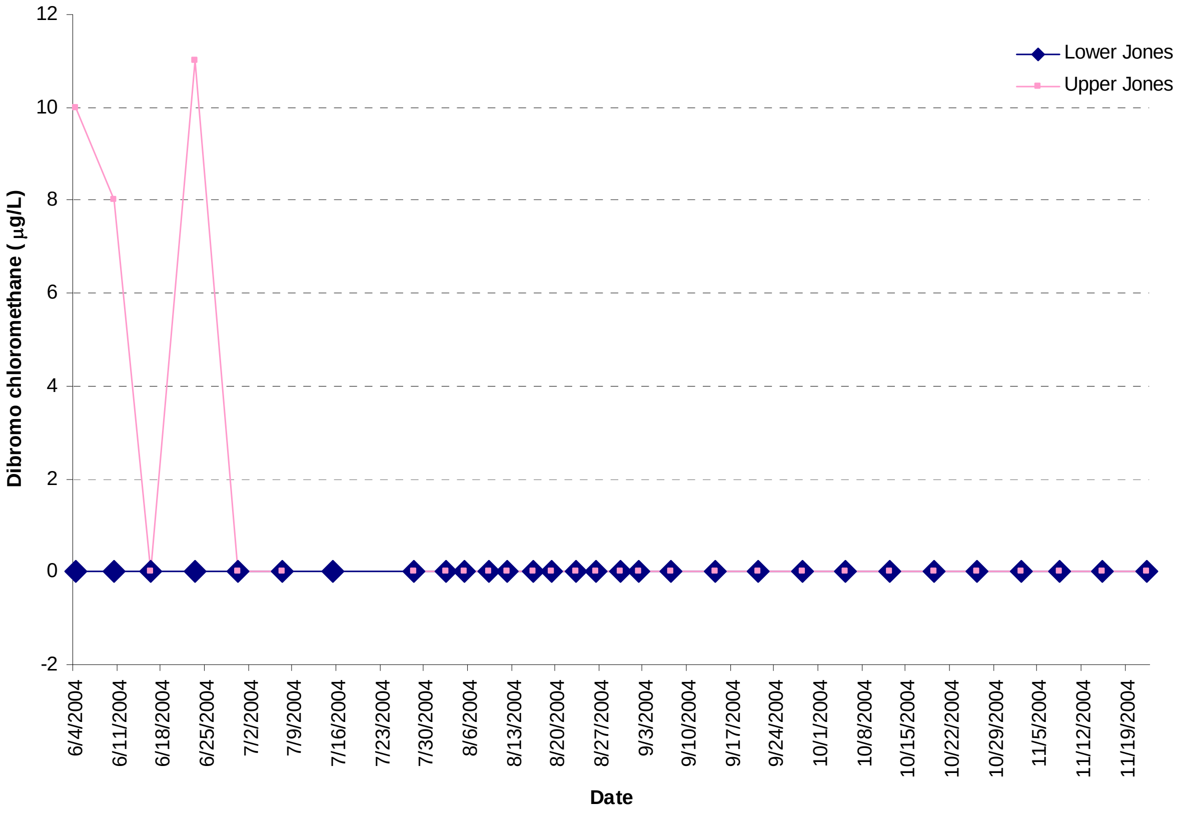


Figure 3.3.8 Relationship between UV absorbance at 254 nm and chloroform

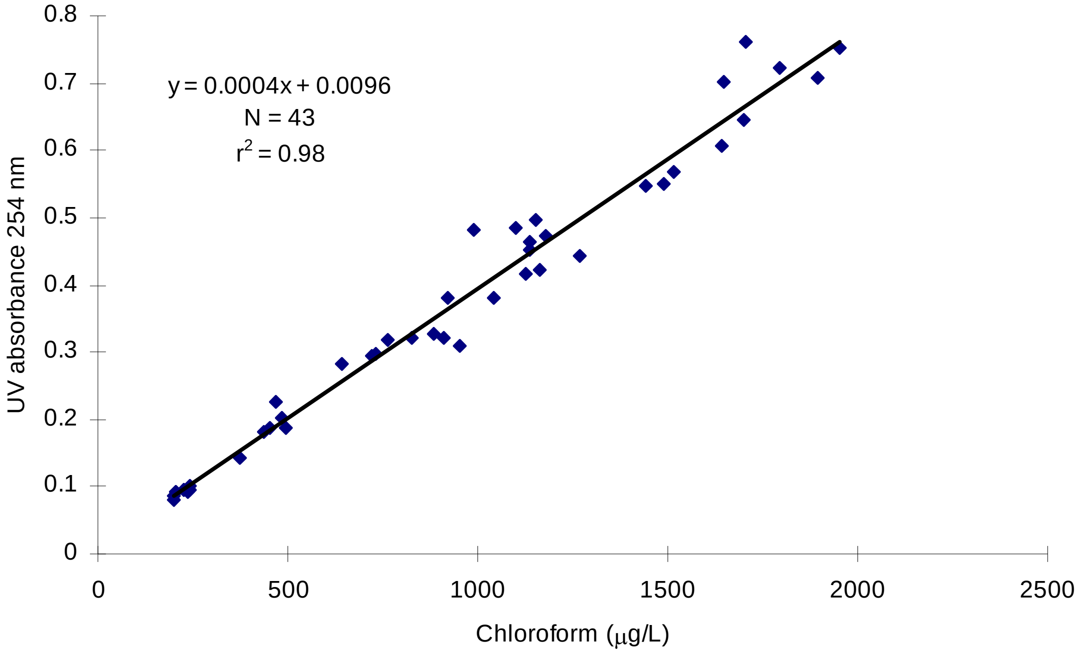


Figure 3.3.9 Relationship between UV absorbance at 254 nm and bromodichloromethane

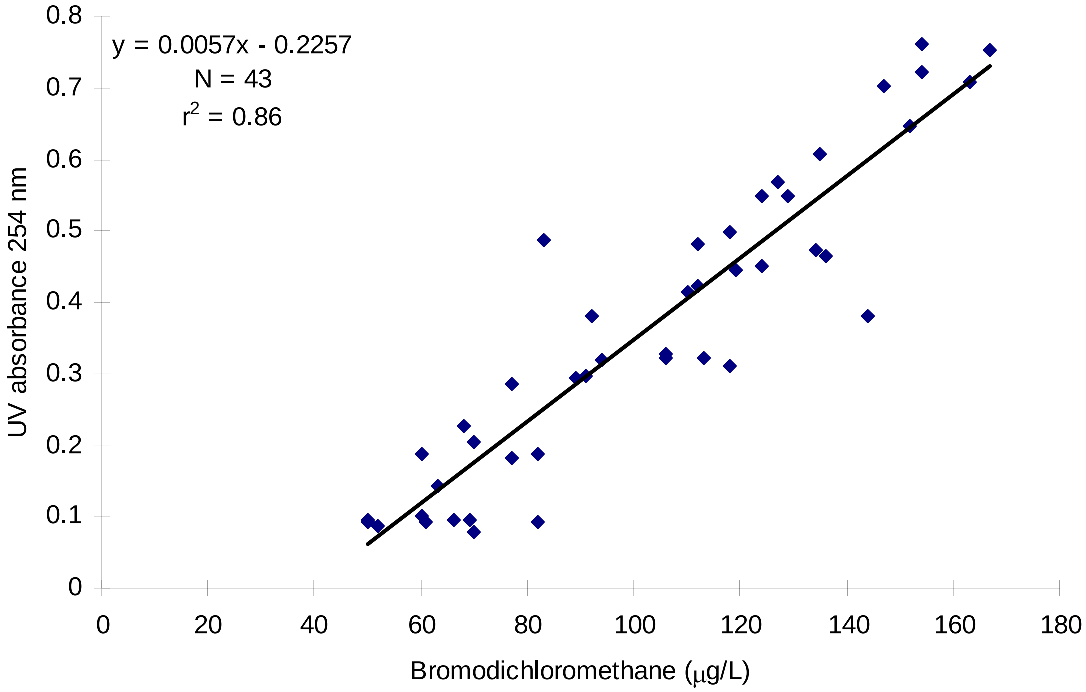


Figure 3.3.10 Relationship between dissolved organic carbon (ox) and chloroform concentrations

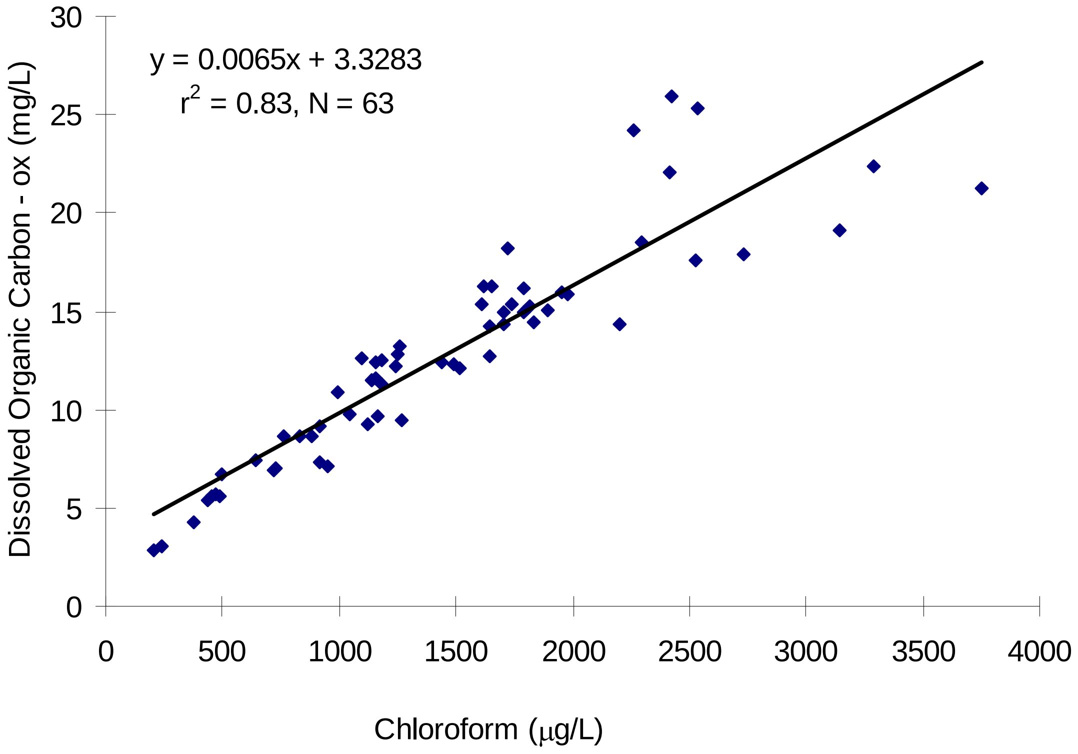


Figure 3.3.11 Relationship between dissolved organic carbon (comb) and chloroform concentrations

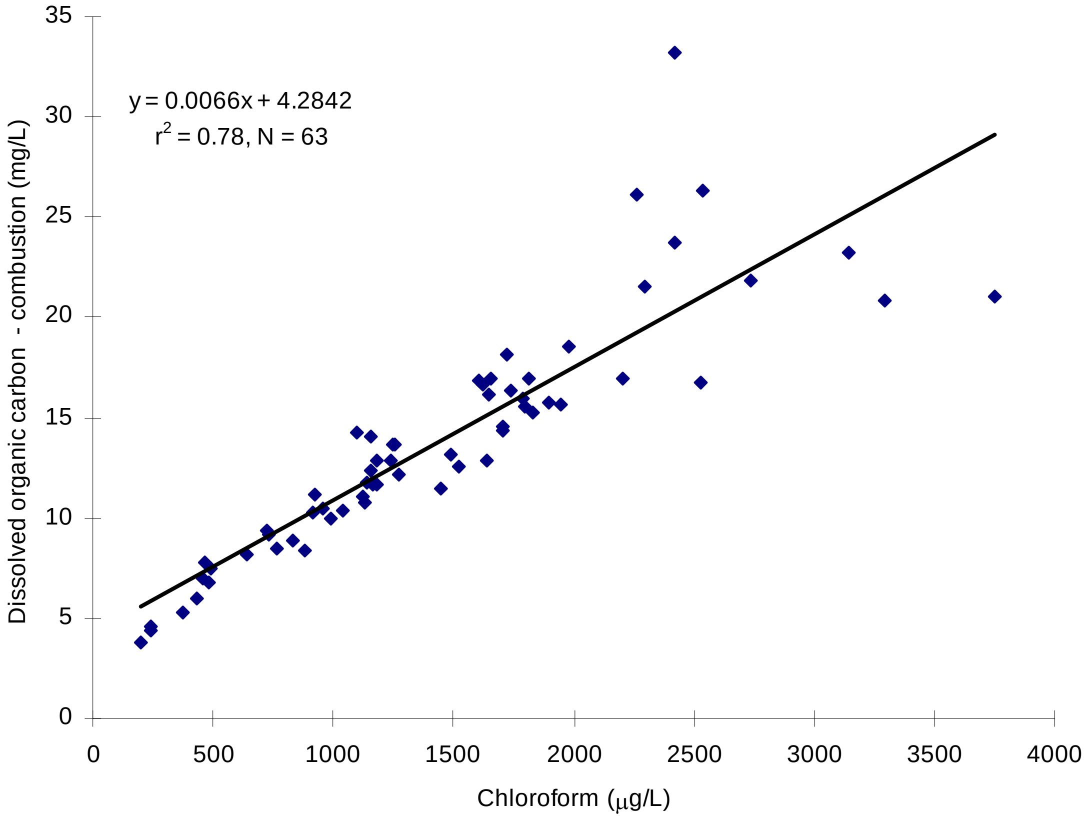


Table 3.3.1a Chloroform at Jones Tract (Bryte Lab), June–Nov 2004

Chloroform concentrations from Jones Tract waters, µg/L

	LJES	LJD	LJI	LJM Bottom	LJM Top	UJB	UJD	UJI	UJM Bottom	UJM Top
	Chloroform concentrations in µg/L									
6/4/2004	1100					202				
6/10/2004	454					242				
6/16/2004	486					374				
6/23/2004	467					243				
6/30/2004	642					435				
7/7/2004	920					493				
7/15/2004			1126	1271	1161					
7/21/2004							913	953	723	731
7/28/2004		1443	1492	1642	1518		883		761	828
8/2/2004		1701					1041			
8/5/2004		1648					1180			
8/9/2004		1794					1135			
8/12/2004		1896					1136			
8/16/2004		1706					990			
8/19/2004		1950					1153			
8/23/2004		1623					1153			
8/26/2004		1736					1248			
8/30/2004		1652					1242			
9/2/2004		1791					1178			
9/7/2004		1978					1257			
9/14/2004		2530					1829			
9/21/2004		2735					1814			
9/28/2004		2299					1608			
10/5/2004		3146					2204			
10/12/2004		3751								
10/19/2004		3290								
10/26/2004		2418					1720			
11/2/2004										
11/8/2004		2424								
11/15/2004		2265								
11/22/2004		2536								

Table 3.3.1b Average chloroform at Jones Tract (Bryte Lab), June–Nov 2004

from Jones Tract waters, ug/L

	Lower Jones (Average ± std.dev.)	Upper Jones (Average ± std.dev.)	Middle River
		in µg/L	
6/4/2004	1100	202	206
6/10/2004	454	242	236
6/16/2004	486	374	201
6/23/2004	467	243	204
6/30/2004	642	435	227
7/7/2004	920	493	227
7/15/2004	1186 ± 76		
7/21/2004		830 ± 120	
7/28/2004	1524 ± 85	824 ± 61	
8/2/2004	1701	1041	
8/5/2004	1648	1180	
8/9/2004	1794	1135	
8/12/2004	1896	1136	
8/16/2004	1706	990	
8/19/2004	1950	1153	
8/23/2004	1623	1153	
8/26/2004	1736	1248	
8/30/2004	1652	1242	
9/2/2004	1791	1178	
9/7/2004	1978	1257	
9/14/2004	2530	1829	
9/21/2004	2735	1814	
9/28/2004	2299	1608	
10/5/2004	3146	2204	
10/12/2004	3751		
10/19/2004	3290		
10/26/2004	2418	1720	
11/2/2004			
11/8/2004	2424		
11/15/2004	2265		
11/22/2004	2536		

Chapter 3 Results and Discussion

3.4 Nutrients

Figures

Table

Figure 3.4.1a Ammonia at Jones Tract (Bryte Lab and Contract Lab), June–Nov 2004

Nondetects plotted as zeros

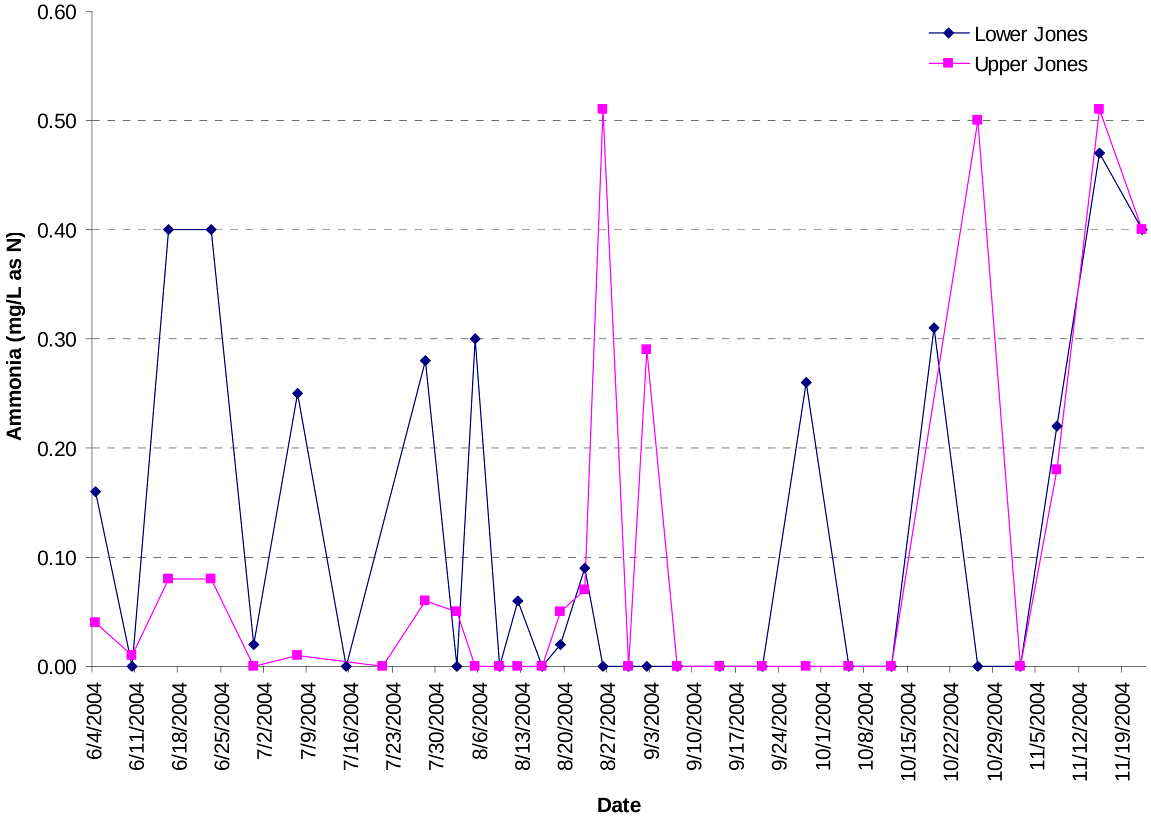


Figure 3.4.1b Average ammonia at Upper and Lower Jones Tract (Bryte Lab and Contract Lab data)

Nondetects graphed as zeros

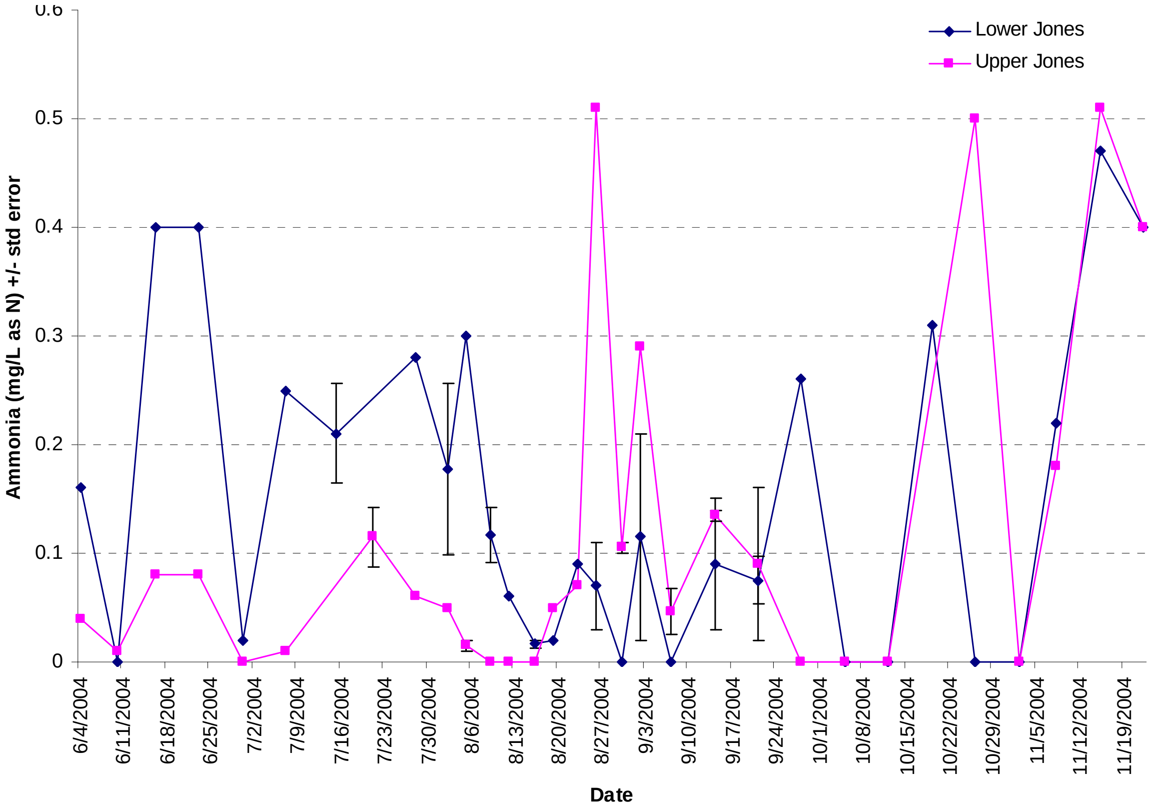


Figure 3.4.2a Kjeldahl nitrogen in Jones Tract (Bryte Lab), June–Sep 2004)

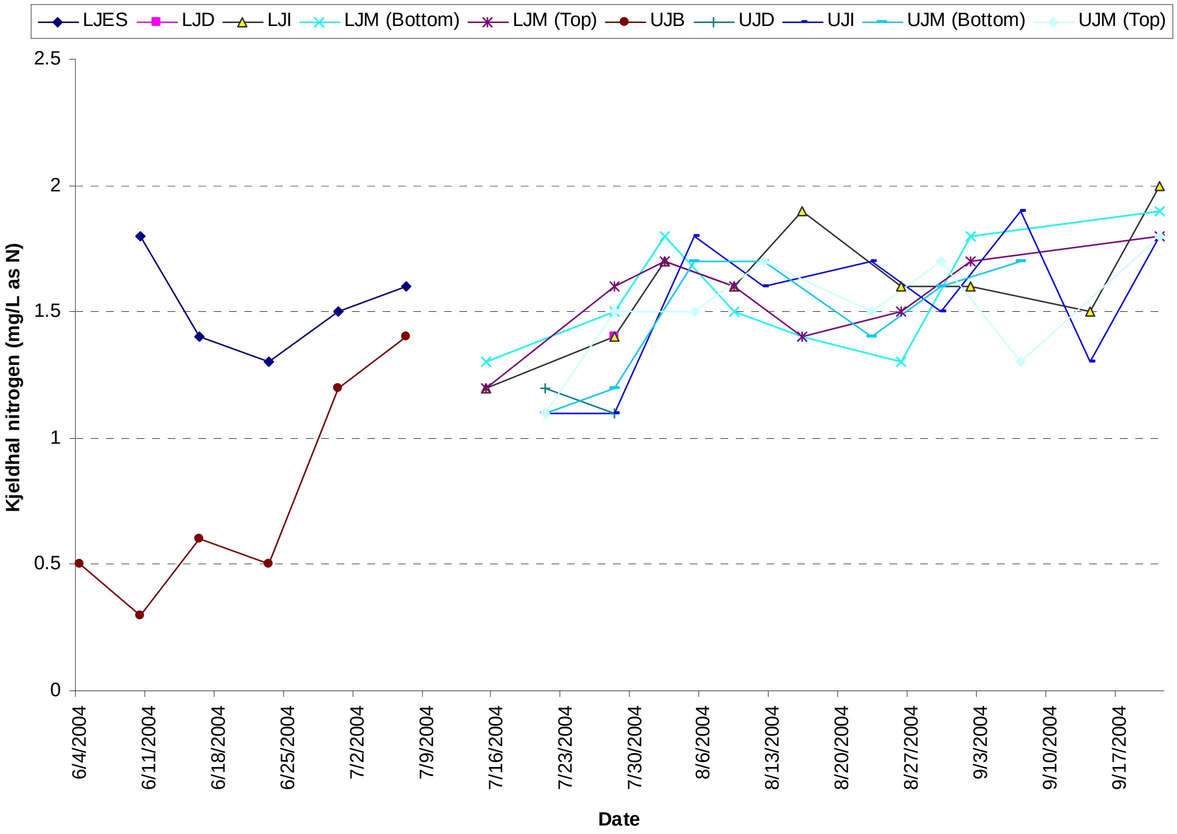


Figure 3.4.2b Average Kjeldahl nitrogen in Jones Tract (Bryte Lab), June–Sep 2004

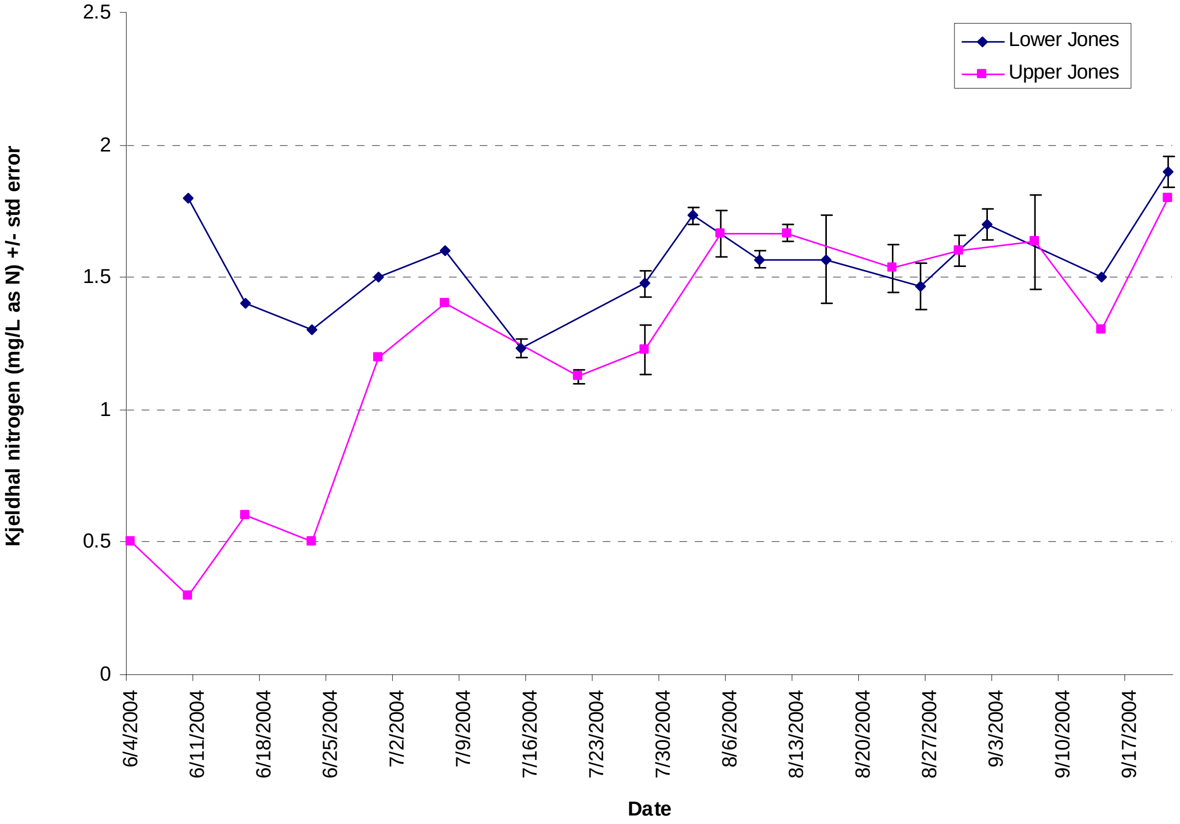


Figure 3.4.3 Nitrate at Jones Tract (Bryte Lab), June–Nov 2004

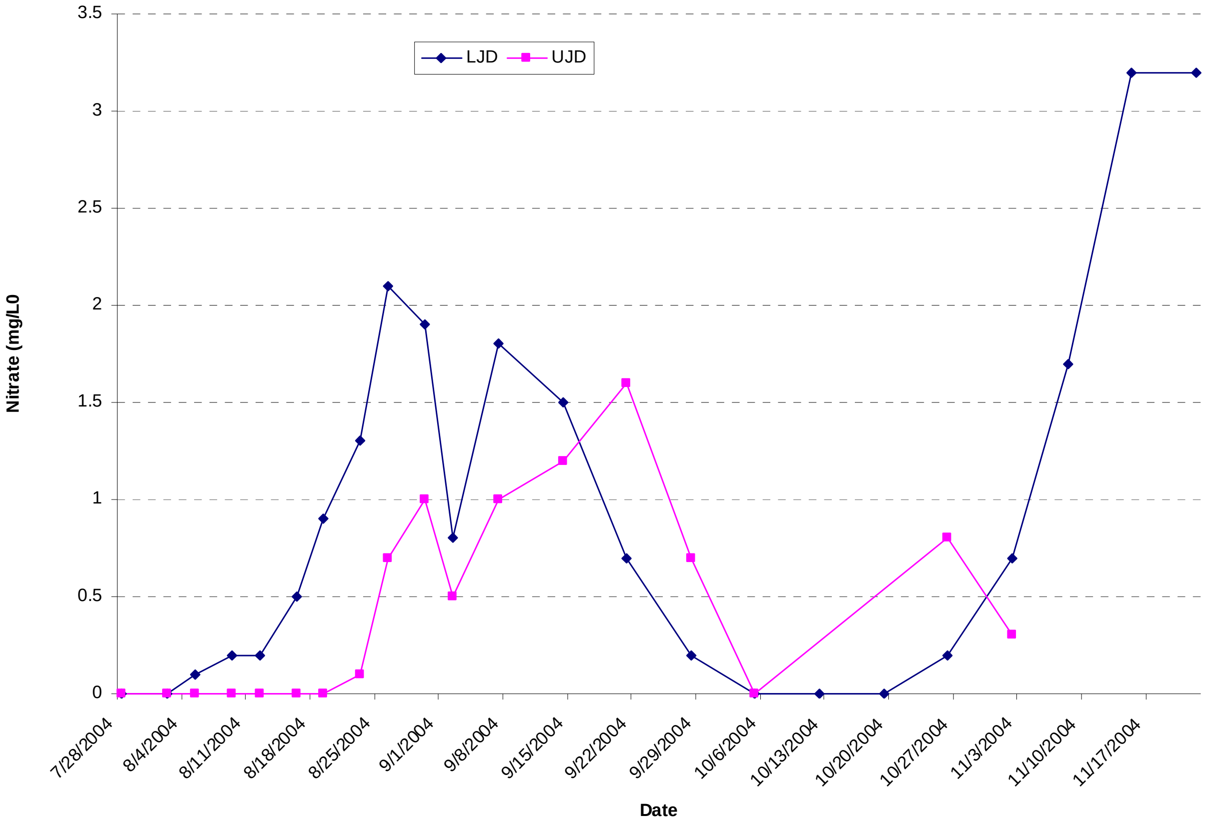


Figure 3.4.4a Nitrite and nitrate in Jones Tract (Bryte Lab), June–Nov 2004

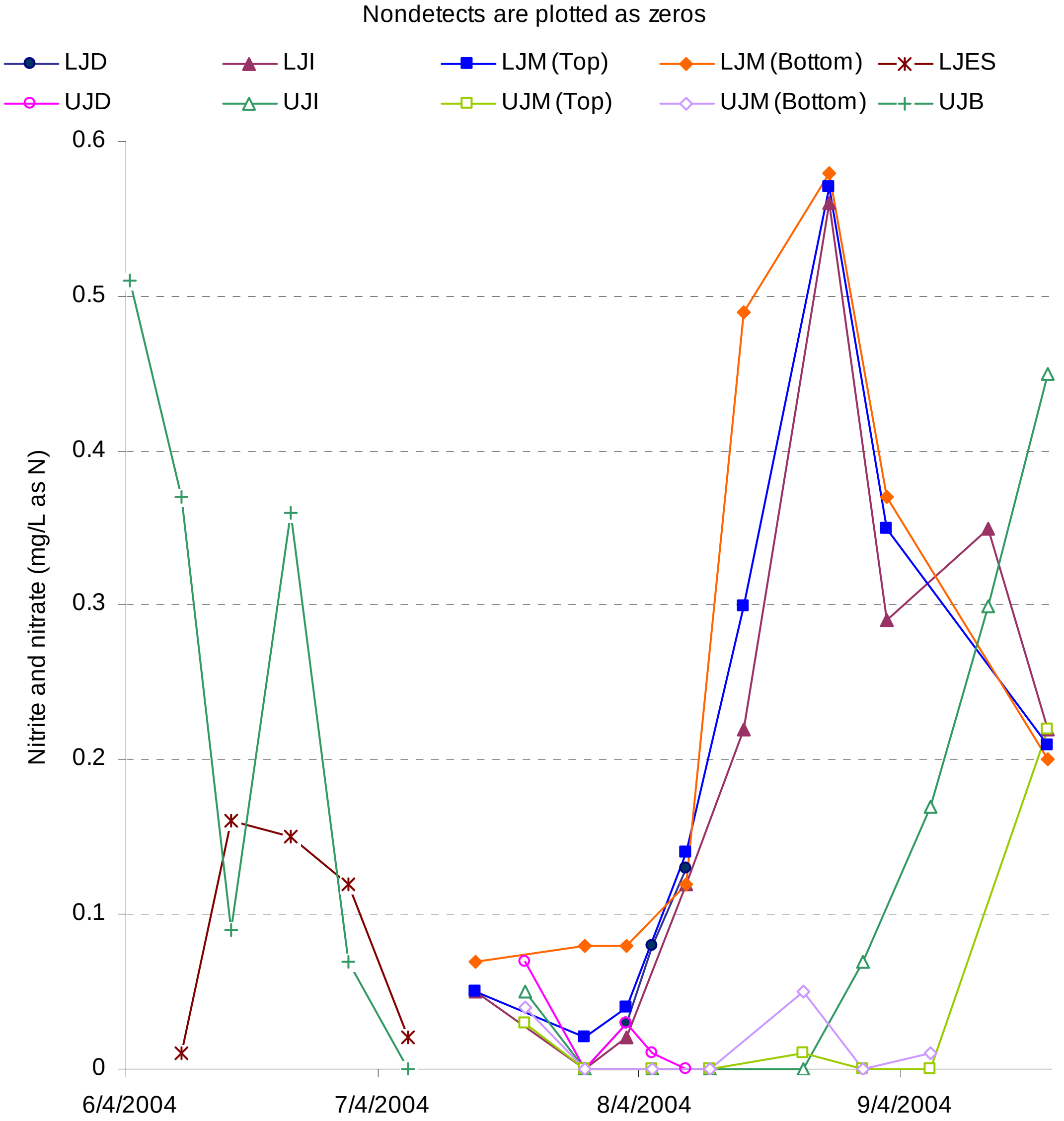
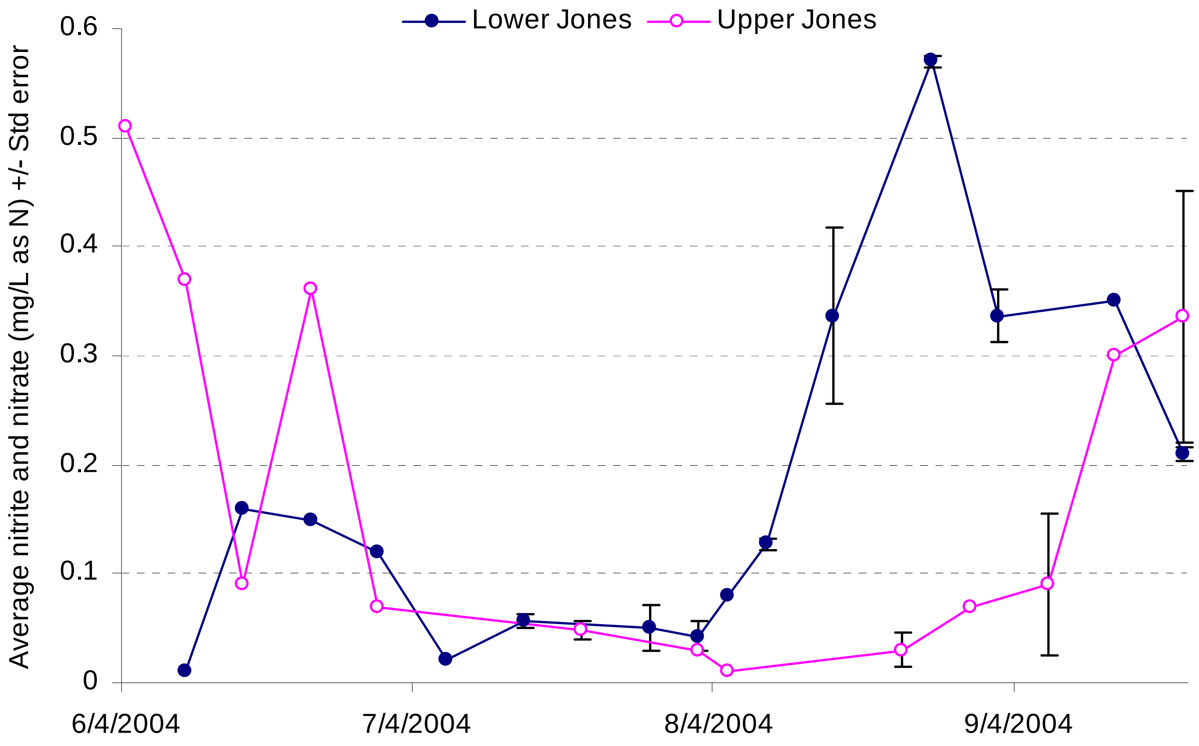


Figure 3.4.4b Average nitrite and nitrate (Bryte Lab), June–Nov 2004



` * Average was calculated when more than one observation was recorded at Upper or Lower Jones.
All other values are single observations.

Figure 3.4.5a Total phosphorus in Jones Tract (Bryte Lab), June–Sep 2004

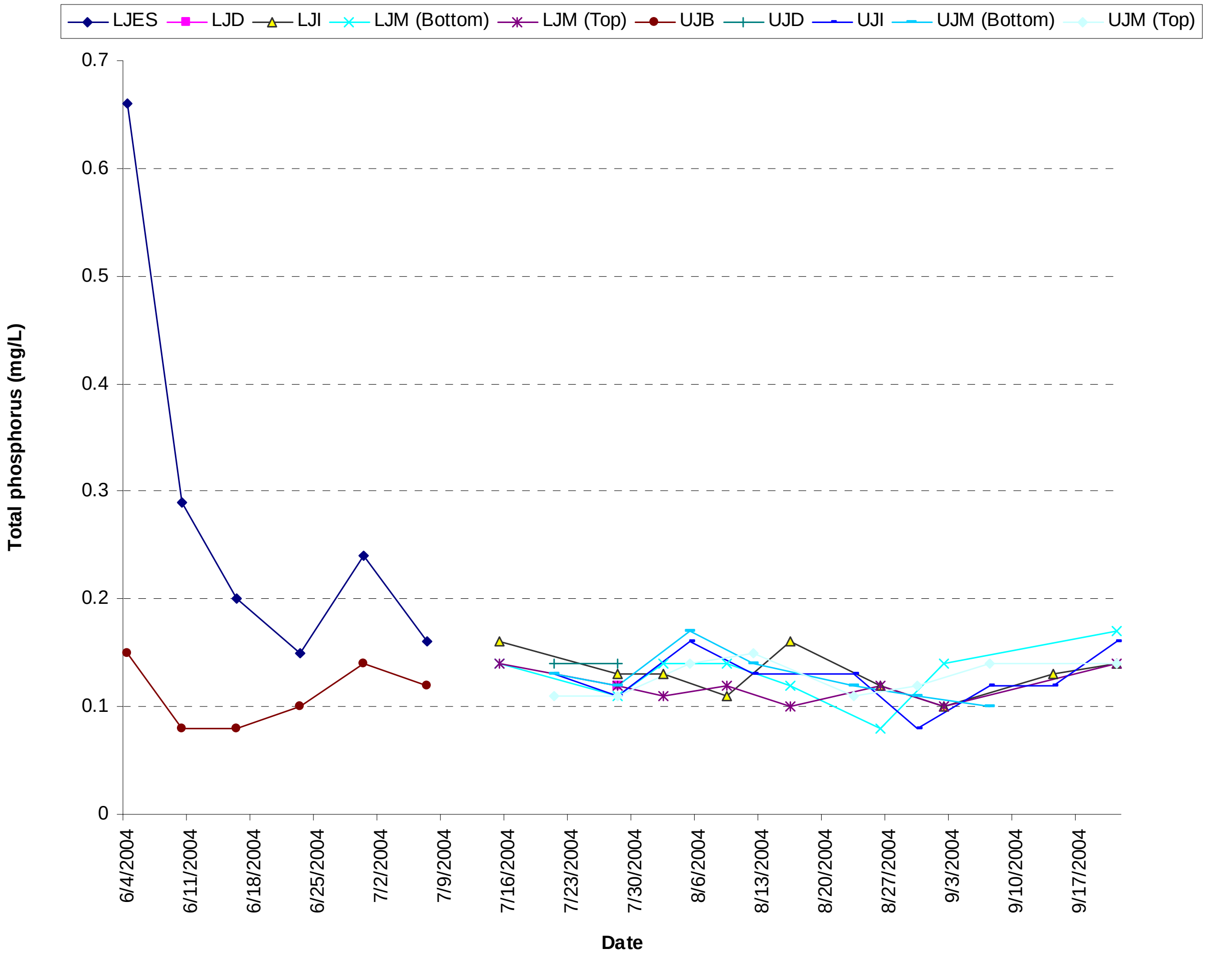


Figure 3.4.5b Average total phosphorus in Jones Tract (Bryte Lab), June–Sep 2004

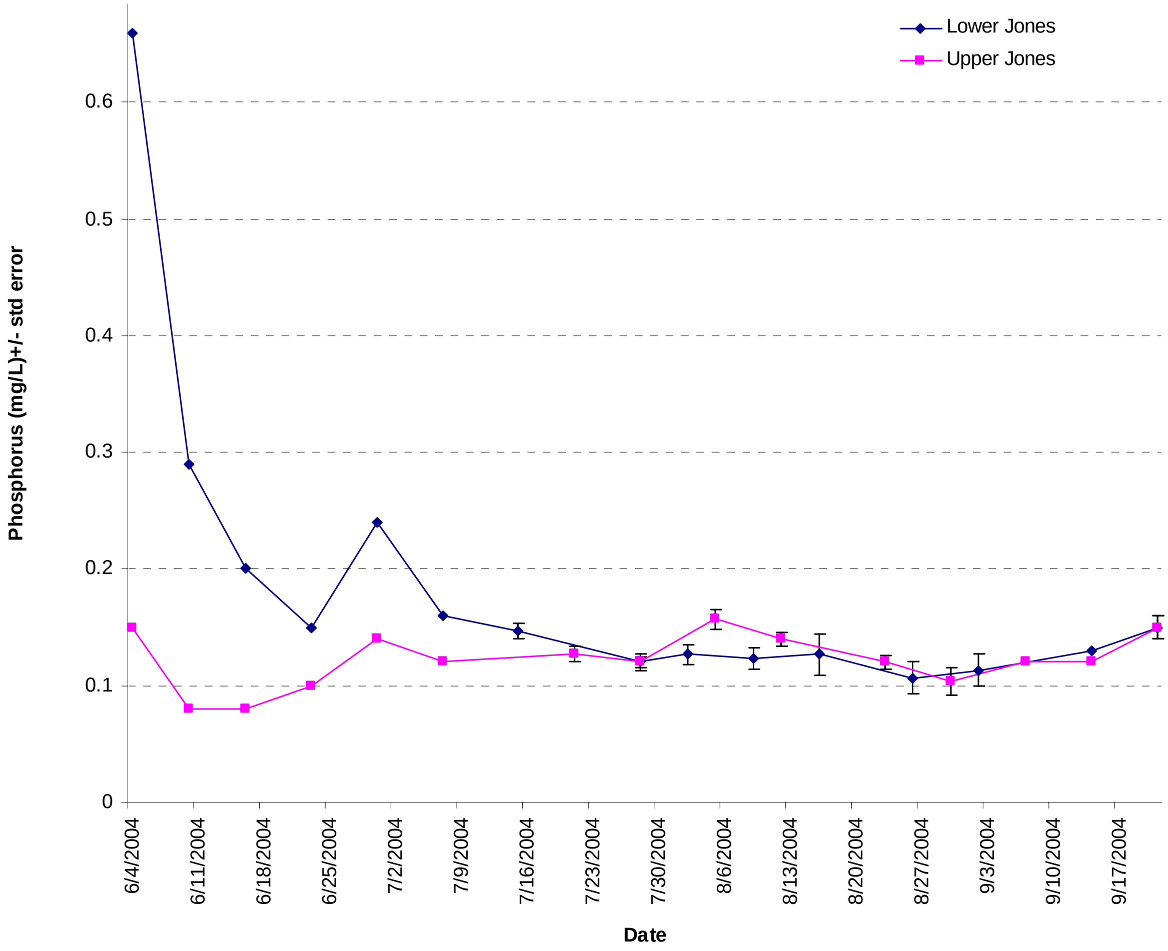


Figure 3.4.6a Orthophosphate in Jones Tract (Bryte Lab), June–Sep 2004

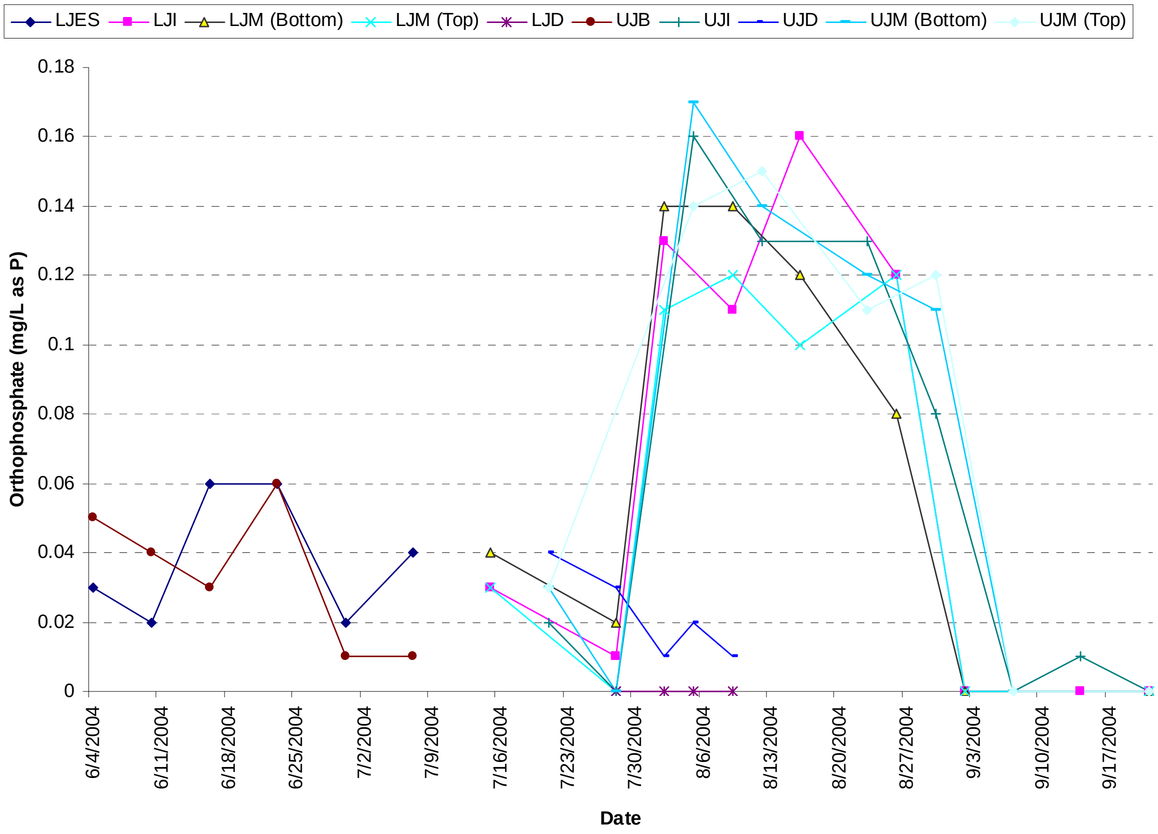


Figure 3.4.6b Average orthophosphate in Upper and Lower Jones Tract (Bryte Lab), June–Sep 2004

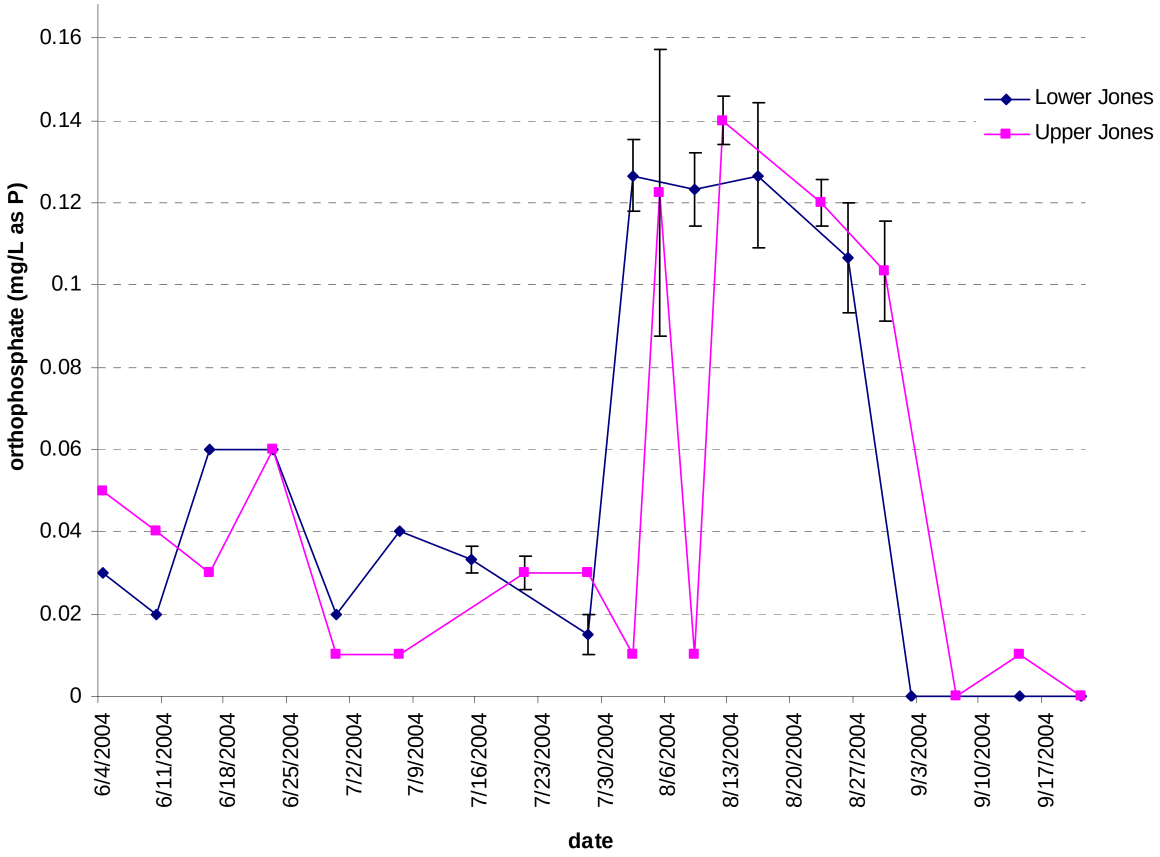


Figure 3.4.7a Kjeldahl nitrogen – ammonia

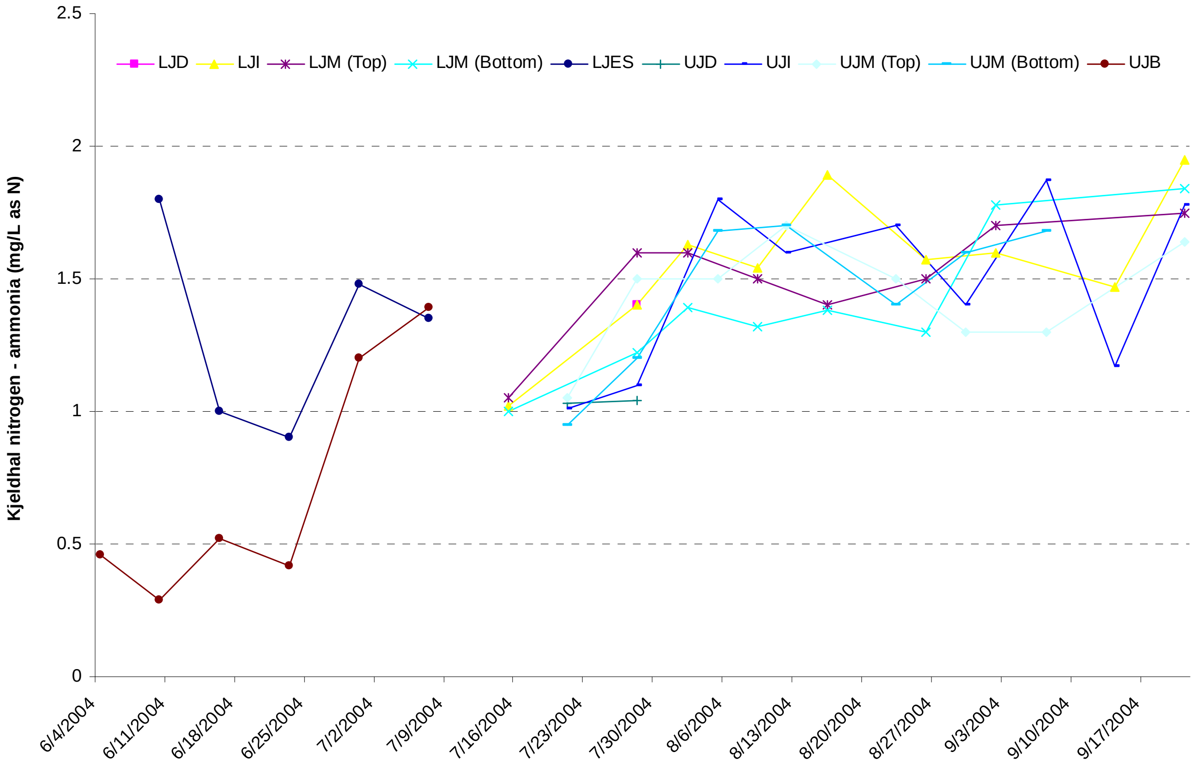


Figure 3.4.7b Average Kjeldahl nitrogen - ammonia

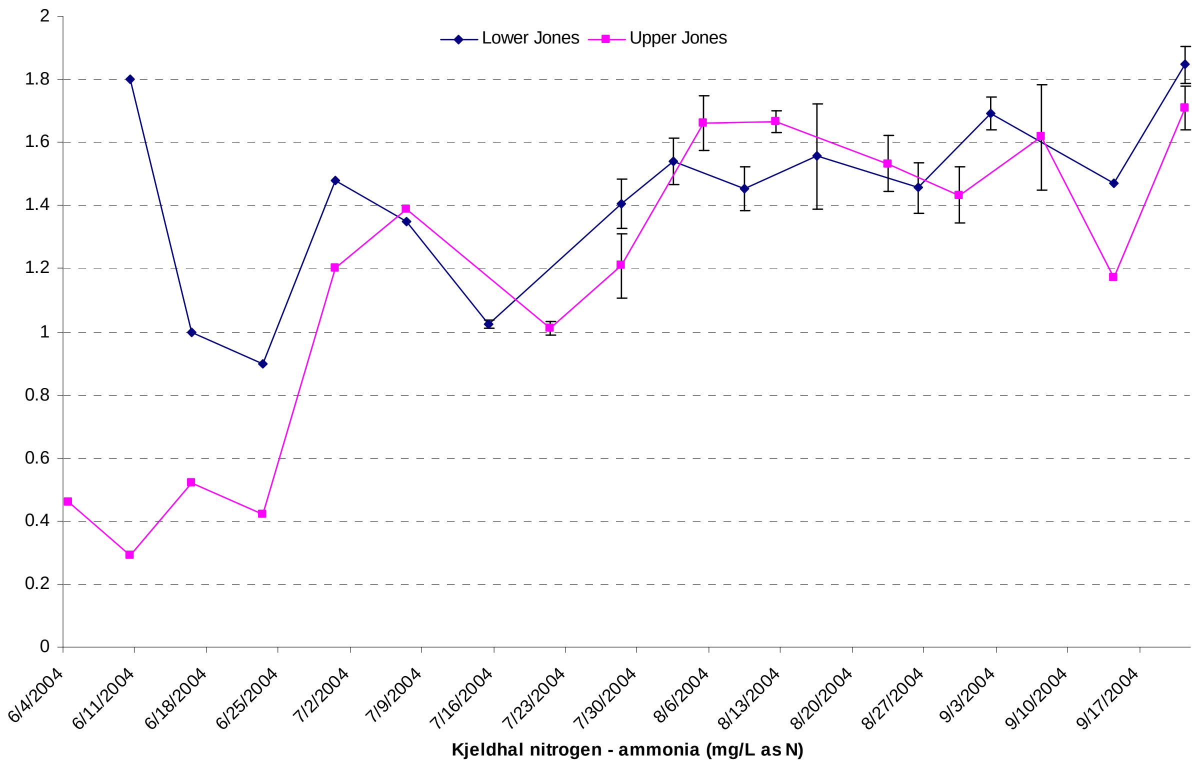


Table 3.4.1 Average ammonia at Upper and Lower Jones Tract, mg/L as N

	Lower Jones Average ± st.dev.	Upper Jones Average ± st.dev.	Middle River Measurement
6/4/2004	0.16	0.04	0.04
6/10/2004	< 0.01	0.01	0.02
6/16/2004	0.40	0.08	0.04
6/23/2004	0.40	0.08	0.06
6/30/2004	0.02	< 0.01	0.04
7/7/2004	0.25	0.01	0.03
7/15/2004	0.21 ± 0.08		
7/20/2004			
7/21/2004		0.115 ± 0.06	
7/27/2004			
7/28/2004	0.28	0.06	
7/30/2004			
8/2/2004	0.18 ± 0.16	0.05	
8/3/2004			
8/5/2004	0.30	0.015 ± 0.01	
8/9/2004	0.1175 ± 0.05	< 0.01	
8/12/2004	0.06	< 0.01	
8/16/2004	0.02 ± 0.01	< 0.01	
8/19/2004	0.02	0.05	
8/23/2004	0.09	0.07	
8/26/2004	0.07 ± 0.06	0.51	
8/30/2004	<0.10	0.11 ± 0.01	
9/2/2004	0.12 ± 0.13	0.29	
9/7/2004	<0.082	0.05 ± 0.04	
9/9/2004			
9/14/2004	0.09 ± 0.08	0.14 ± 0.01	
9/15/2004			
9/21/2004	0.08 ± 0.04	0.09 ± 0.10	
9/23/2004			
9/27/2004			
9/28/2004	0.26	<0.10	
10/5/2004	<0.10	<0.10	
10/12/2004	<0.10	<0.10	
10/19/2004	0.31		
10/26/2004	<0.10	0.50	
11/2/2004	<0.10	<0.10	
11/8/2004	0.22	0.18	
11/15/2004	0.47	0.51	
11/22/2004	0.40	0.40	

Chapter 3 Results and Discussion

3.5 Electrical Conductivity, Common Elements, Alkalinity, and Hardness

Figures

Table

Figure 3.5.1a Electrical conductivity at Jones Tract (Bryte Lab), June–Nov 2004

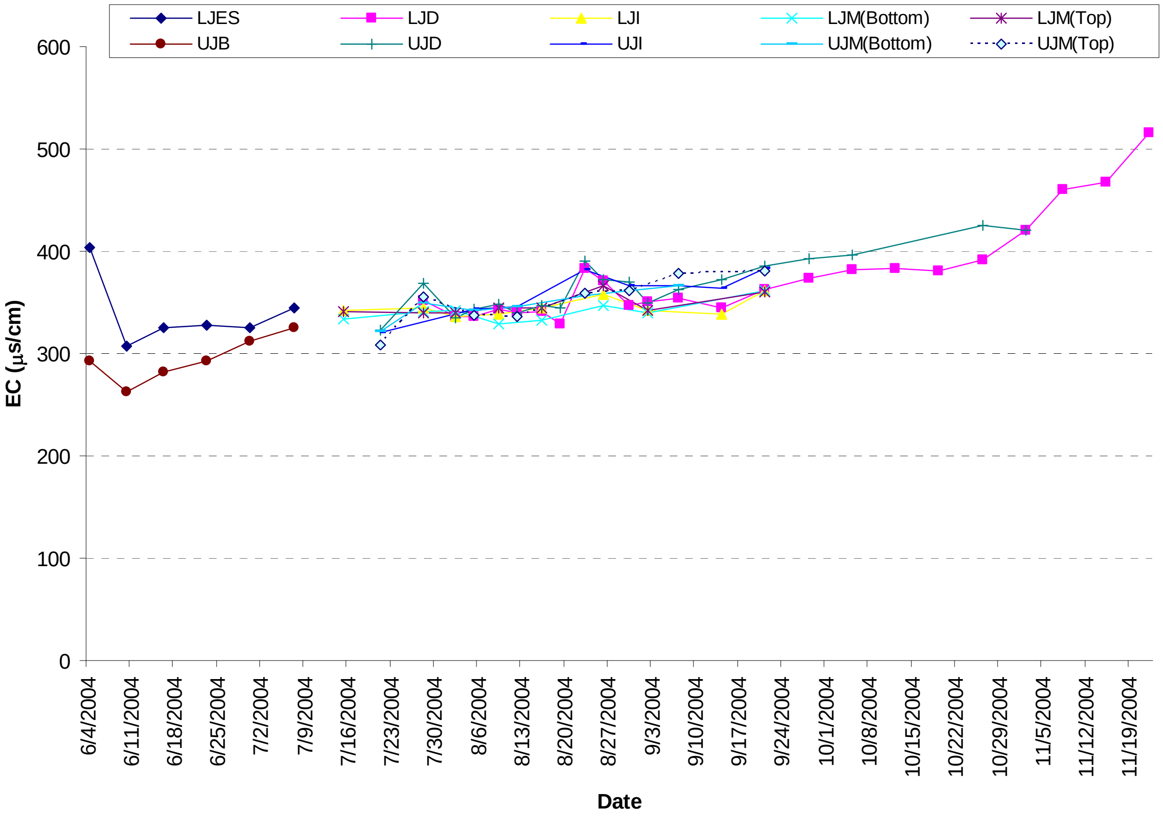


Figure 3.5.1b Average electric conductity at Jones Tract (Bryte Lab), June–Nov 2004

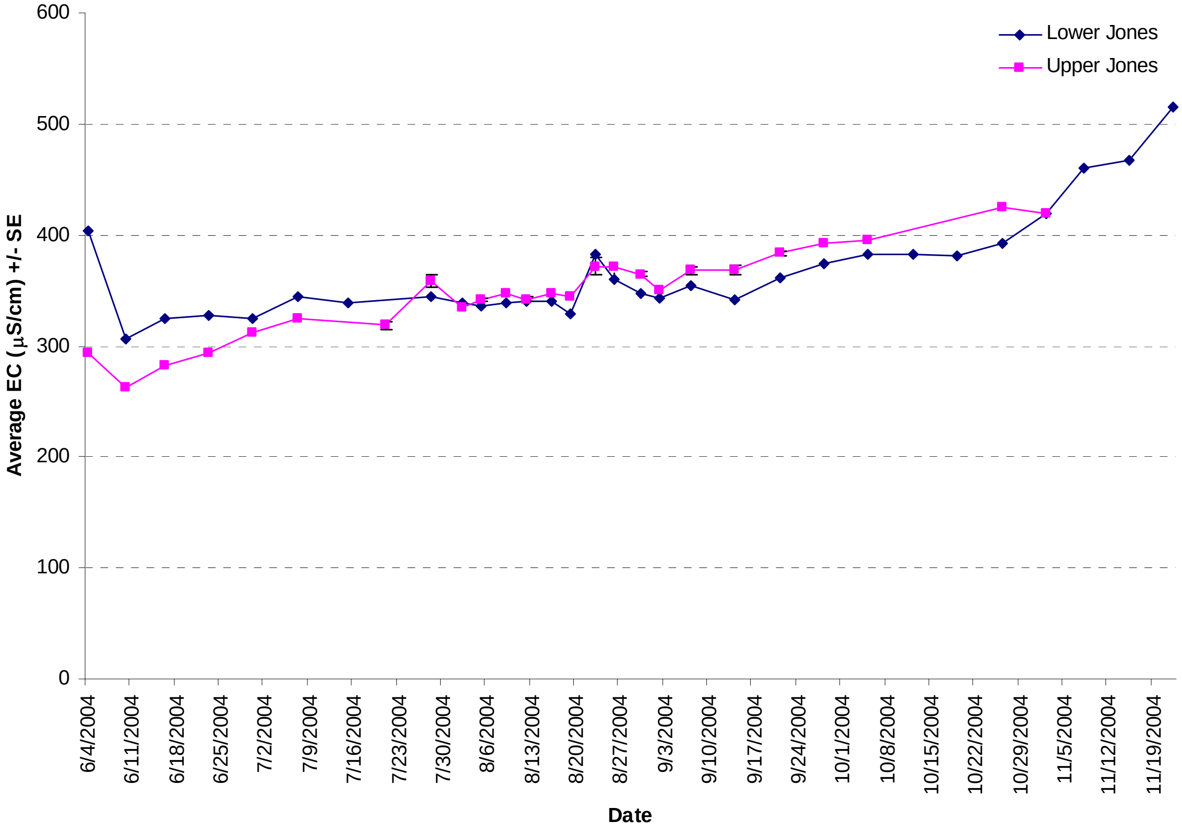


Figure 3.5.2a Electrical conductivity at Jones Tract (Bryte field data), June–Oct 2004

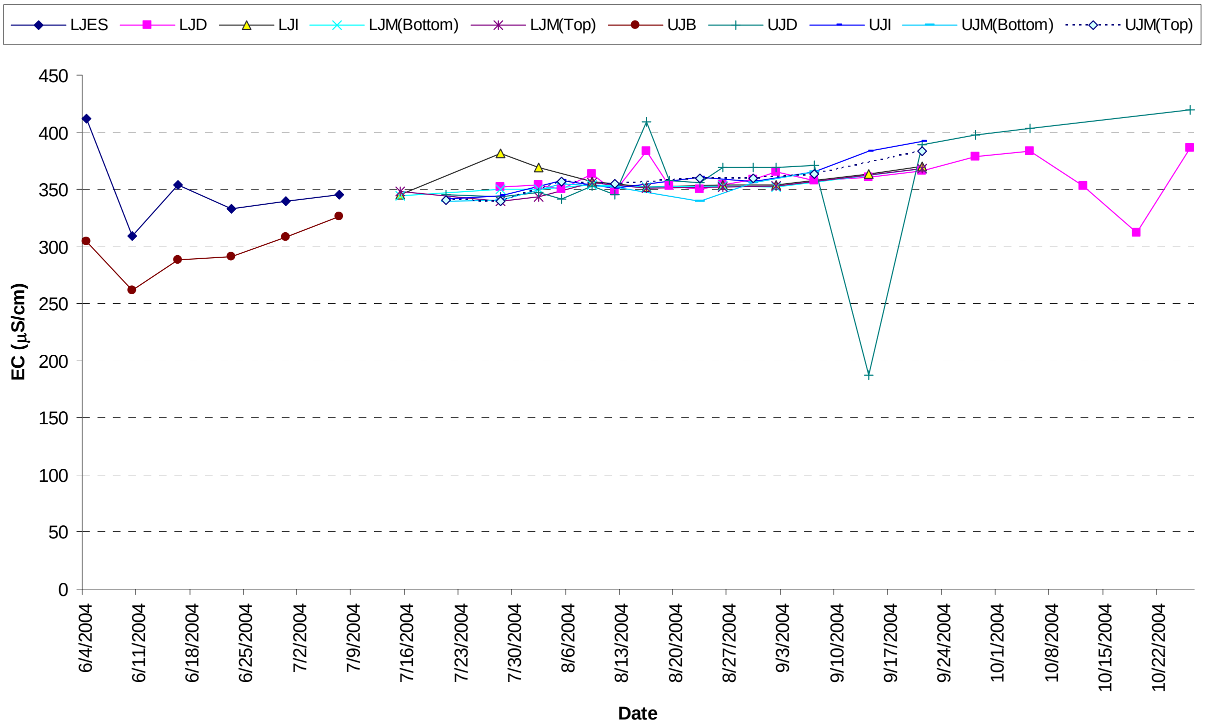


Figure 3.5.2b Average electrical conductivity at Jones Tract (Bryte field data), June–Oct 2004

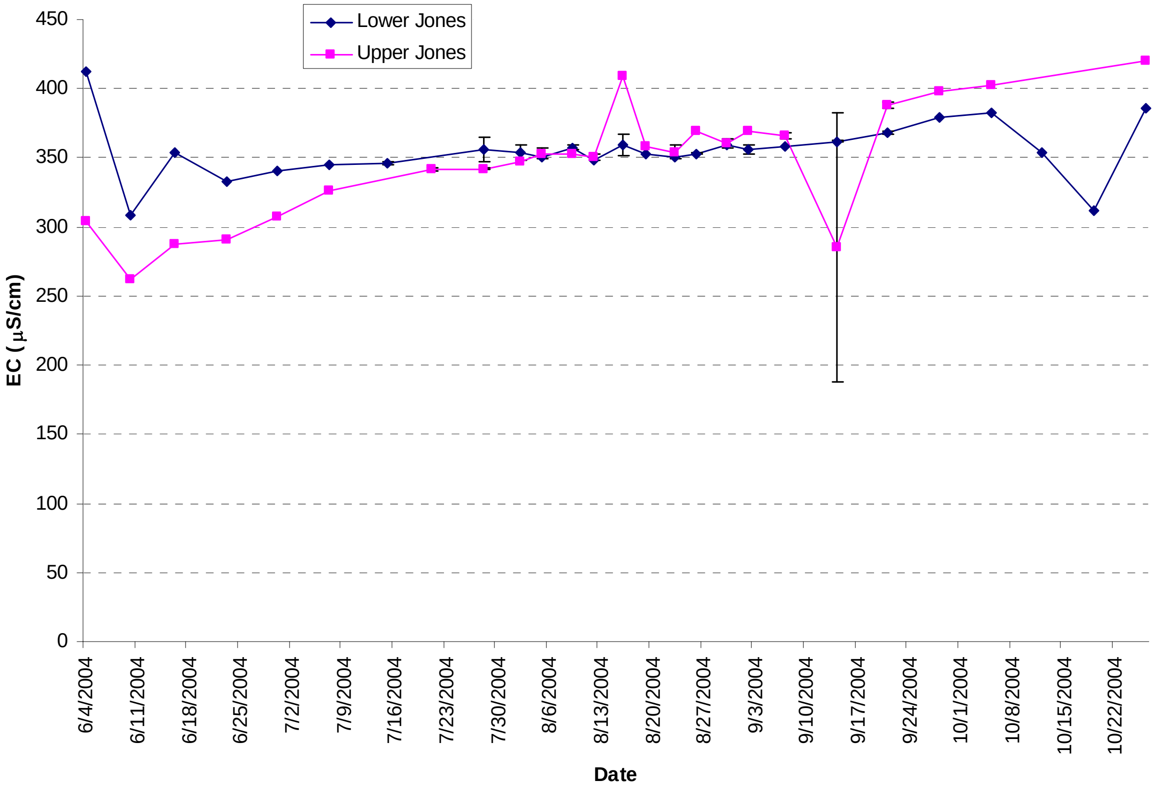


Figure 3.5.3 Average specific conductivity at Upper Jones Intake (sonde data), July–Nov 2004

Each data point is an average of 96 observations

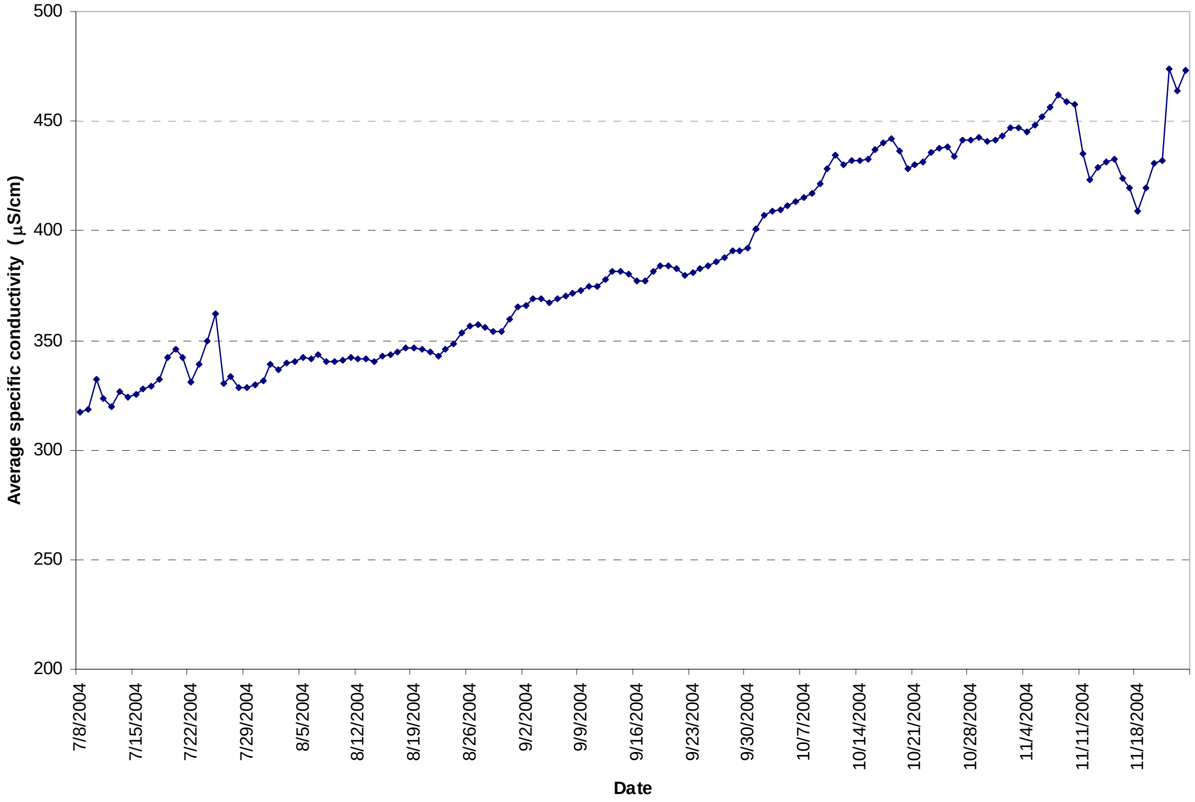


Figure 3.5.4a Total dissolved solids in Jones Tract (Bryte Lab), June–Nov 2004

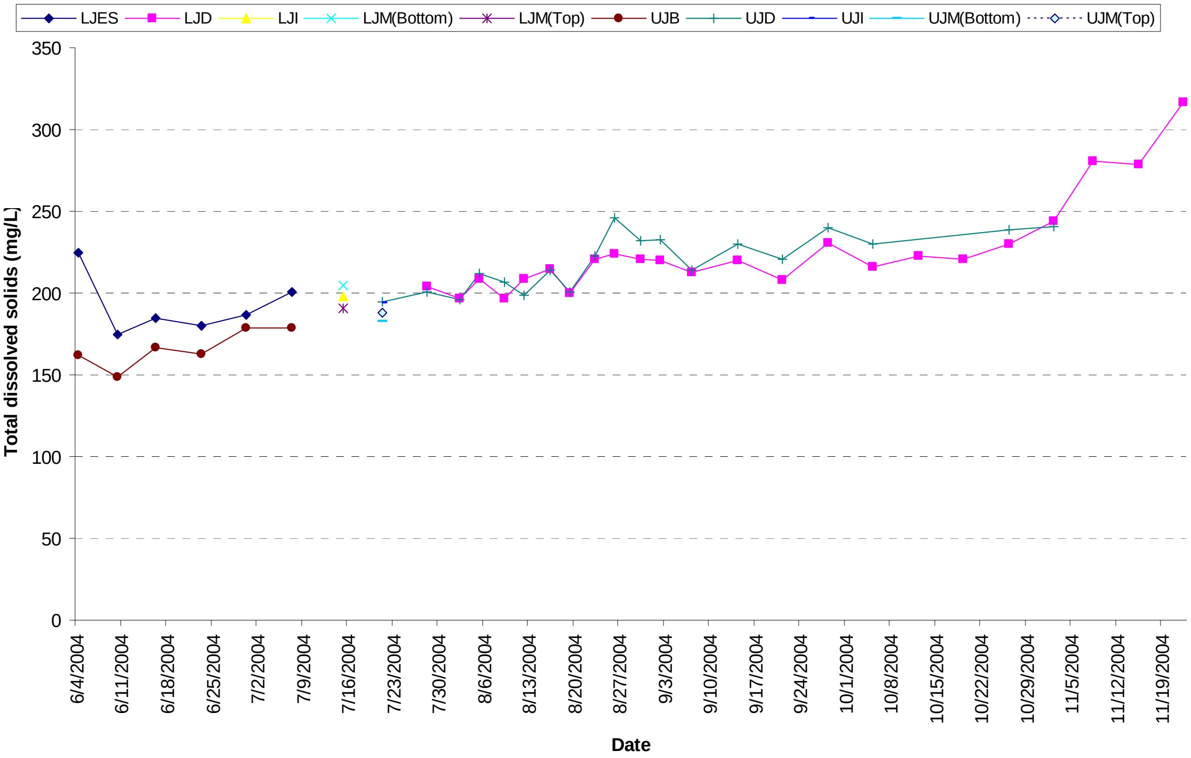


Figure 3.5.4b Average total dissolved solids (mg/L) at Jones Tract (Bryte Lab), June–Nov 2004

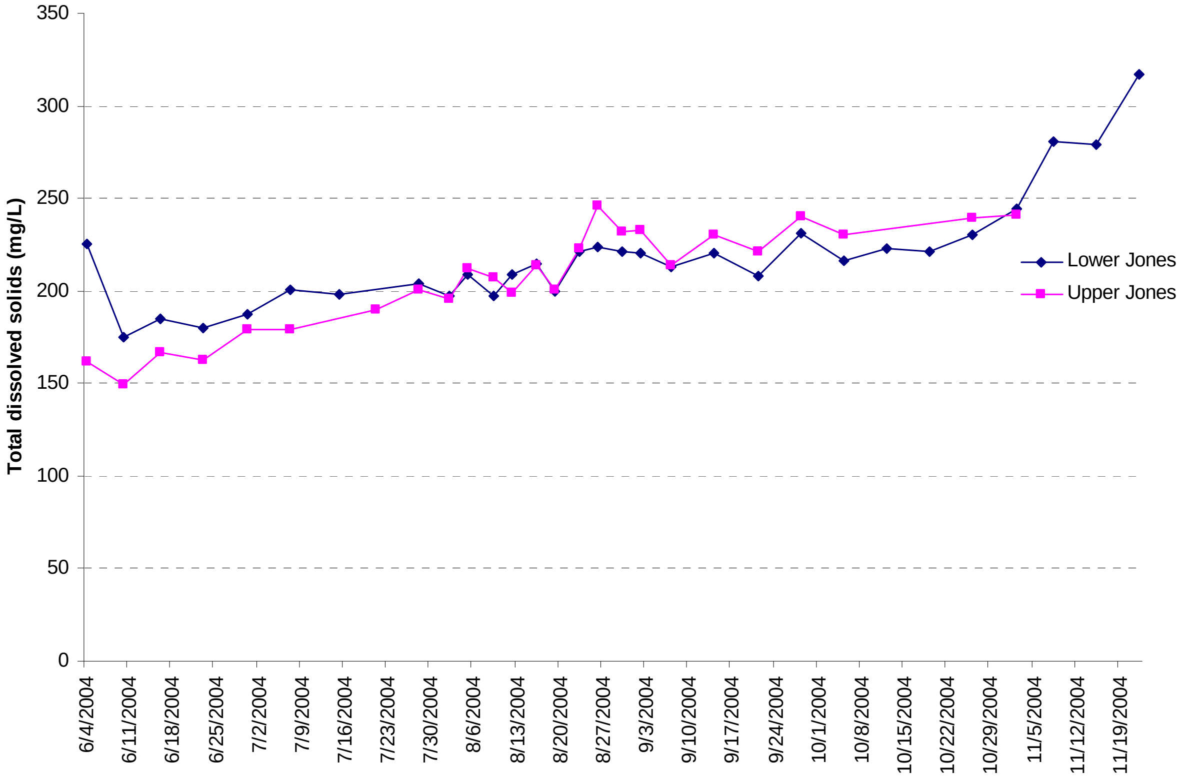


Figure 3.5.5 Relationship between electrical conductivity and total dissolved solids

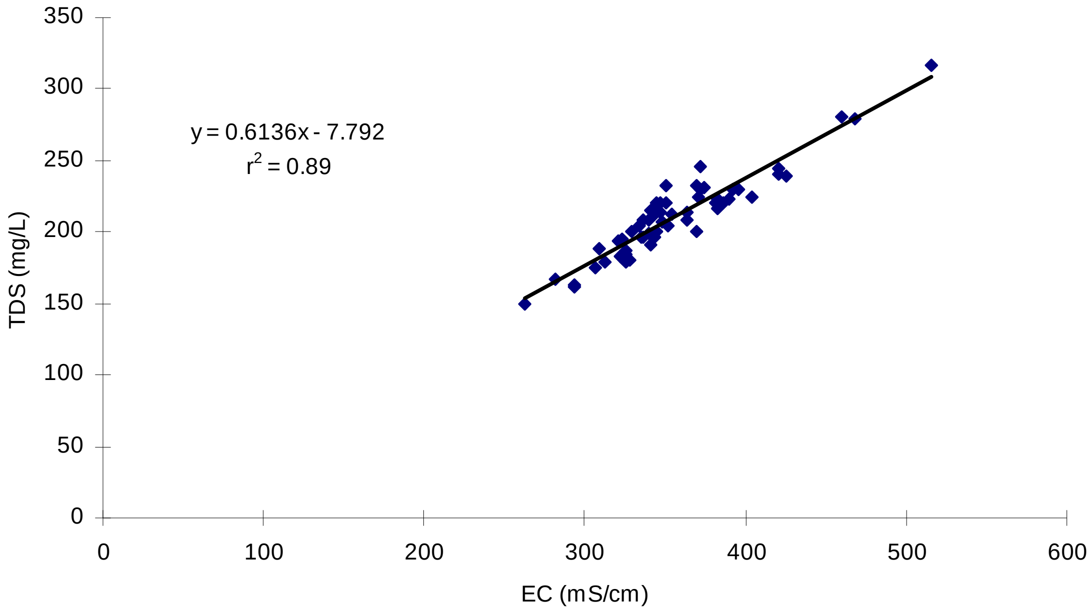


Figure 3.5.6 The relationship between electrical conductivity and Na+Ca+Mg

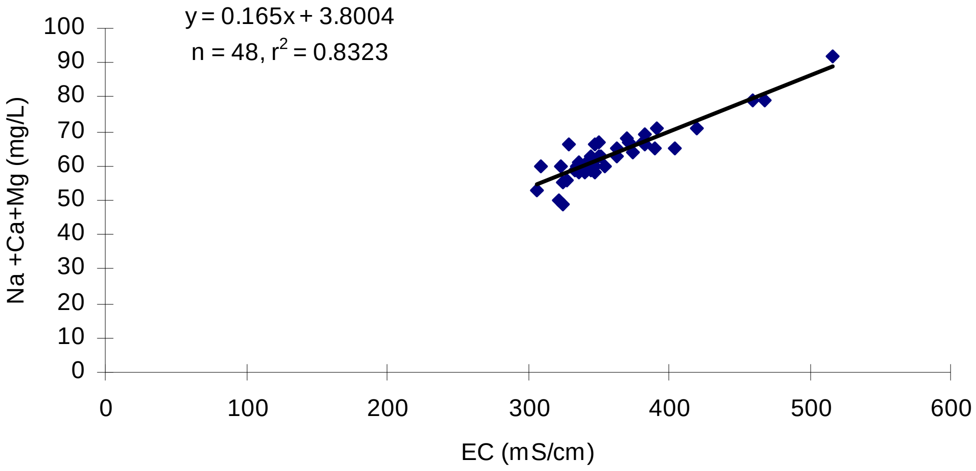


Figure 3.5.7 Relationship between electrical conductivity and Cl + SO4

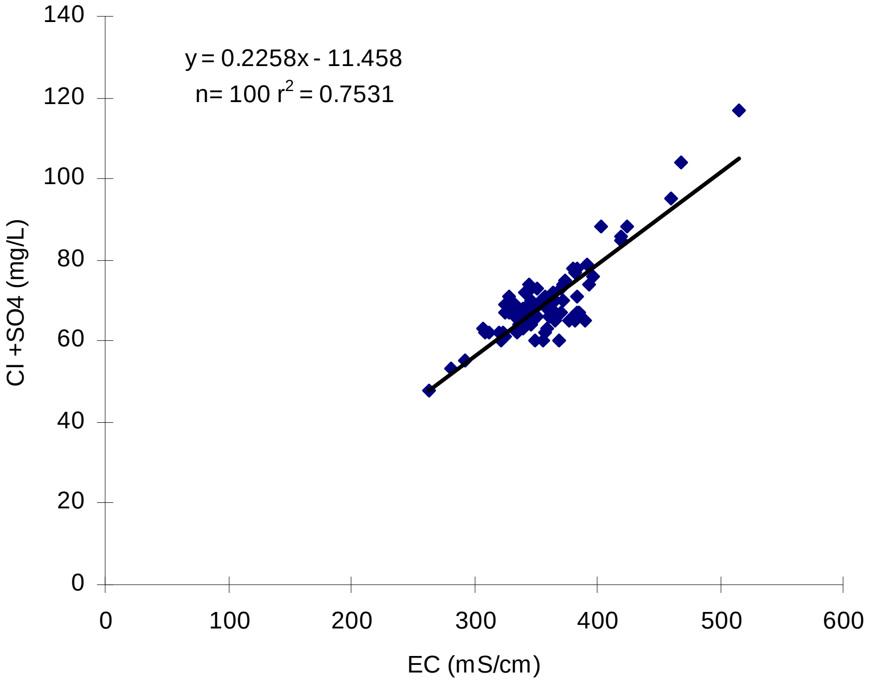


Figure 3.5.8a Sodium in Jones Tract (Bryte Lab), June–Nov 2004

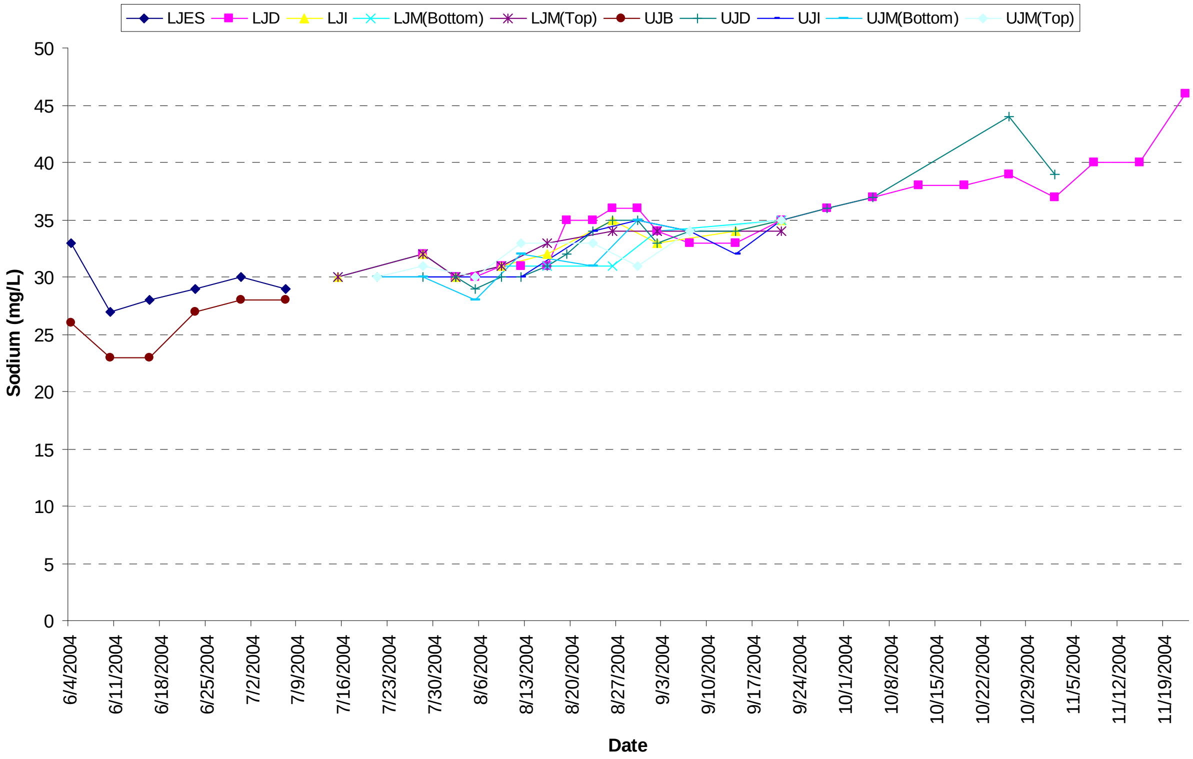


Figure 3.5.8b Average sodium in Jones Tract (Bryte Lab), June–Nov 2004

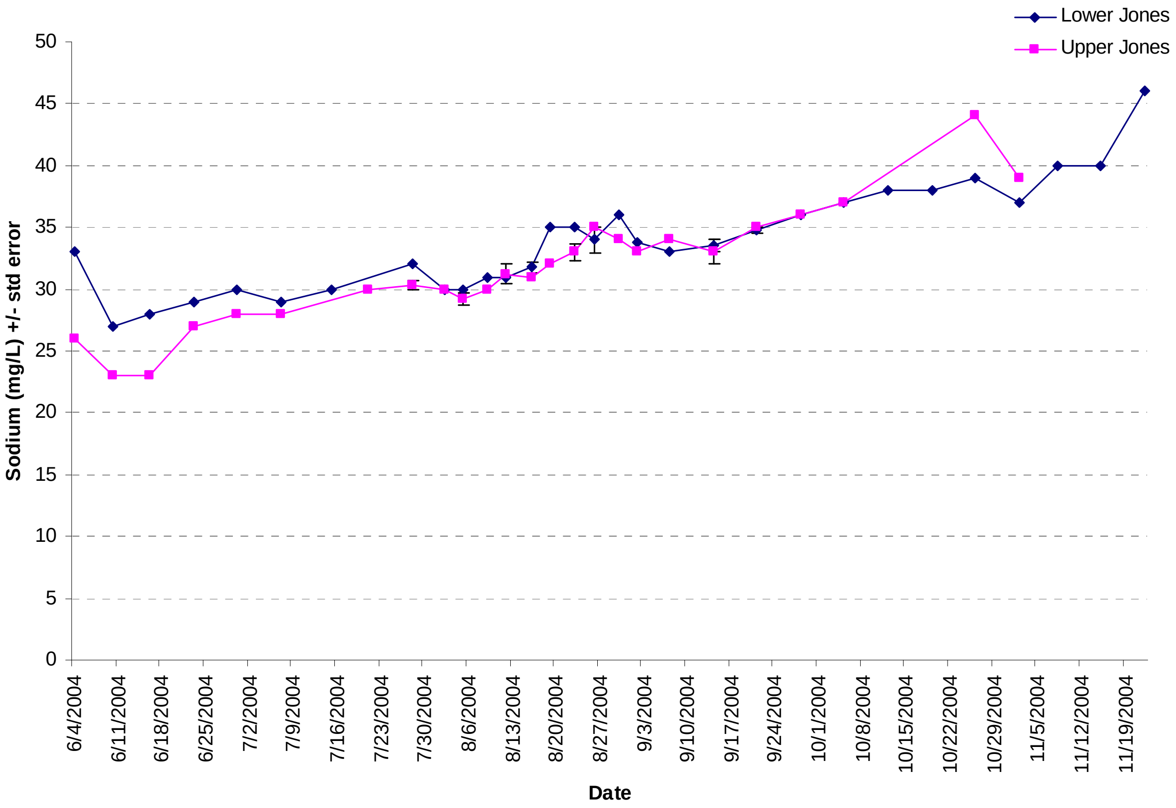


Figure 3.5.9a Calcium in Jones Tract (Bryte Lab), June–Nov 2004

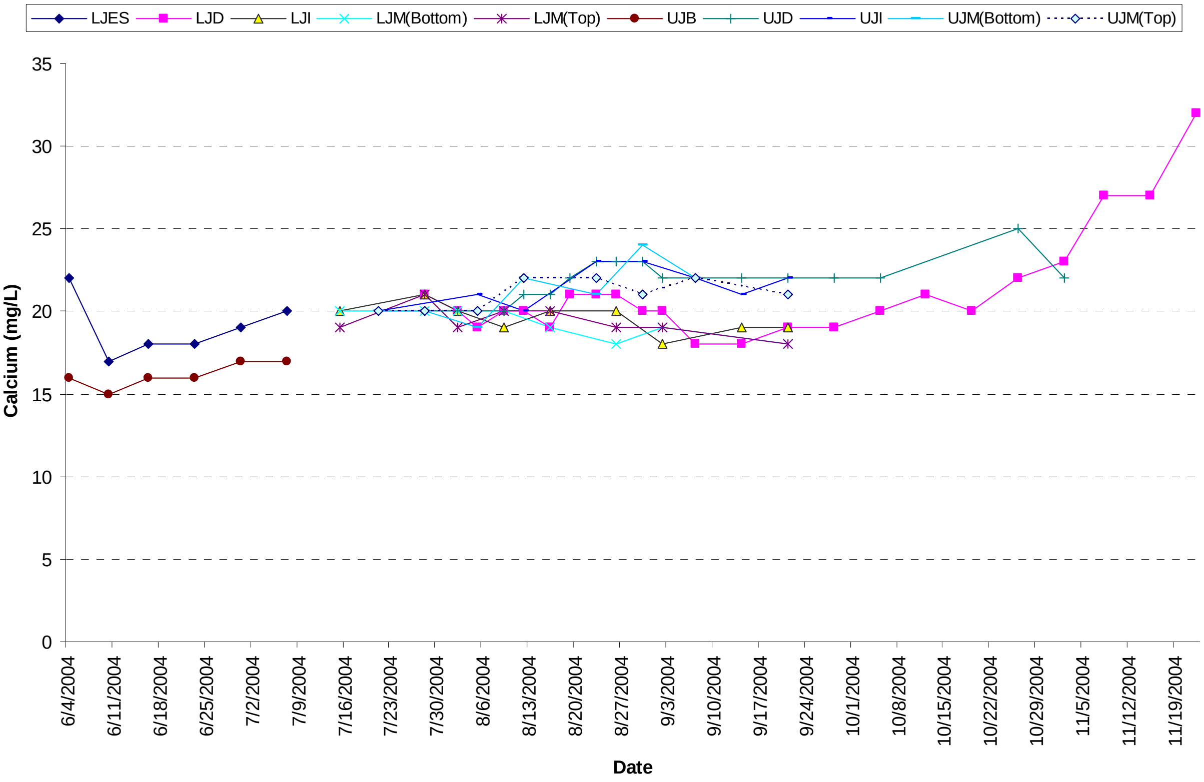


Figure 3.5.9b Average calcium at Jones Tract (Bryte Lab), June–Nov 2004

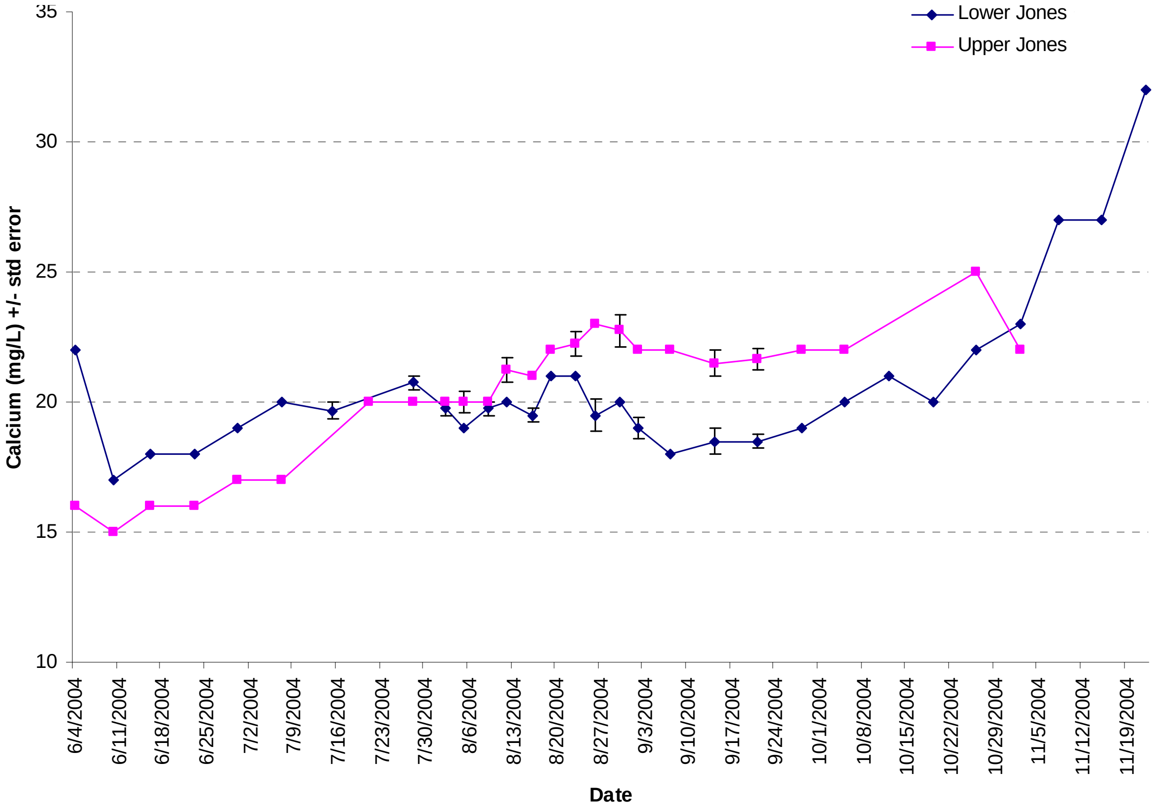


Figure 3.5.10a Magnesium in Jones Tract (Bryte Lab), June–Nov 2004

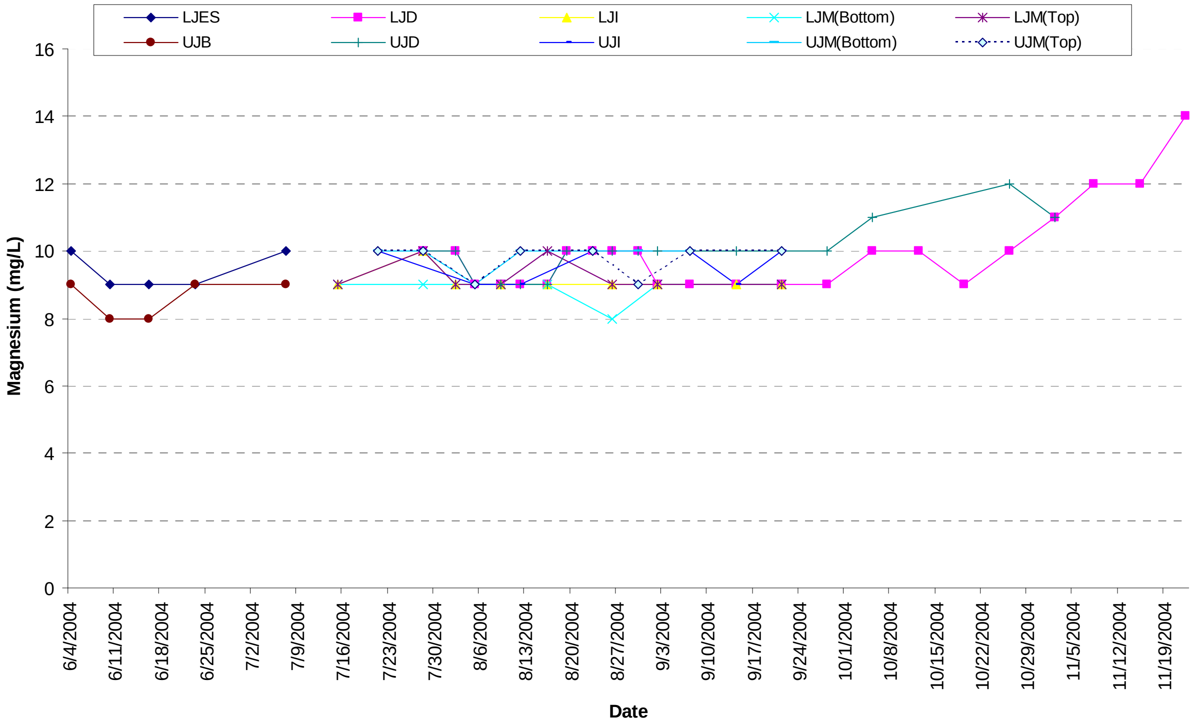


Figure 3.5.10b Average magnesium in Jones Tract (Bryte Lab), June–Nov 2004

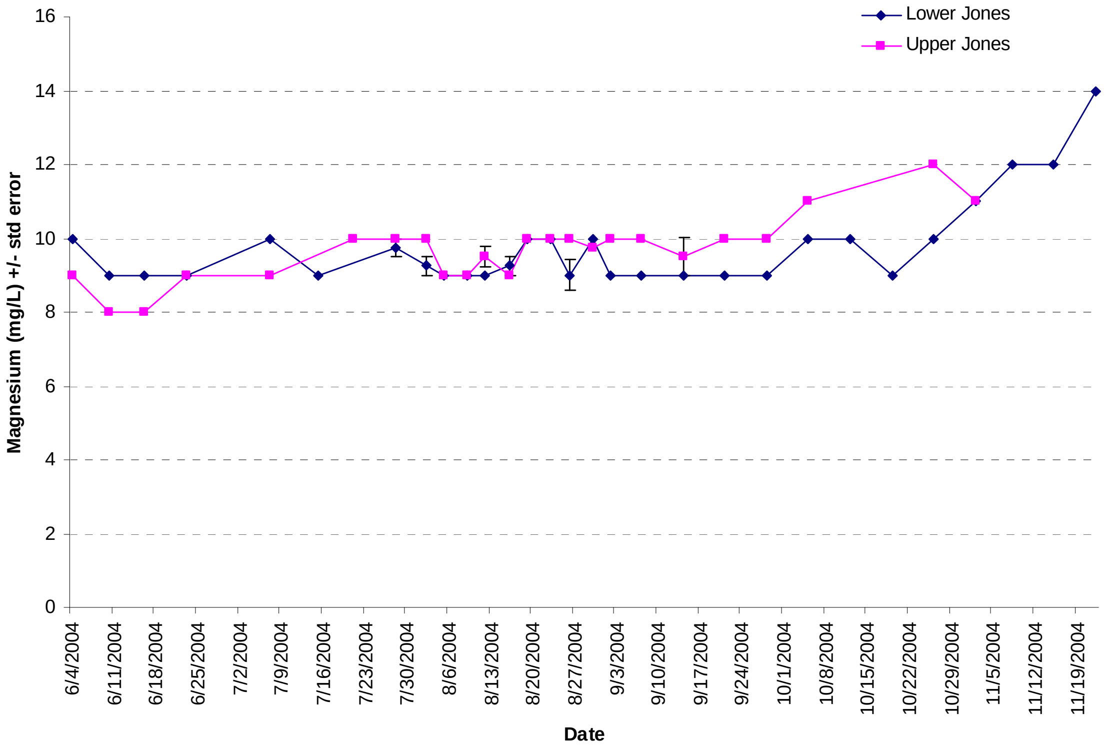


Figure 3.5.11a Potassium in Jones Tract (Bryte Lab), June–Nov 2004

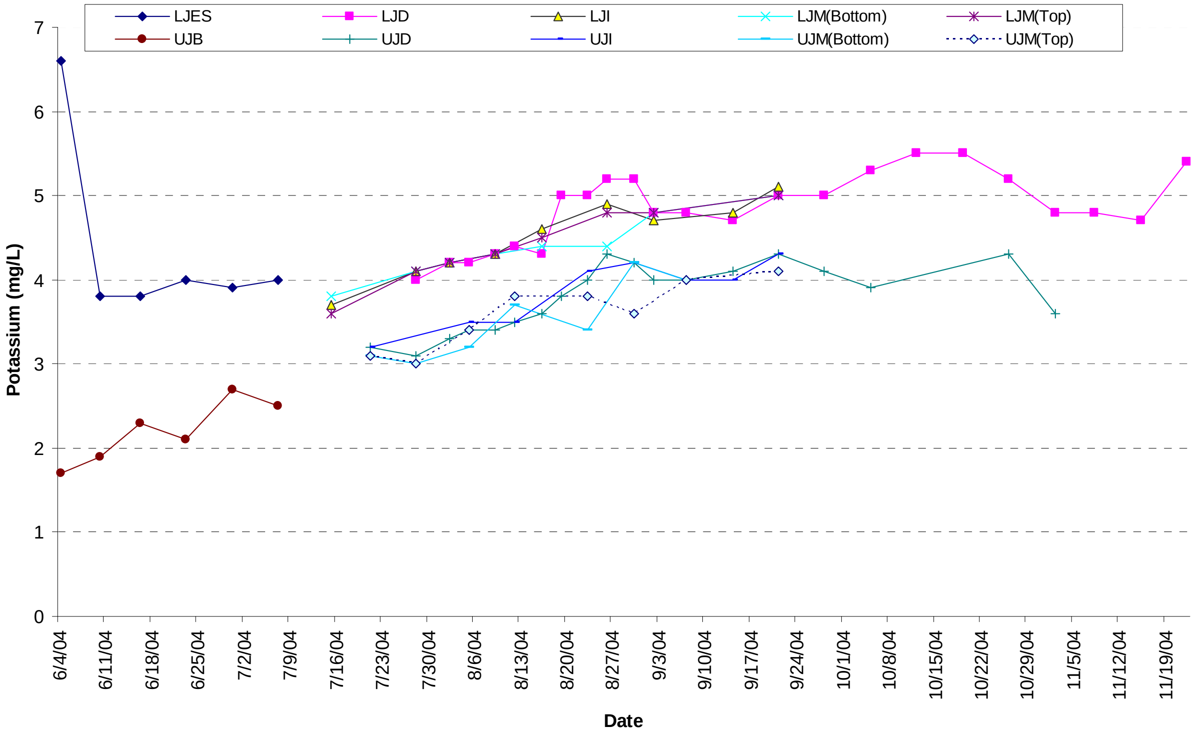


Figure 3.5.11b Average potassium in Jones Tract (Bryte Lab), June–Nov 2004

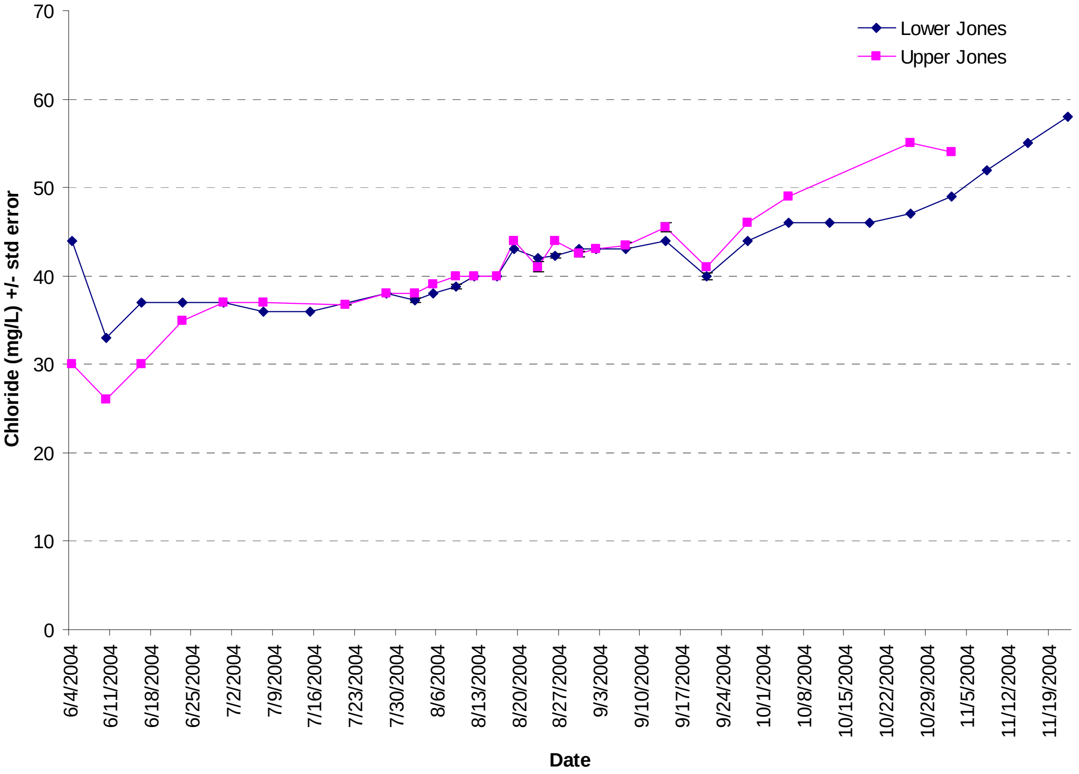


Figure 3.5.12a Chloride in the Jones Tract (Bryte Lab), June–Nov 2004

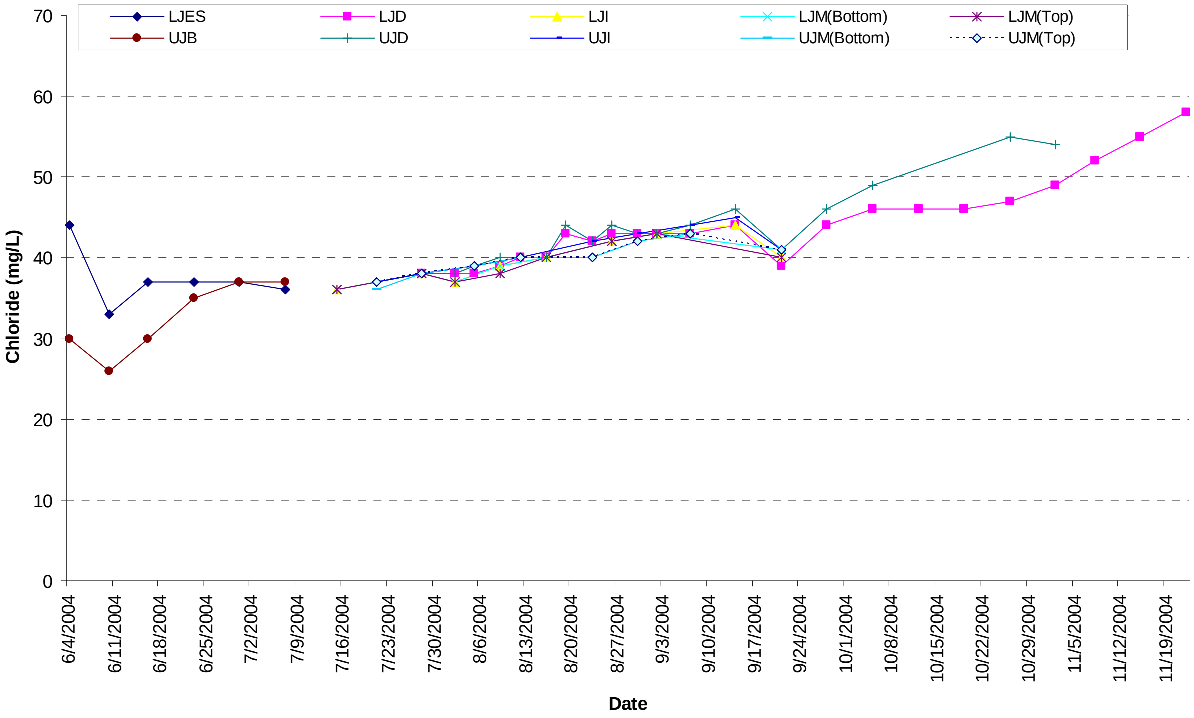


Figure 3.5.12b Average chloride in Jones Tract (Bryte Lab), June–Nov 2004

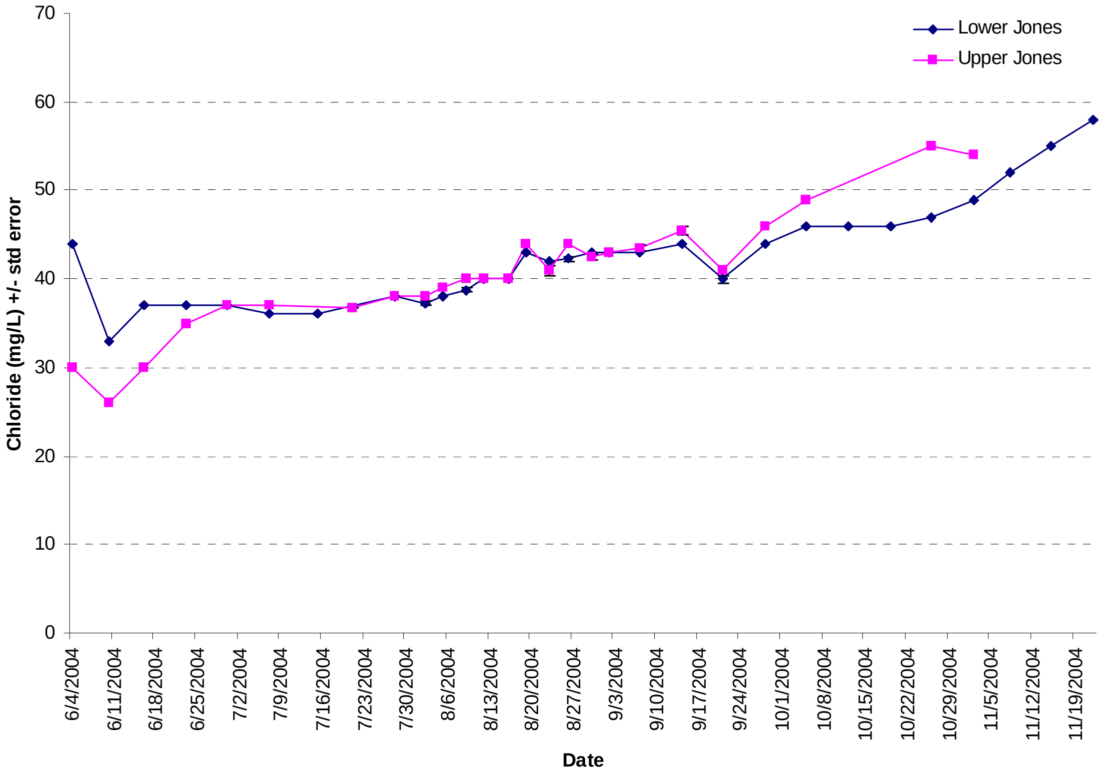


Figure 3.5.13a Sulfate in Jones Tract (Bryte Lab), June–Nov 2004

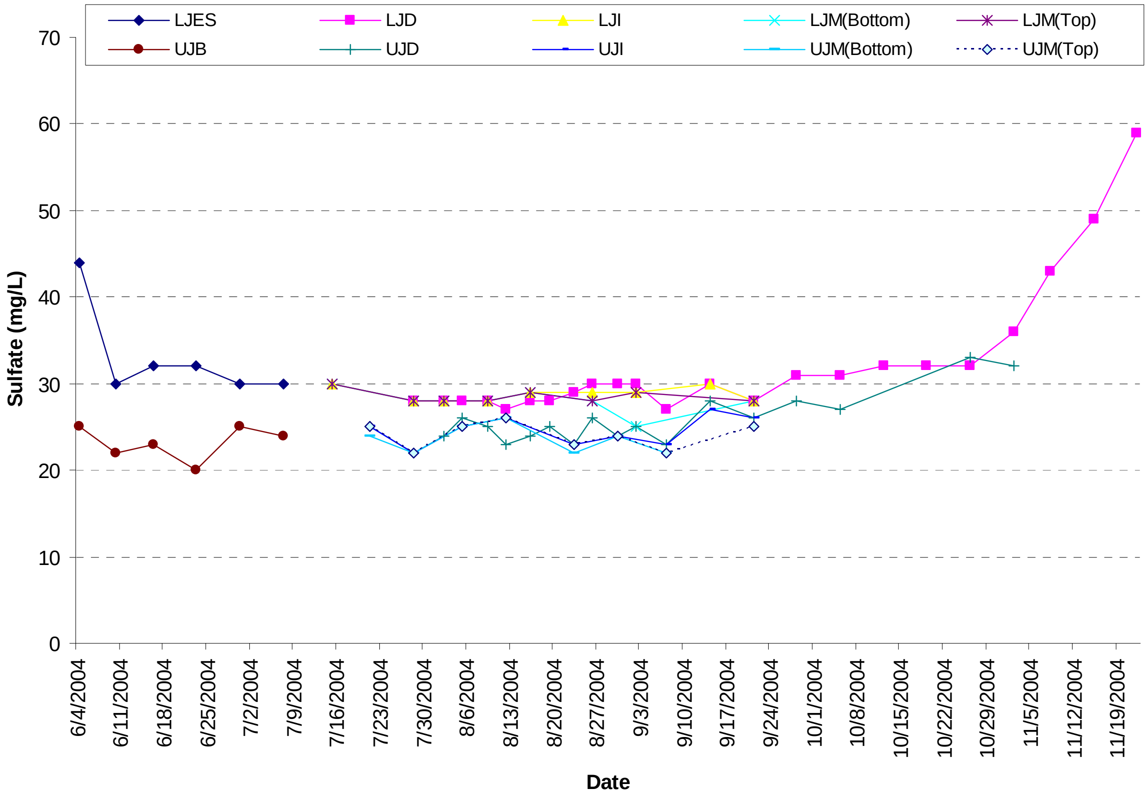


Figure 3.5.13b Average sulfate in Jones Tract (Bryte Lab), June–Nov 2004

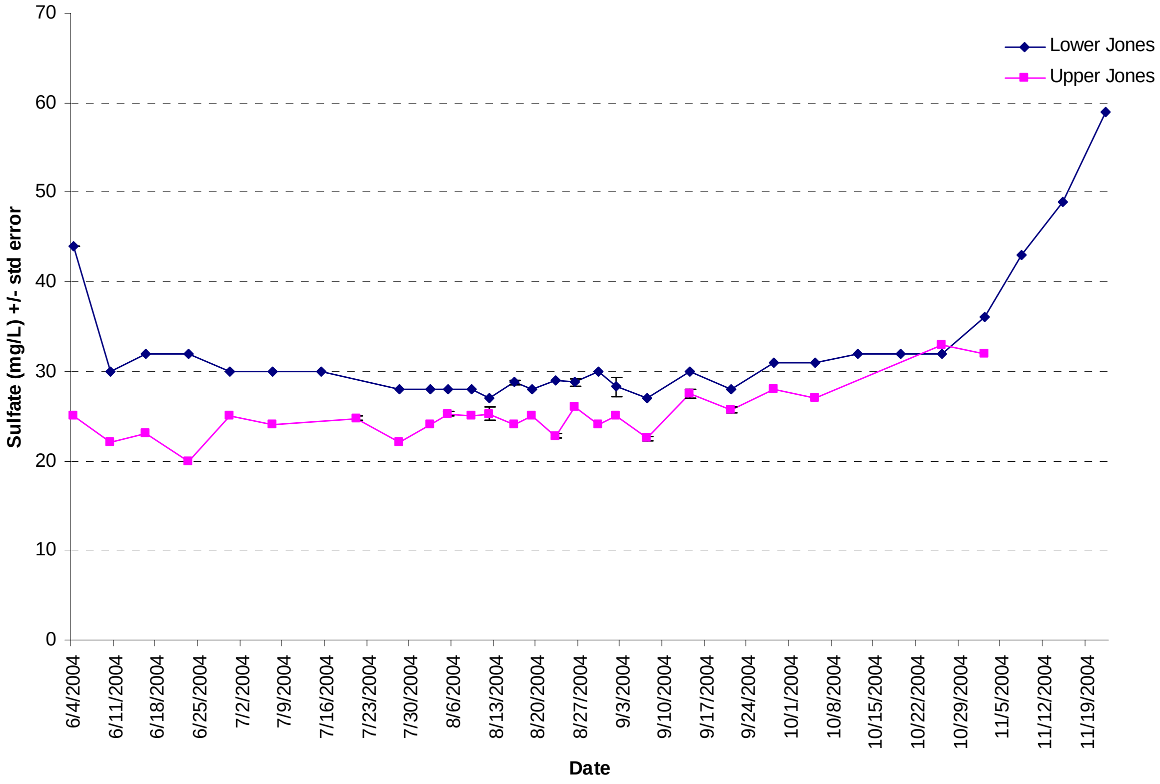


Figure 3.5.14a Alkalinity at Jones Tract (Bryte Lab), June–Nov 2004

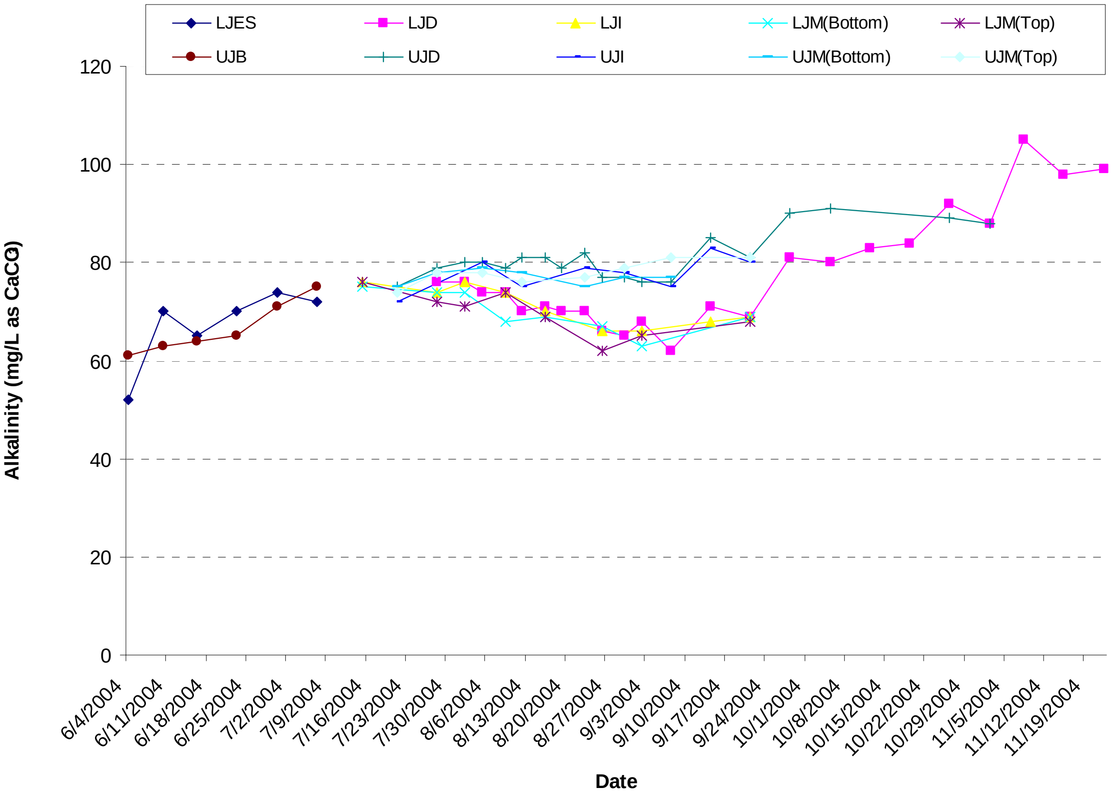


Figure 3.5.14b Average alkalinity at Jones Tract (Bryte Lab), June–Nov 2004

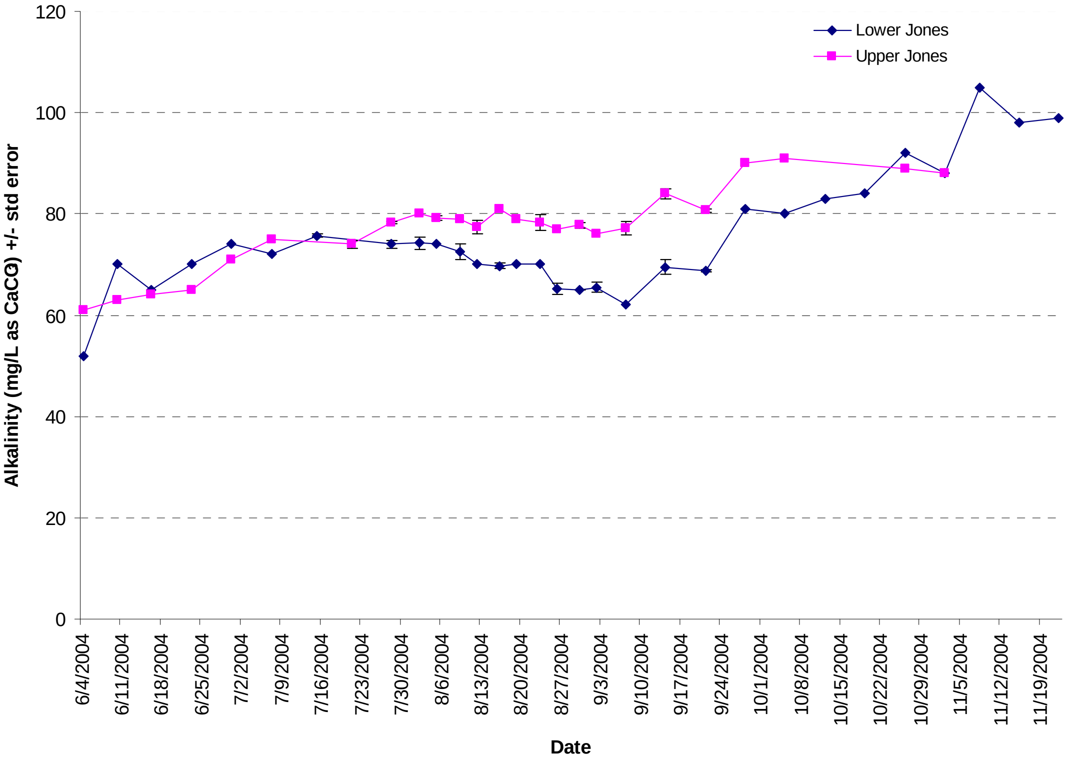


Figure 3.5.15a Dissolved hardness at Jones Tract (Bryte Lab), June–Nov 2004

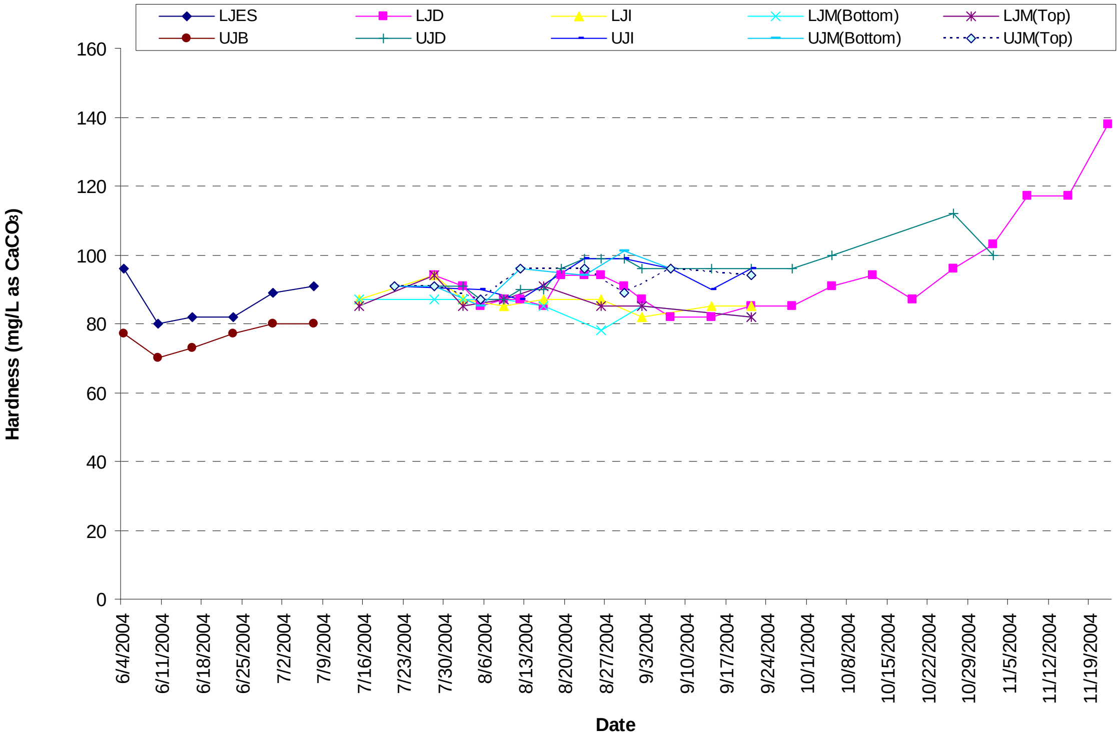


Figure 3.5.15b Average dissolved hardness in Jones Tract (Bryte Lab), June–Nov 2004

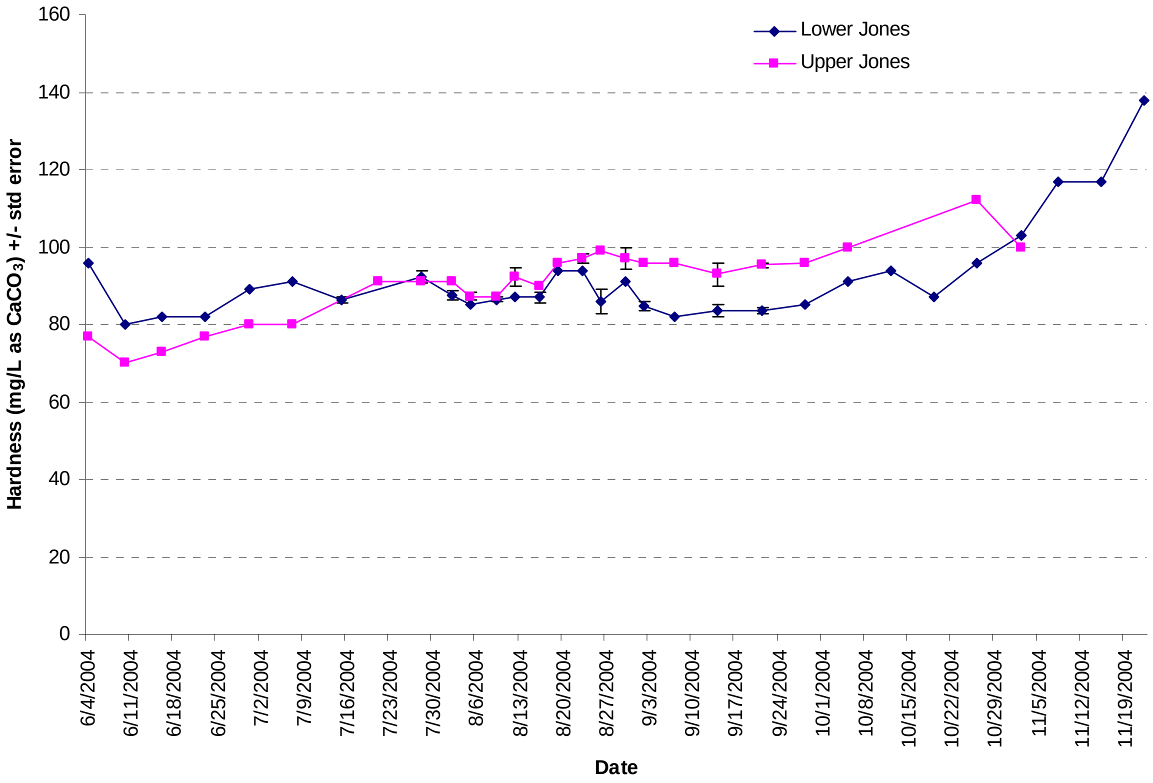


Figure 3.5.16a Boron in Jones Tract (Bryte Lab), June–Nov 2004

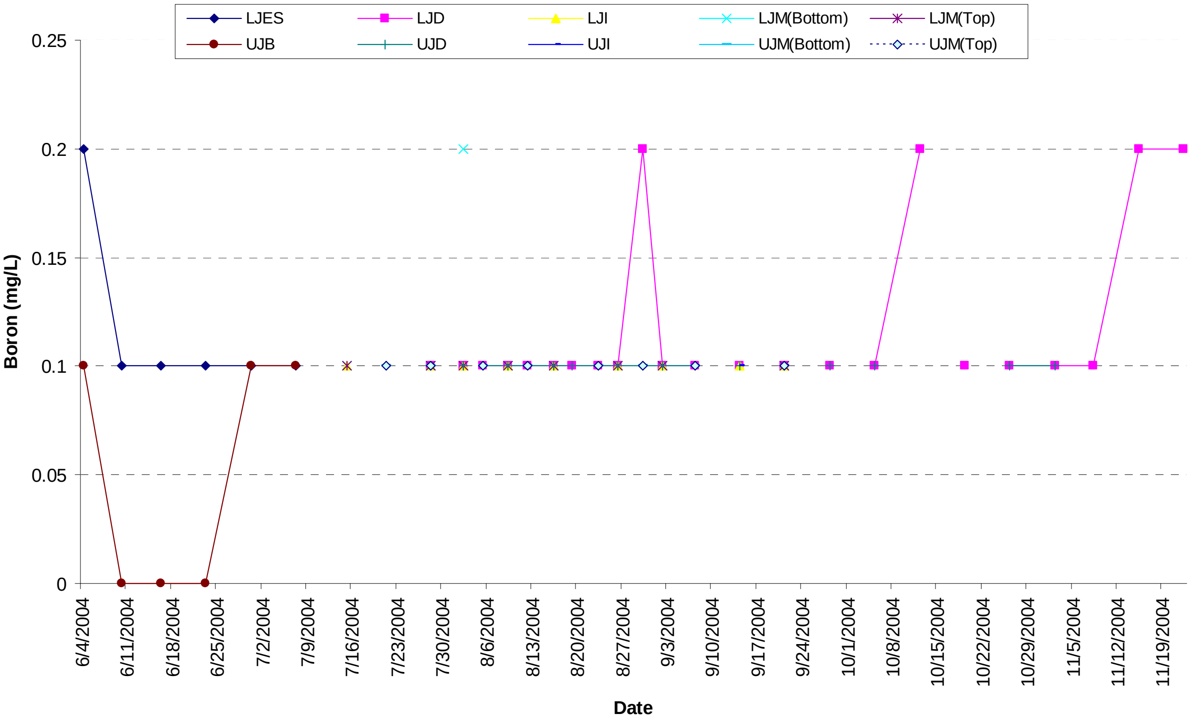


Figure 3.5.16b Average boron in Jones Tract (Bryte Lab), June–Nov 2004

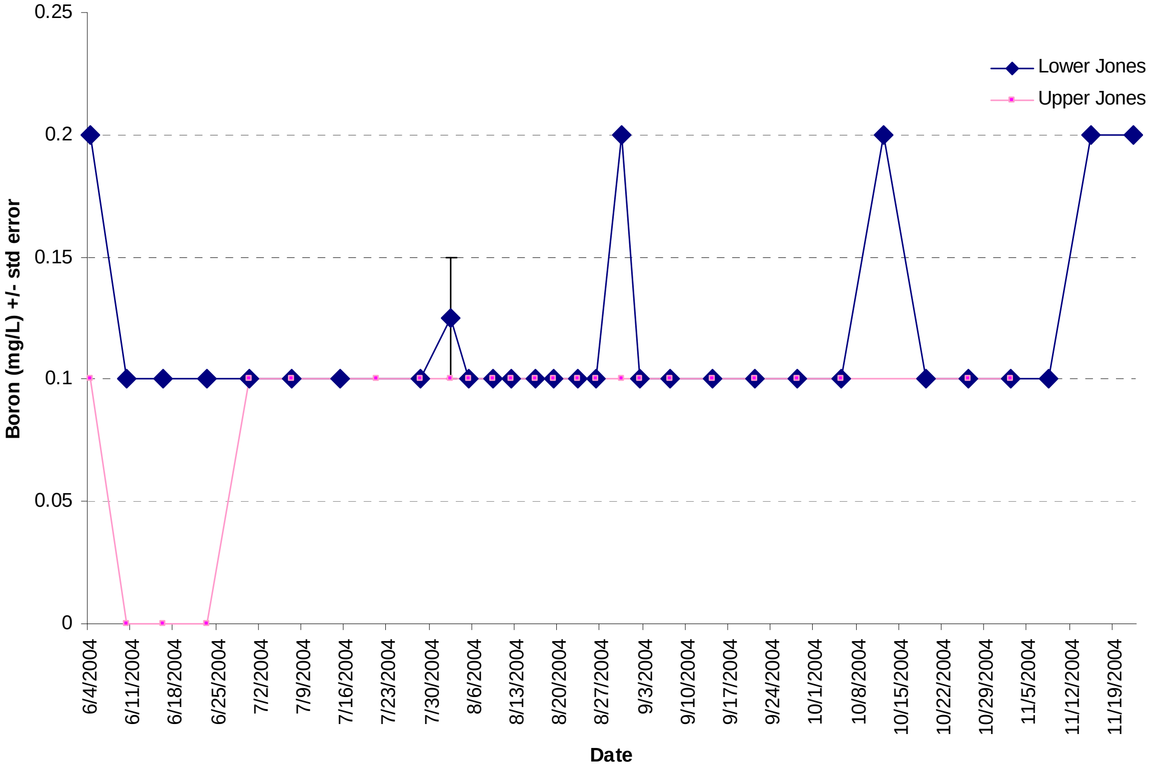


Table 3.5.1 Alkalinity

	Lower Jones Avg ± std dev	Upper Jones Avg ± std dev	Middle River	UJT Levee Middle River Site A	UJT Levee Middle River Site B	UJT Levee Santa Fe Cut
6/4/2004	52	61	75			
6/10/2004	70	63	63			
6/16/2004	65	64	62			
6/23/2004	70	65	66			
6/30/2004	74	71	64			
7/7/2004	72	75	61			
7/15/2004	76 ± 0.6					
7/21/2004		74 ± 1.4				
7/27/2004				57	57	54
7/28/2004	74 ± 1.6	78 ± 0.6				
7/30/2004				57	58	56
8/2/2004	74 ± 2.4	80				
8/3/2004				59	59	57
8/5/2004	74	79 ± 1				
8/9/2004	73 ± 3	79		59	61	58
8/12/2004	70	78 ± 2.6		62	62	60
8/16/2004	70 ± 1	81				
8/19/2004	70	79		58	60	58
8/23/2004	70	78 ± 3		60	63	62
8/26/2004	65 ± 2	77		66	63	63
8/30/2004	65	78 ± 1		59	64	60
9/2/2004	65.5 ± 2.1	76		67	59	65
9/7/2004	62	77.3 ± 2.6				
9/9/2004				76	75	
9/14/2004	69.5 ± 2.1	84 ± 1.4				
9/15/2004				69	72	
9/21/2004	68.7 ± 0.5	80.7 ± .6				
9/23/2004				74	75	
9/27/2004				75	74	
9/28/2004	81	90				
10/4/2004				75	80	
10/5/2004	80	91				
10/12/2004	83					
10/13/2004				74	82	
10/18/2004				83	84	
10/19/2004	84					
10/25/2004				86	88	
10/26/2004	92	89				
11/2/2004	88	88				
11/8/2004	105					
11/15/2004	98					
11/22/2004	99					

Table 3.5.2 Water hardness and boron concentrations

	Lower Jones Hardness Avg ± std dev	Upper Jones Hardness Avg ± std dev	Lower Jones Boron Average	Upper Jones Boron Average
6/4/2004	96	77	0.2	0.1
6/10/2004	80	70	0.1	< 0.1
6/16/2004	82	73	0.1	< 0.1
6/23/2004	82	77	0.1	< 0.1
6/30/2004	89	80	0.1	0.1
7/7/2004	91	80	0.1	0.1
7/15/2004	86.3 ± 1.2		0.1	
7/21/2004		91		0.1
7/27/2004				
7/28/2004	92.3 ± 3.5	91	0.1	0.1
7/30/2004				
8/2/2004	87.5 ± 2.5	91	0.125	0.1
8/3/2004				
8/5/2004	85	87.3 ± 2.1	0.1	0.1
8/9/2004	86.5 ± 1	87	0.1	0.1
8/12/2004	87	92.3 ± 4.5	0.1	0.1
8/16/2004	87 ± 2.8	90	0.1	0.1
8/19/2004	94	96	0.1	0.1
8/23/2004	94	97 ± 2.4	0.1	0.1
8/26/2004	86 ± 6.6	99	0.1	0.1
8/30/2004	91	97 ± 5.4	0.2	0.1
9/2/2004	84.8 ± 2.1	96	0.1	0.1
9/7/2004	82	96	0.1	0.1
9/9/2004				
9/14/2004	83.5 ± 2.1	93 ± 4.2	0.1	0.1
9/15/2004				
9/21/2004	83.5 ± 1.7	95.3 ± 1.2	0.1	0.1
9/23/2004				
9/27/2004				
9/28/2004	85	96	0.1	0.1
10/4/2004				
10/5/2004	91	100	0.1	0.1
10/12/2004	94		0.2	
10/13/2004				
10/18/2004				
10/19/2004	87		0.1	
10/25/2004				
10/26/2004	96	112	0.1	0.1
11/2/2004	103	100	0.1	0.1
11/8/2004	117		0.1	
11/15/2004	117		0.2	
11/22/2004	138		0.2	

Chapter 3 Results and Discussion

3.6 Trace Elements

Figures

Tables

Figure 3.6.1 Mottle formation at Upper Jones Tract as the water receded from the shore (photo)

Figure 3.6.2 Iron at Jones Tract (Bryte Lab), July to Nov 2004

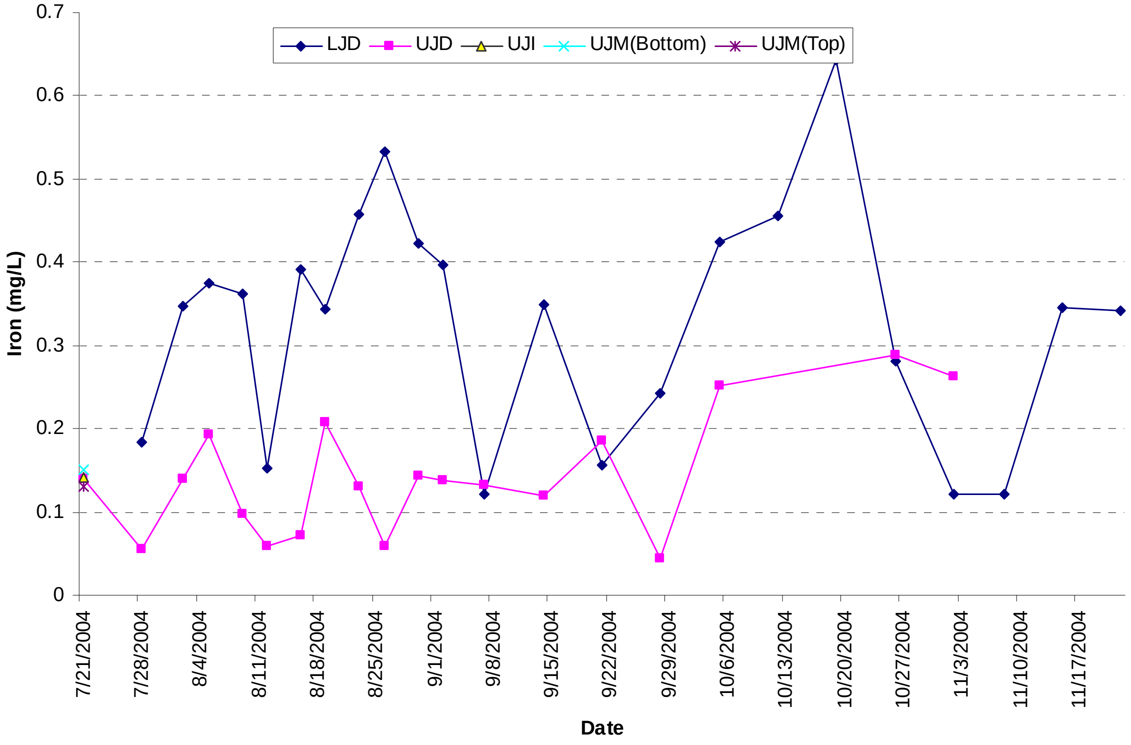


Figure 3.6.3 Manganese in the Jones Tract (Bryte Lab), July to Nov 2004

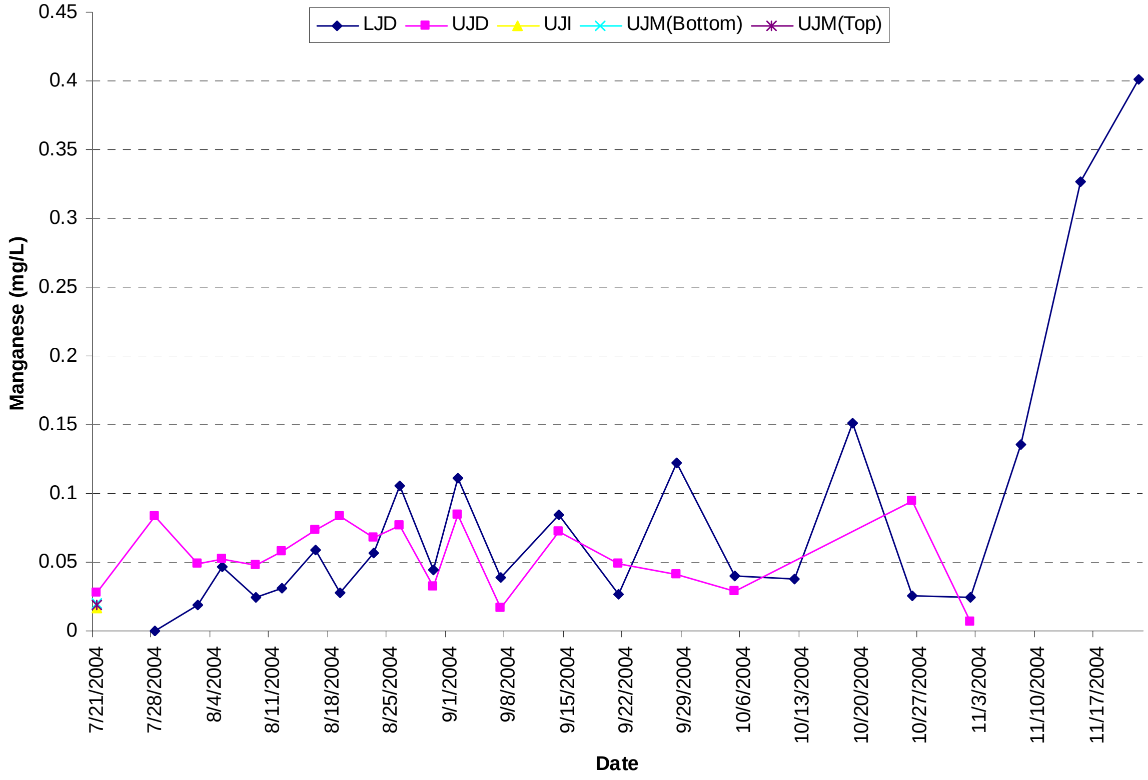


Figure 3.6.4 Zinc in Jones Tract (Bryte Lab), July to Nov 2004

Nondetects are graphed as zeros, MCL = 5 mg/L

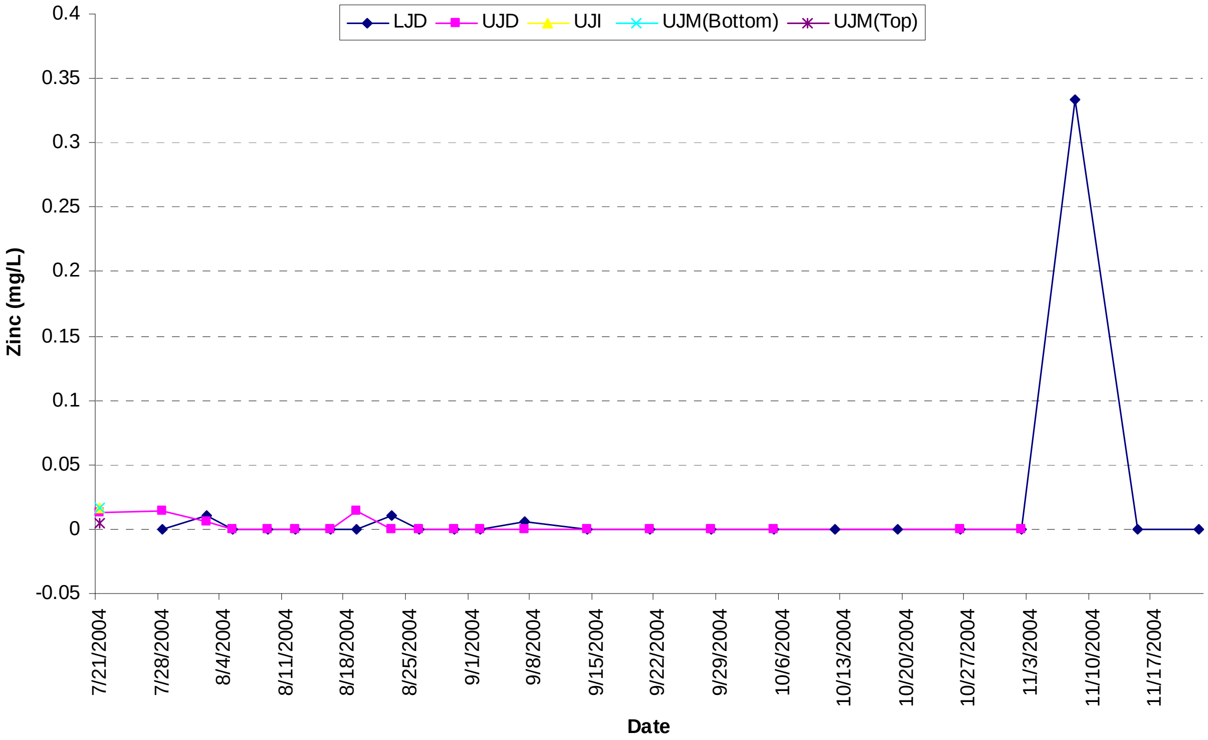


Figure 3.6.5 Aluminum in the Jones Tract (Bryte Lab) July to Nov 2004

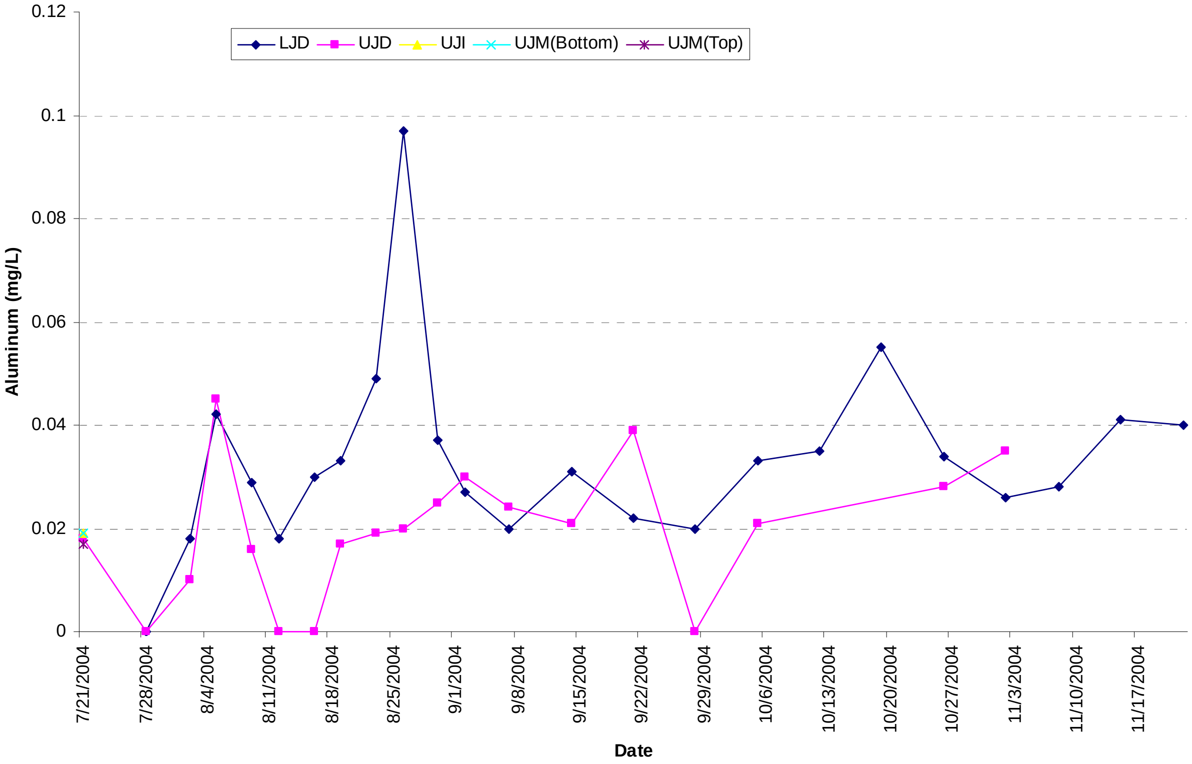


Figure 3.6.6 Nickel at Jones Tract (Bryte Lab), July to Nov 2004

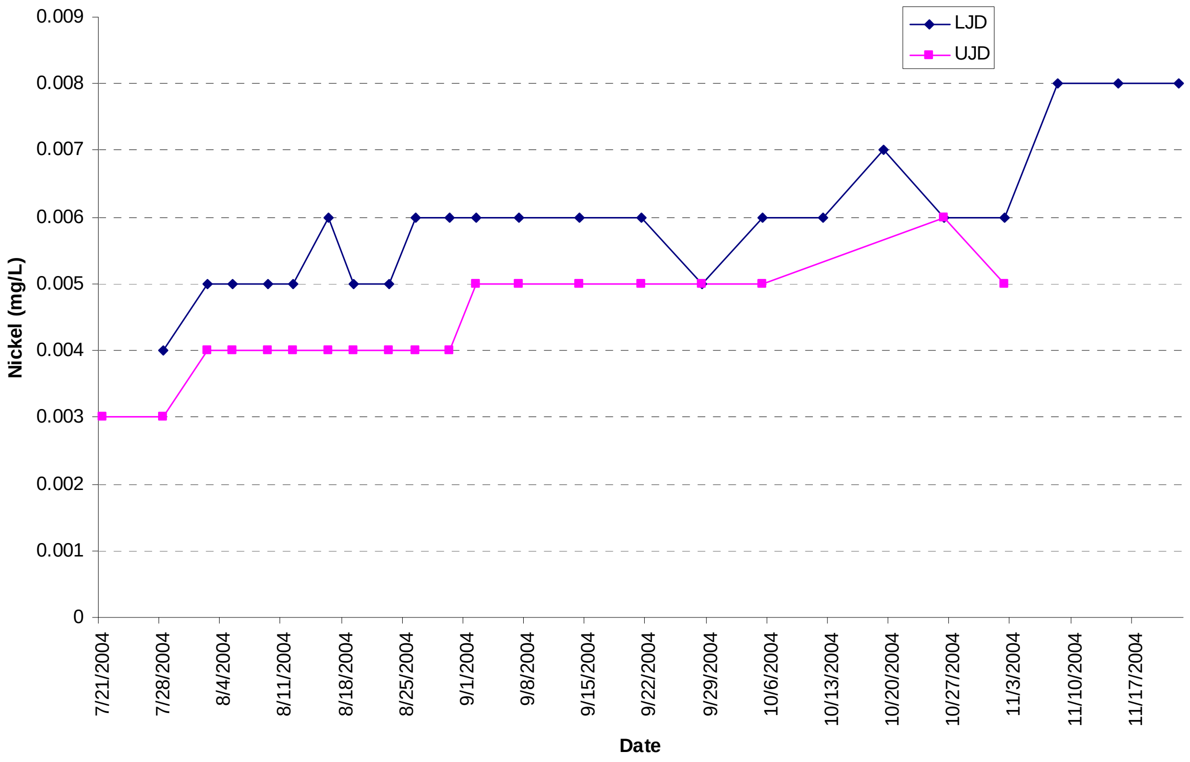


Figure 3.6.7 Arsenic in Jones Tract (Bryte Lab), July to Nov 2004

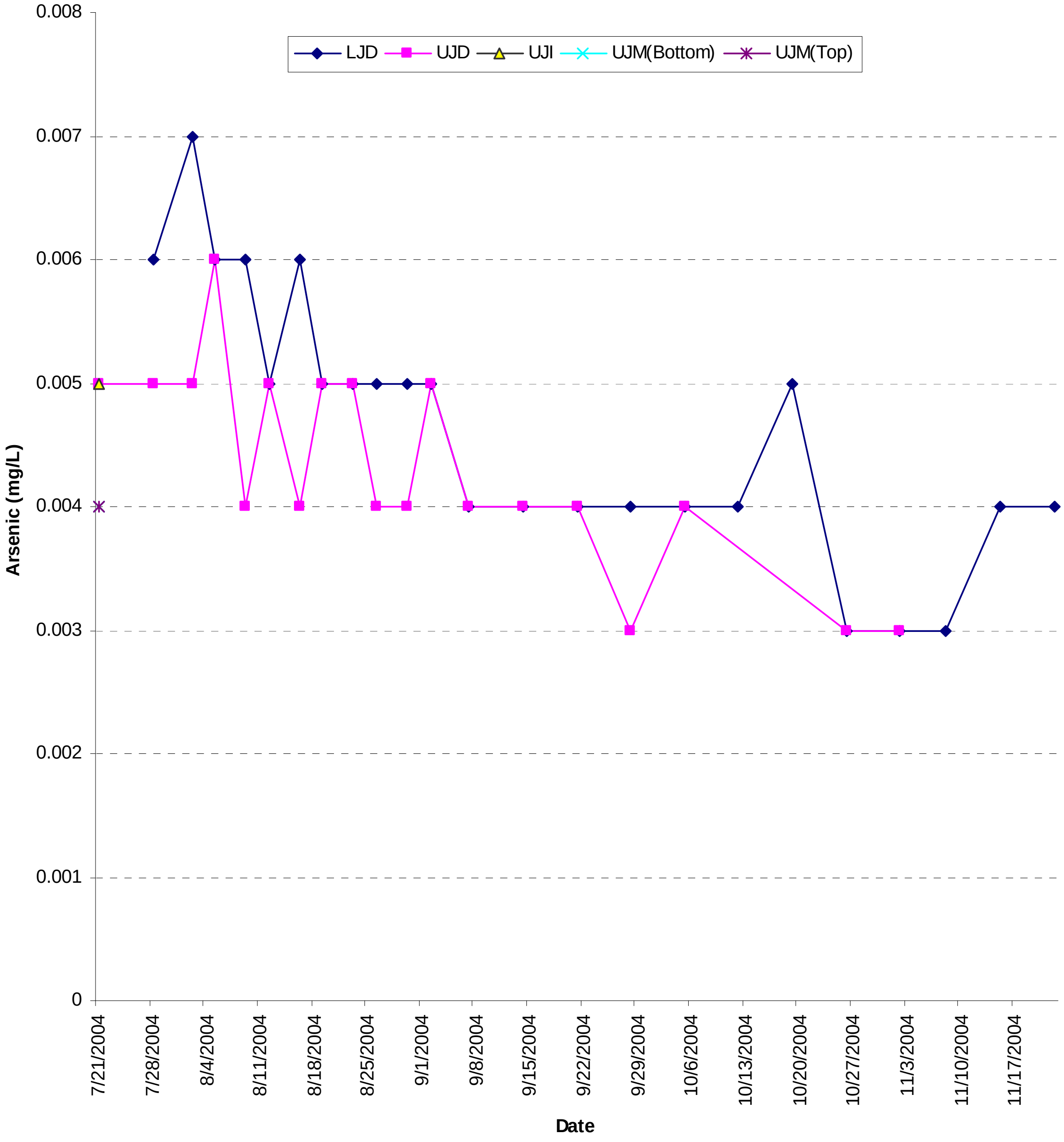


Figure 3.6.8 Barium in Jones Tract (Bryte Lab), July to Nov 2004

Nondetects are graphed as zeros.

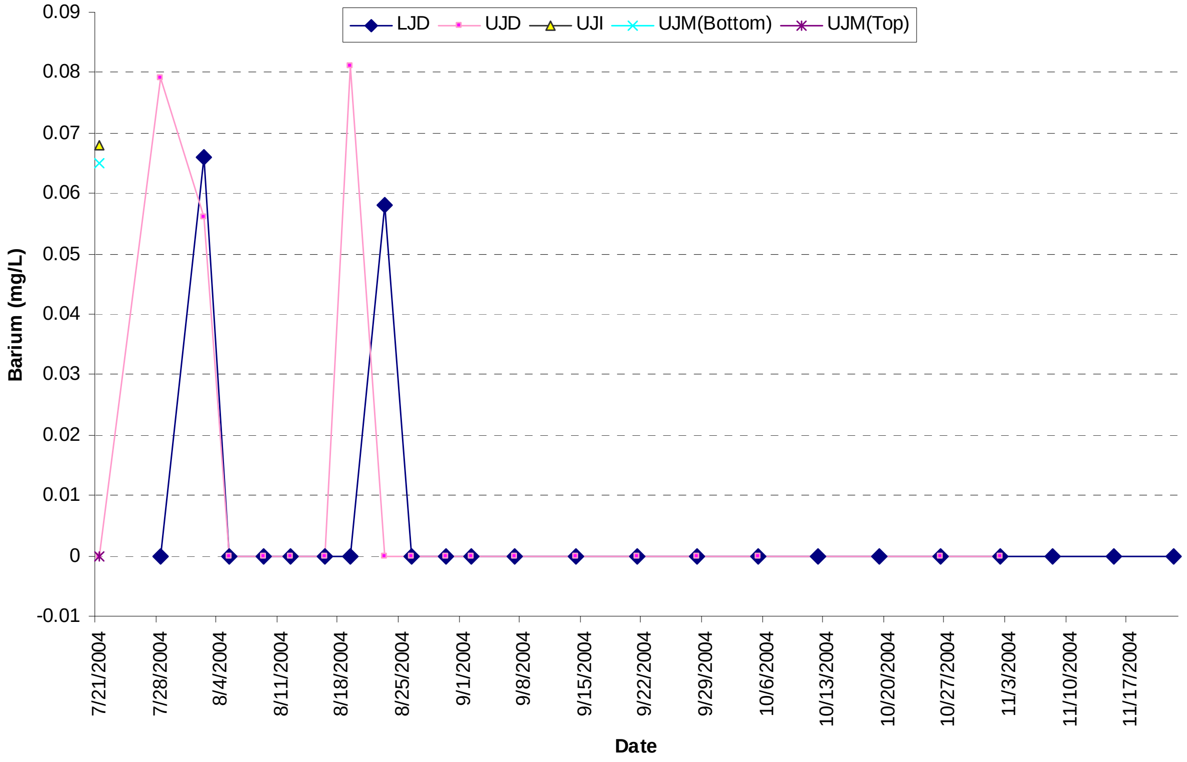


Figure 3.6.9 Chromium at Jones Tract (Bryte Lab), July to Nov 2004

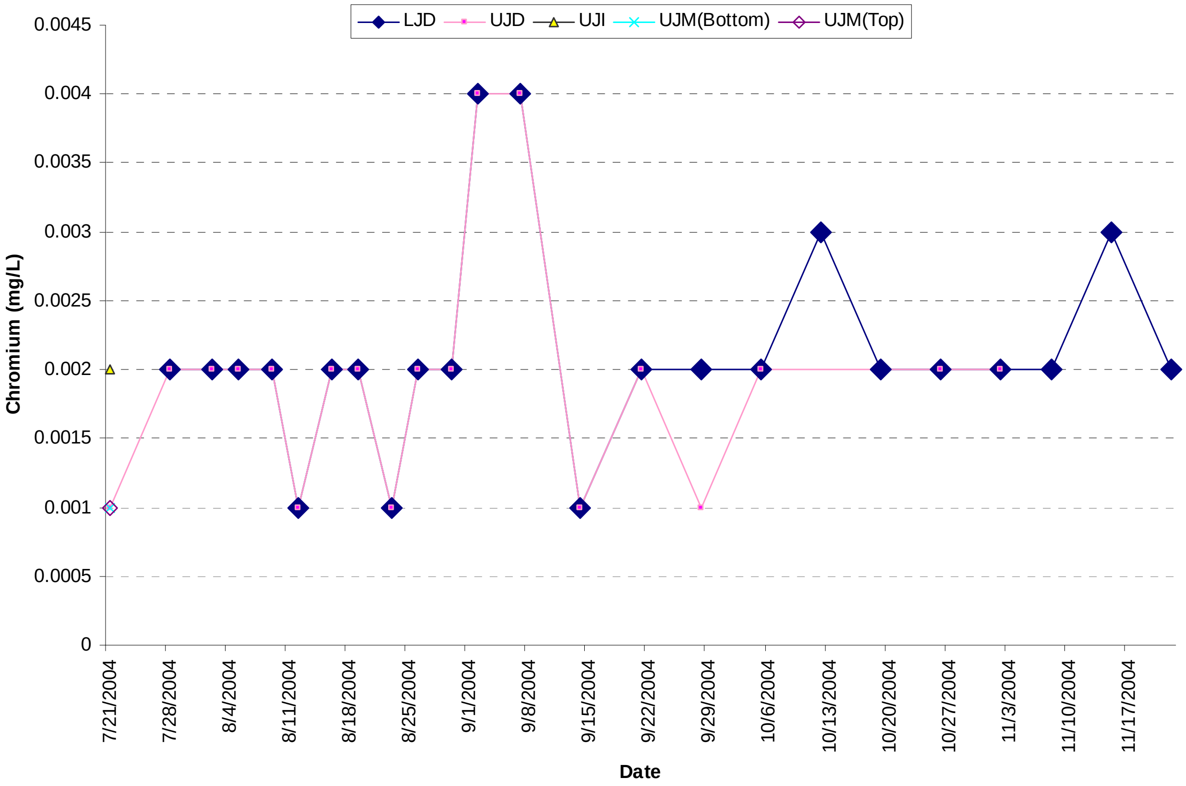


Figure 3.6.10 Copper at Jones Tract (Bryte Lab), July to Nov 2004

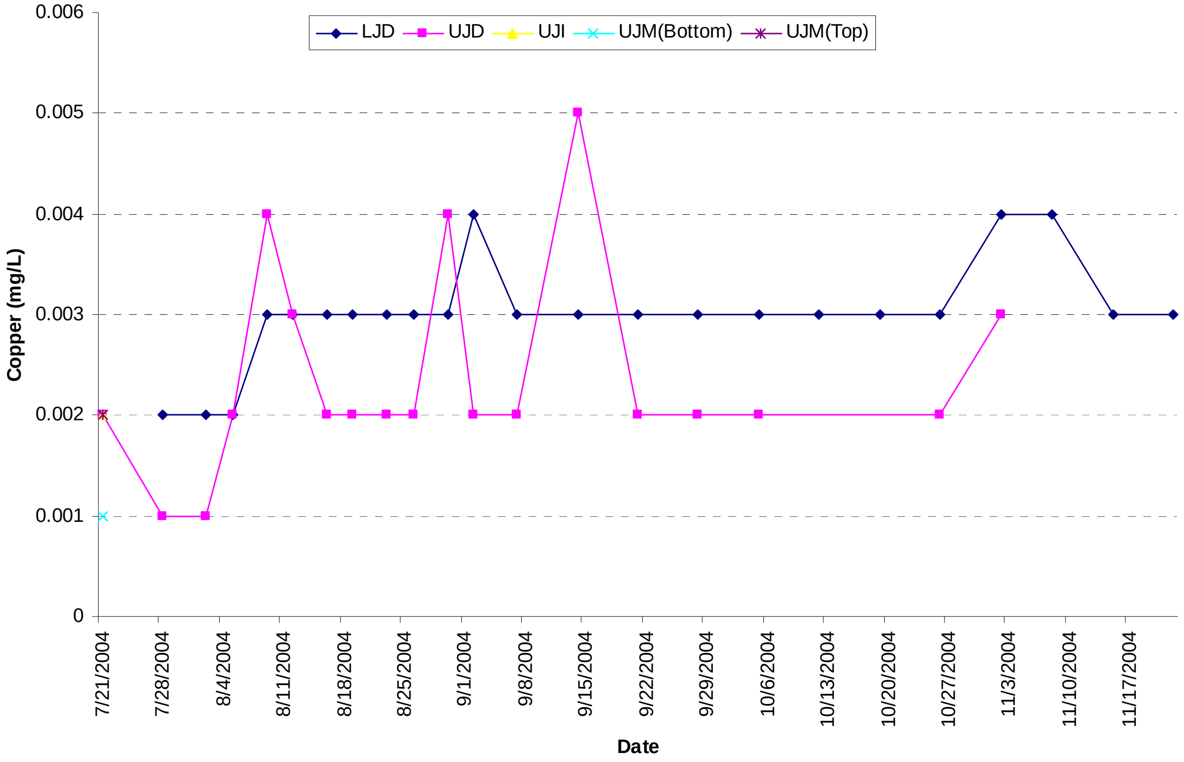


Table 3.6.1 Trace elements

Element	Monitoring period	Reporting limit	LJD	UJD	UJI	UJM (top)	UJM (bottom)
		--------mg/L--------					
Strontium*							
	7/21/2004	0.005		0.321	0.327	0.325	0.307
	7/28/2004		0.354	0.342			
Molybdunum*							
	7/21/2004	0.005		0.008	0.008	0.008	0.007
	7/28/2004		0.008	0.008			
Vanadium*							
	7/21/2004	0.005		0.005	0.006	0.006	0.005
	7/28/2004		0.005	0.005			
Cobalt*	7/21/2004	0.005		<0.005	<0.005	<0.005	<0.005
	7/28/2004		<0.005	<0.005			
Lithium*							
	7/21/2004	0.005		<0.005	<0.005	<0.005	<0.005
	7/28/2004		<0.005	<0.005			
Selenium*							
	7/21/2004	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	7/28/2004		<0.001	<0.001			
Antimony*							
	7/21/2004	0.001		<0.001	<0.001	<0.001	<0.001
	7/28/2004		<0.001	<0.001			
Mercury**							
	8/26/04 to 9/14/04	0.0002	<0.0002	<0.0002			
Lead**							
	7/21/2004	0.001		<0.001	<0.001	<0.001	<0.001
	7/28-11/22/04		<0.001				
	7/28-11/2/04			<0.001			

* Raw data collected on July 21 and 28.

** Data were collected for a longer period. All were non-detects.

Table 3.6.2a Summary of inorganic metallic constituents

		UJTL MR Site A			UJTL MR Site B			UJTL Snta Fe Cut Site C		
Constituents	MCL	Detects/ sample	Range	Median	Detects/ sample	Range	Median	Detects/ sample	Range	Median
Primary										
Arsenic	0.01	18/18	0.002-0.003	0.002	18/18	0.002-0.003	0.002	10/10	0.002-0.003	0.002
Barium	2.0 or 1.0 (DHS)	0/18	<0.005	<0.005	0/18	<0.005	<0.005	0/10	<0.005	<0.005
Chromium	0.1 or 0.05 (DHS)	10/12	0.001-0.003	0.002	10/12	0.001-0.003	0.002	9/10	0.001-0.003	0.002
Nickel	0.1 (DHS)	18/18	0.001-0.002	0.001	18/18	0.001-0.002	0.001	10/10	0.001-0.001	0.001
Secondary										
Aluminum	0.2	18/18	0.015-0.059	0.025	18/18	0.015-0.053	0.028	10/10	0.023-0.051	0.035
Copper	1.0	18/18	0.001-0.003	0.002	18/18	0.001-0.003	0.002	10/10	0.001-0.003	0.001
Iron	0.3	18/18	0.016-0.075	0.033	18/18	0.003-0.080	0.051	10/10	0.023-0.059	0.039
Manganese	0.05	18/18	0.006-0.015	0.009	18/18	0.006-0.088	0.011	10/10	0.005-0.024	0.01
Zinc	5.0	4/18	0.005-0.023	0.005	4/18	0.005-0.18	0.011	0/10	<0.005	<0.005

Table 3.6.2b Summary of inorganic metallic constituents

		LJD			UJD		
Constituents	MCL	Detects/ sample	Range	Median	Detects/ sample	Range	Median
Primary							
Arsenic	0.01	23/23	0.003-0.007	0.005	19/19	0.003-0.006	0.004
Barium	2.0 or 1.0 (DHS)	2/23	0.058-0.066	0.062	3/19	0.056-0.081	0.079
Chromium	0.1 or 0.05 (DHS)	23/23	0.001-0.004	0.002	19/19	0.001-0.004	0.002
Nickel	0.1 (DHS)	23/23	0.004-0.008	0.006	19/19	0.003-0.006	0.004
Secondary							
Aluminum	0.2	22/23	0.018-0.097	0.032	15/19	0.010-0.045	0.021
Copper	1.0	23/23	0.002-0.004	0.003	19/19	0.001-0.005	0.003
Iron	0.3	23/23	0.121-0.643	0.347	19/19	0.045-0.289	0.137
Manganese	0.05	22/23	0.019-0.401	0.046	19/19	0.007-0.094	0.052
Zinc	5.0	4/24	0.006-0.334	0.011	4/19	0.006-0.014	0.013

Chapter 3 Results and Discussion

3.7 Pesticides

3.8 Organic Compounds

Figures

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Figure 3.7.1a Metolachlor (herbicide) at Jones Tract (Bryte Lab), June–Nov 2004

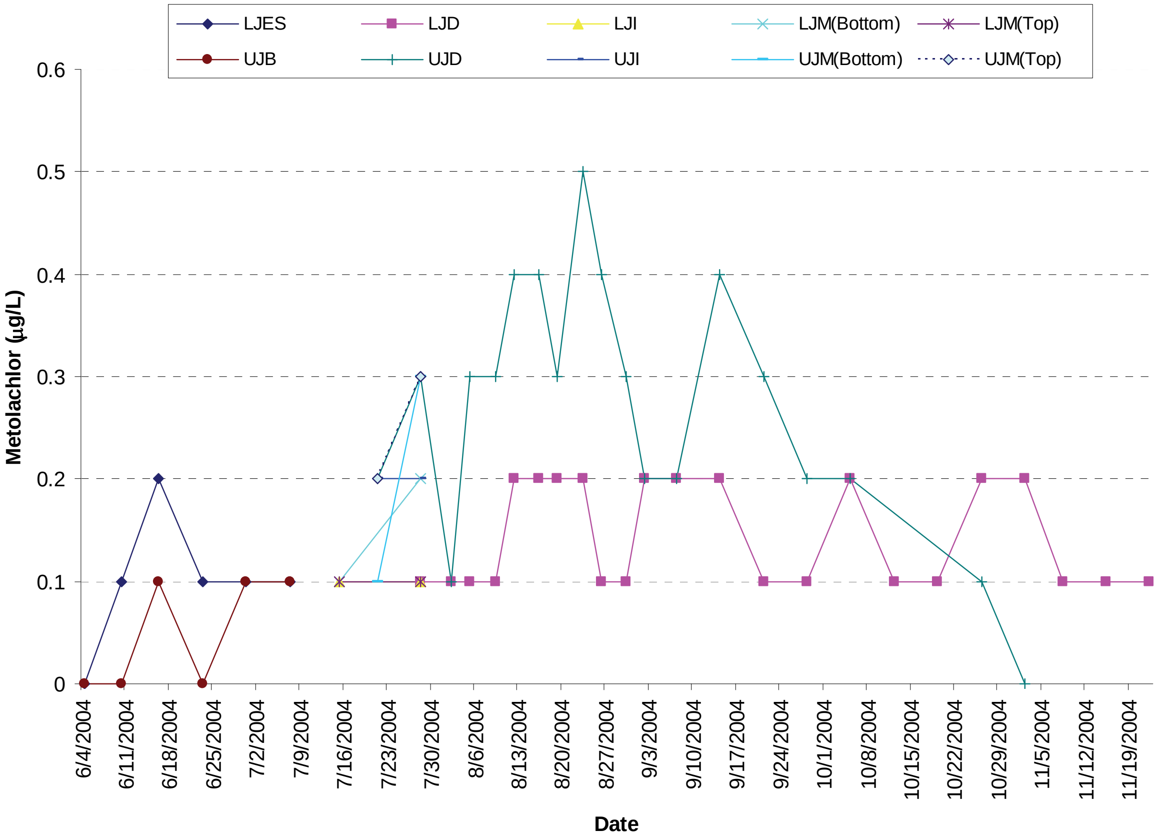


Figure 3.7.1b Average metolachlor (herbicide) at Jones Tract (Bryte Lab), June–Nov 2004

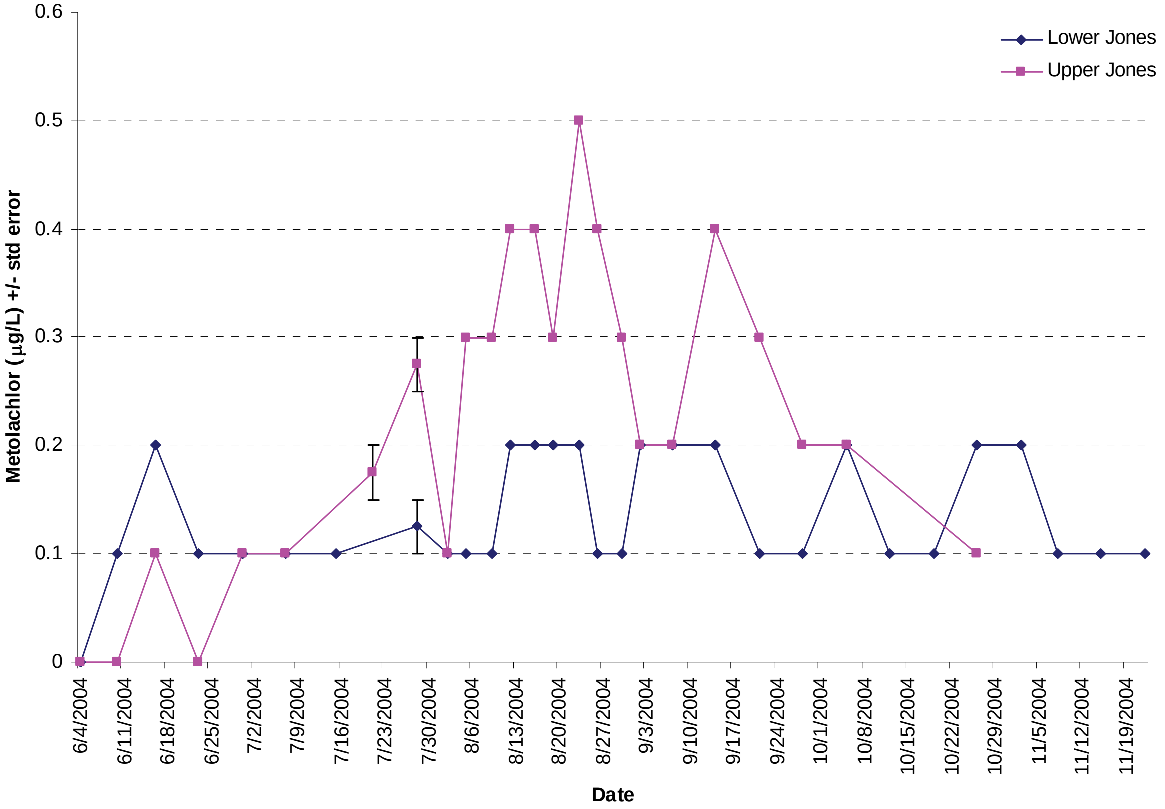


Figure 3.7.2 Diazinon (pesticide) at Jones Tract, June–Sep 2004

Nondetects are graphed as zeros

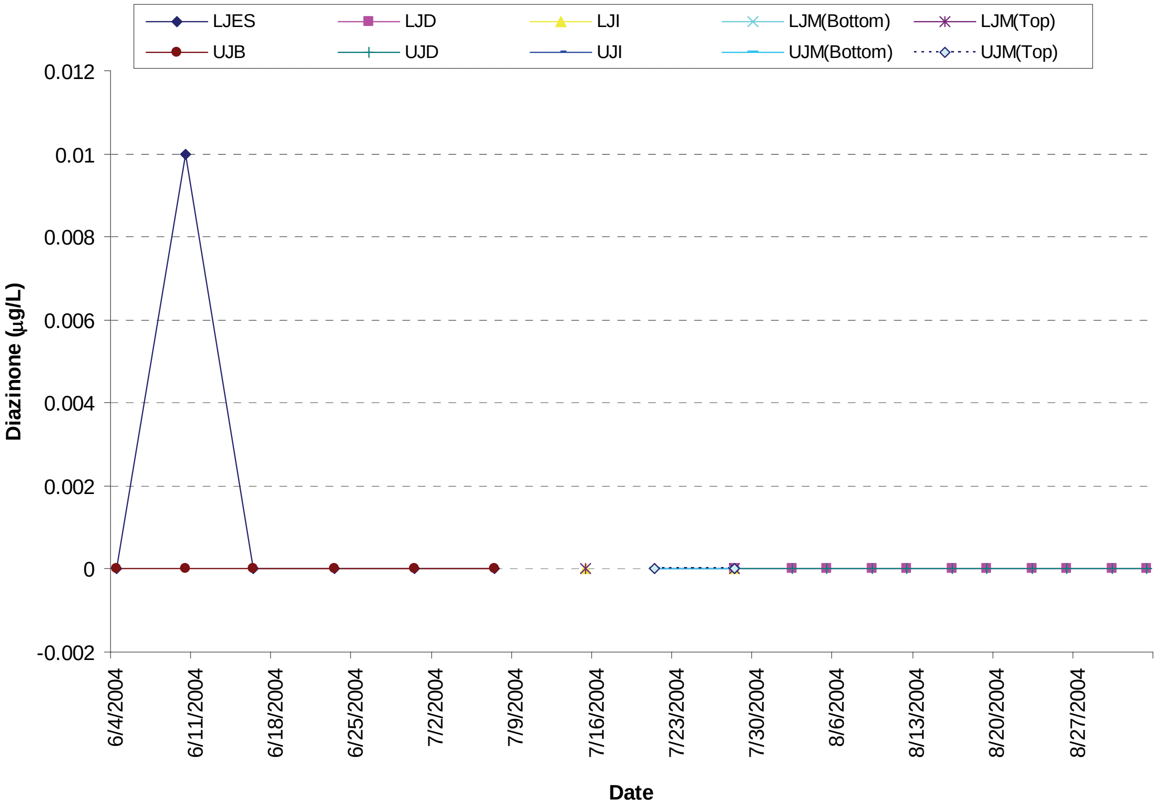


Figure 3.7.3 Molinate (pesticide) in Jones Tract (Bryte Lab), June–Sep 2004

Nondetects graphed as zeros

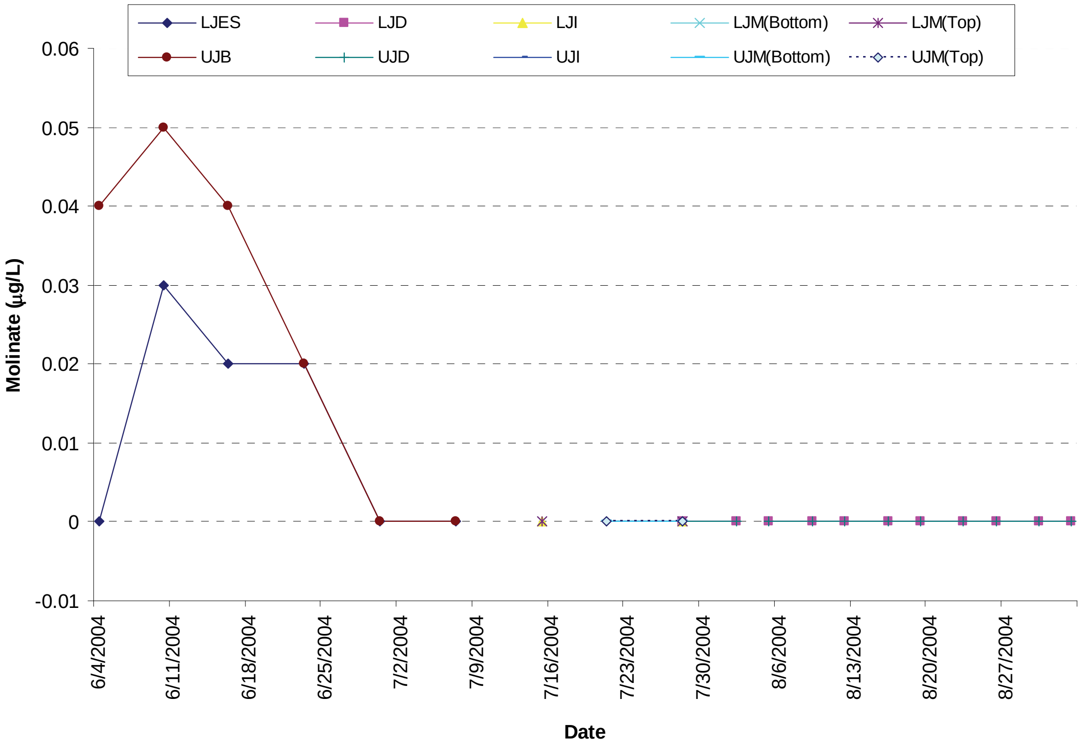


Figure 3.7.4a Atrazine in the Jones Tract (Bryte Lab), June–Nov 2004

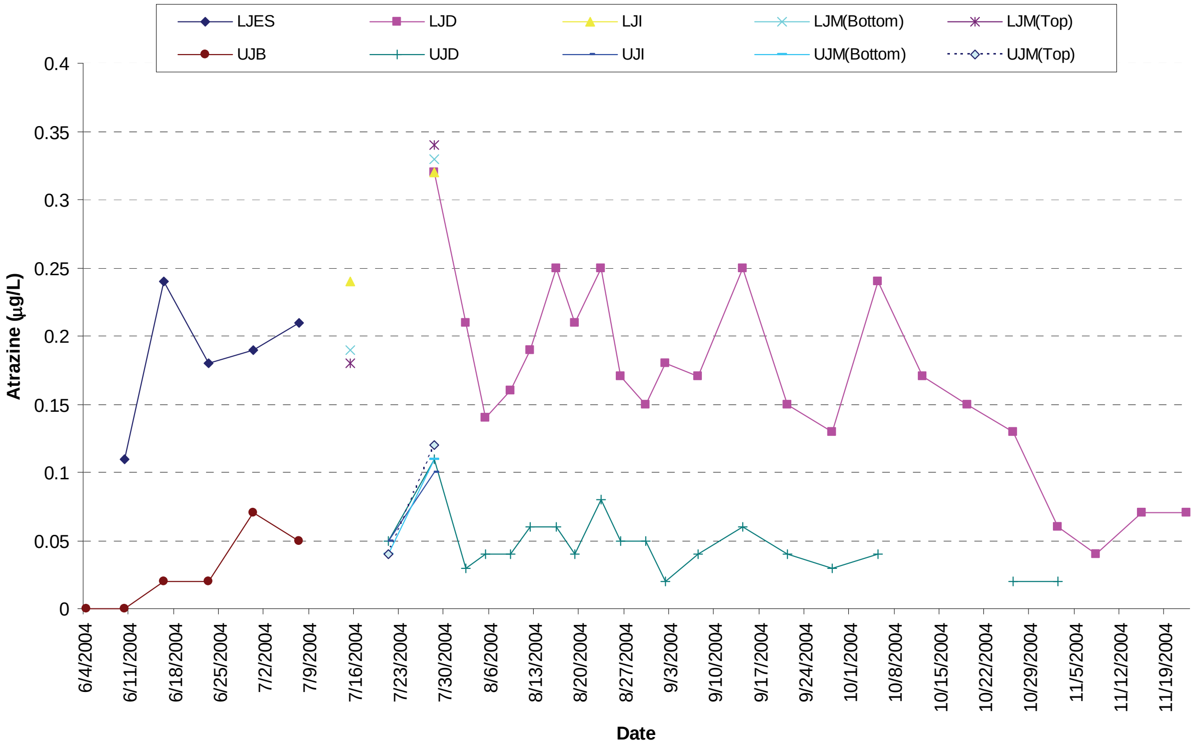


Figure 3.7.4b Average Atrazine in Jones Tract (Bryte Lab), June–Nov 2004

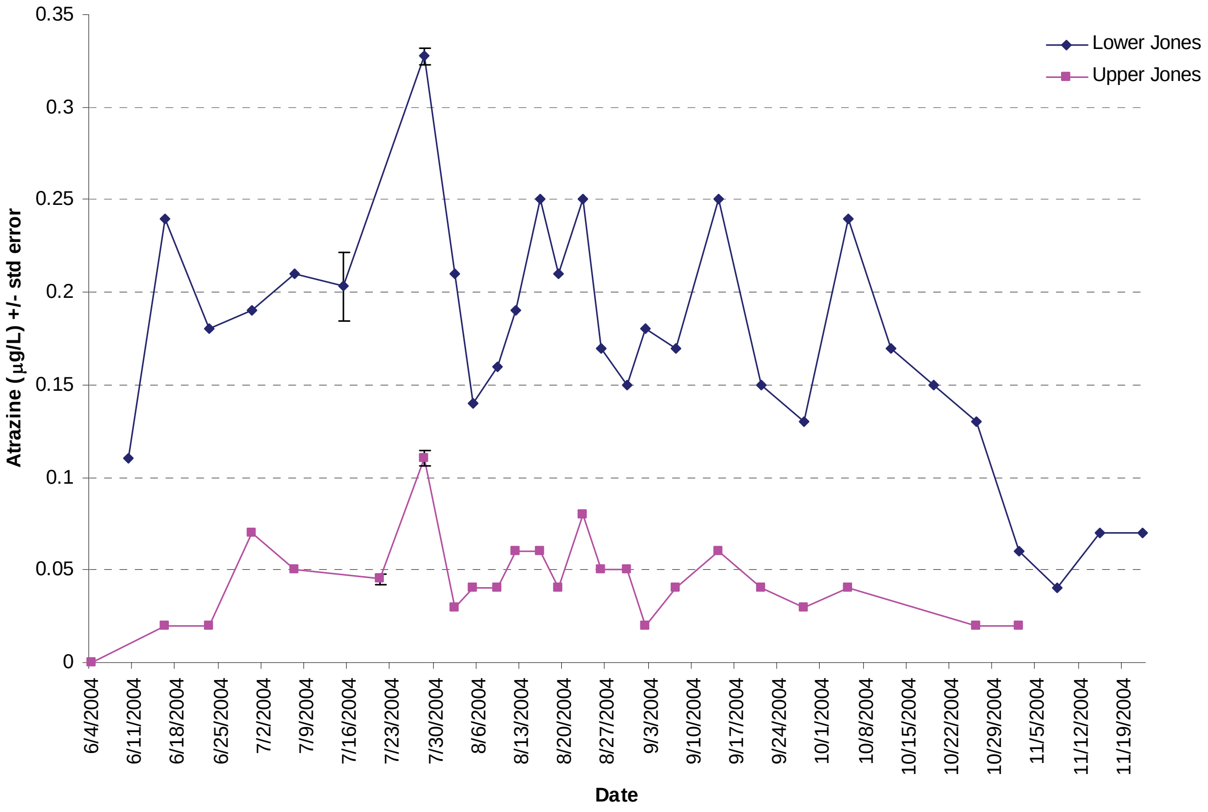


Figure 3.7.5a Diuron (herbicide) at Jones Tract (Bryte Lab), June–Nov 2004

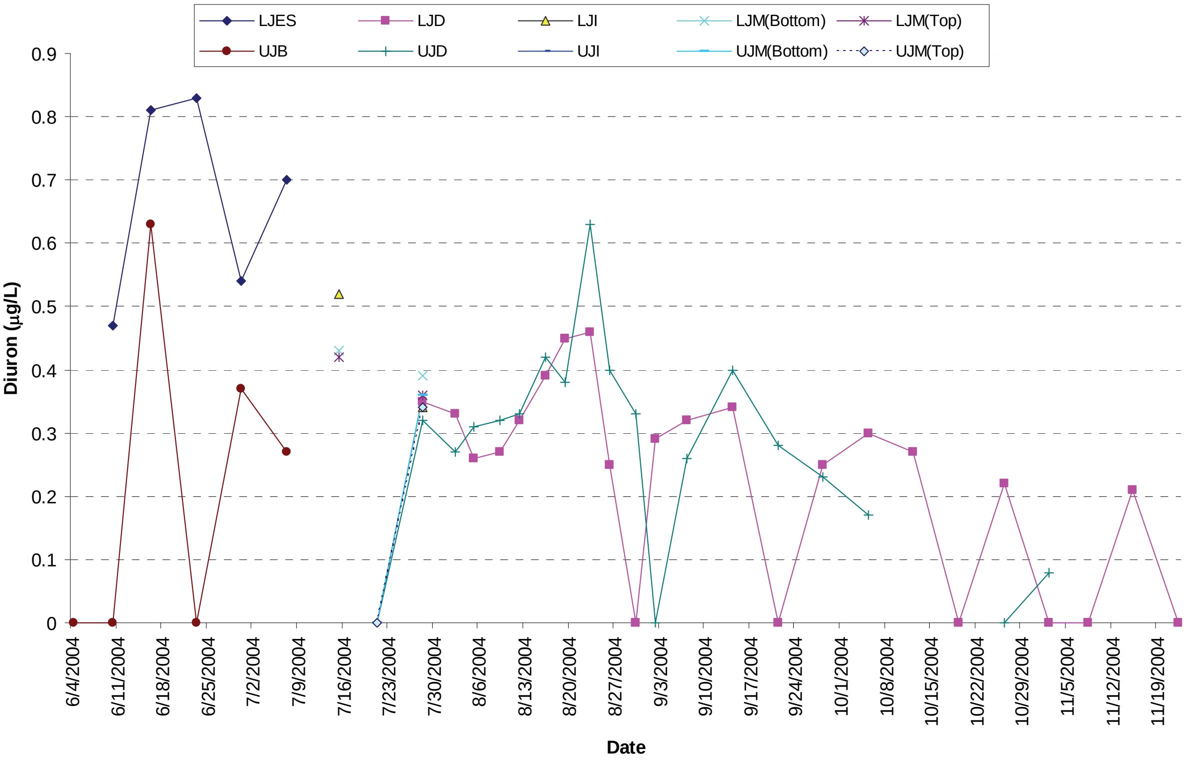


Figure 3.7.5b Average diuron (herbicide) at Jones Tract (Bryte Lab), June–Nov 2004

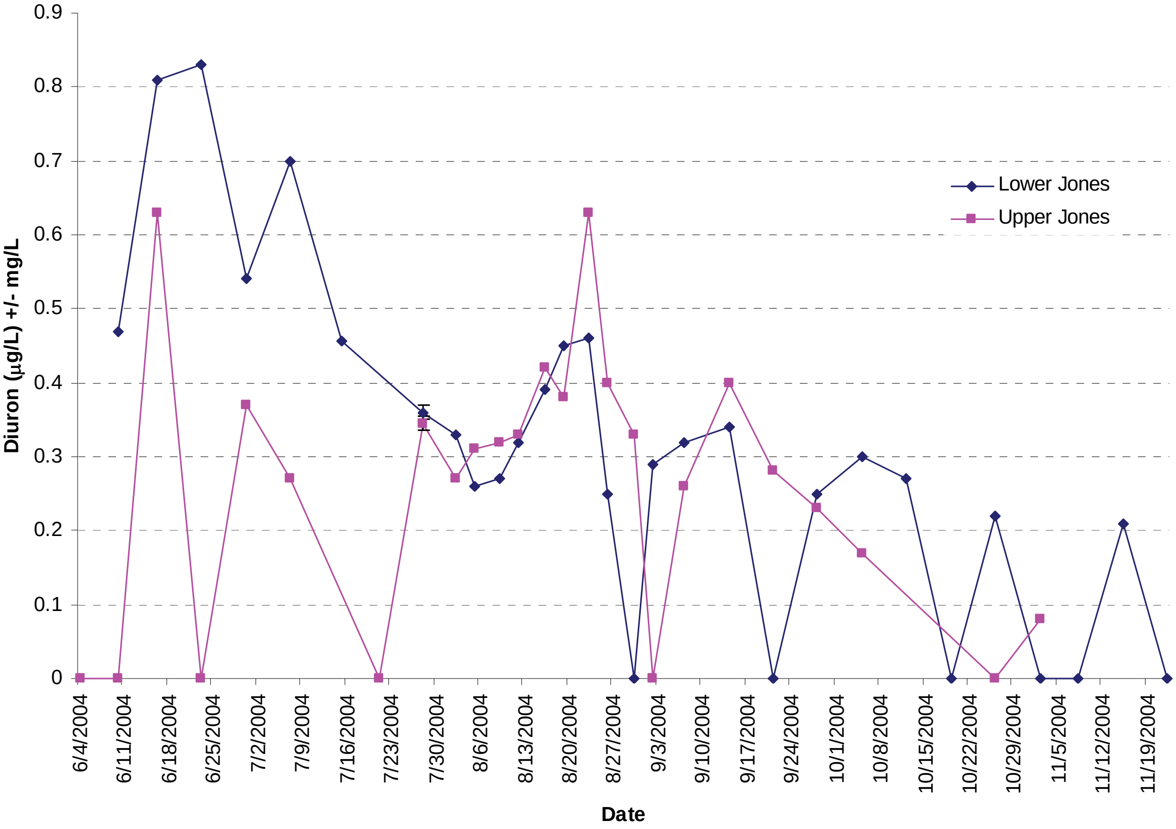


Figure 3.7.6 Simazine (pesticide) at Jones Tract (Bryte Lab), June–Nov 2004

Nondetectables are graphed as zeros

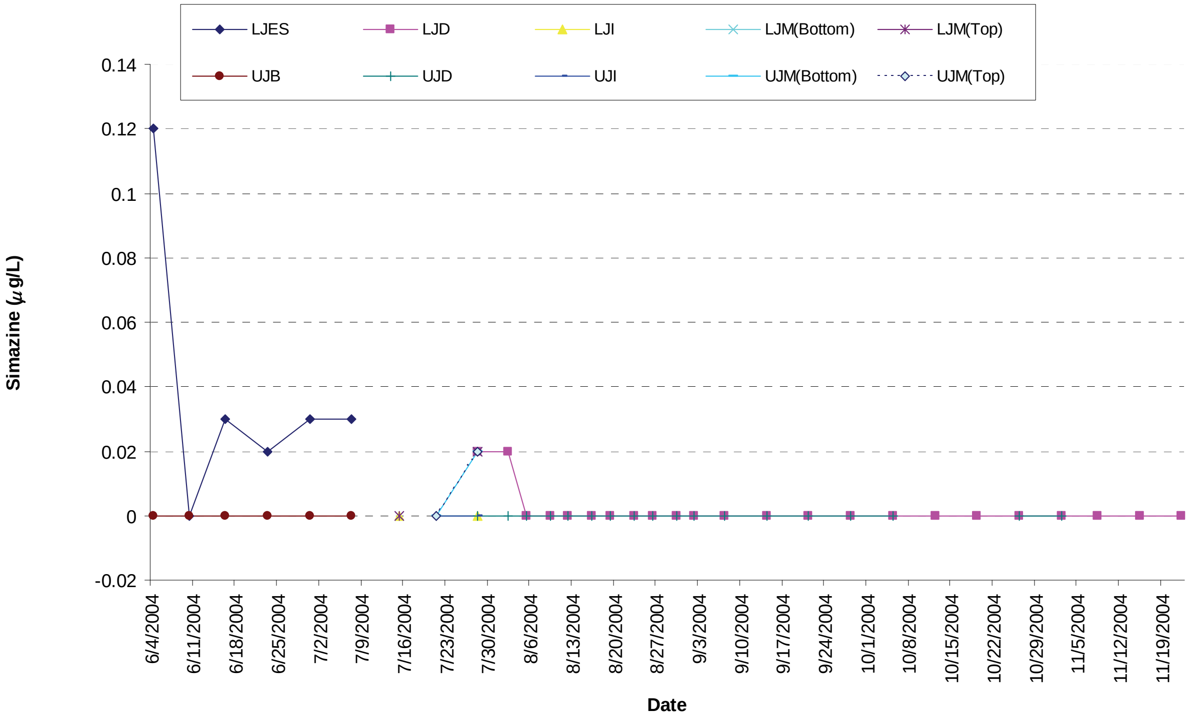


Figure 3.7.7 Trifluralin (pesticide) in Jones Tract (Bryte Lab), June–Sep 2004

nondetectables are graphed as zeros

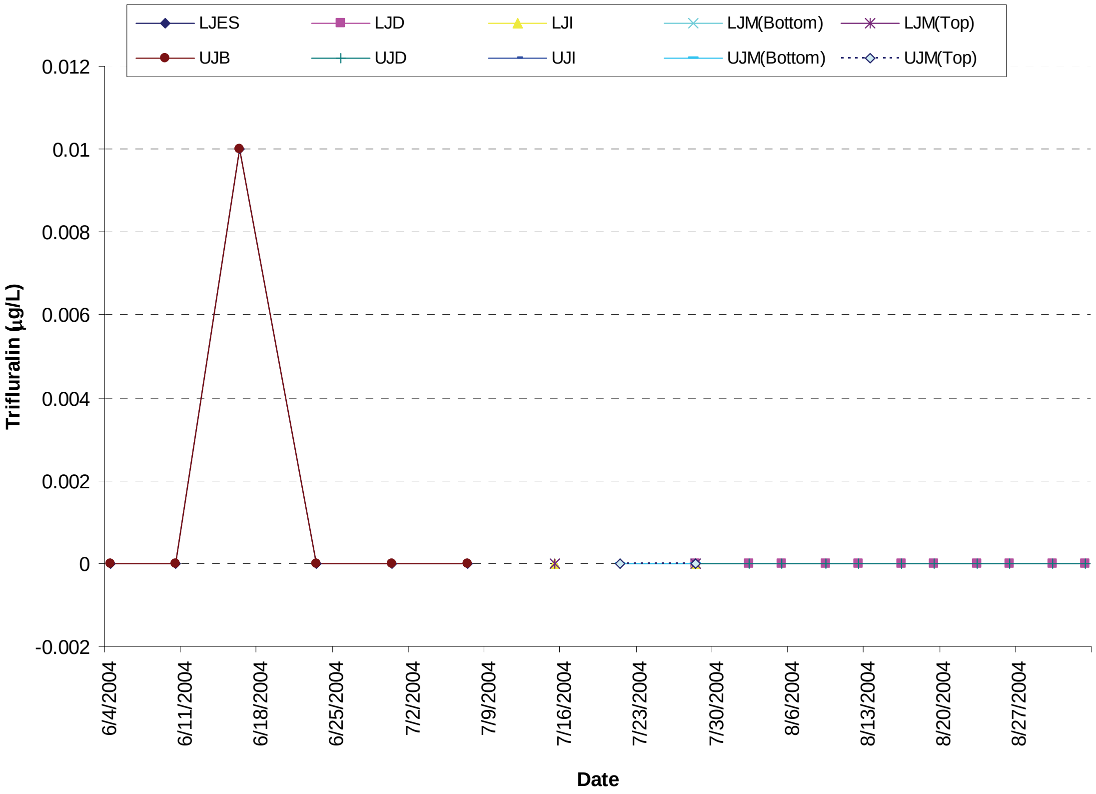


Figure 3.8.1a Diesel range organics at Jones Tract (Contract Lab), June–Sep 2004

Nondetects are graphed as zeros

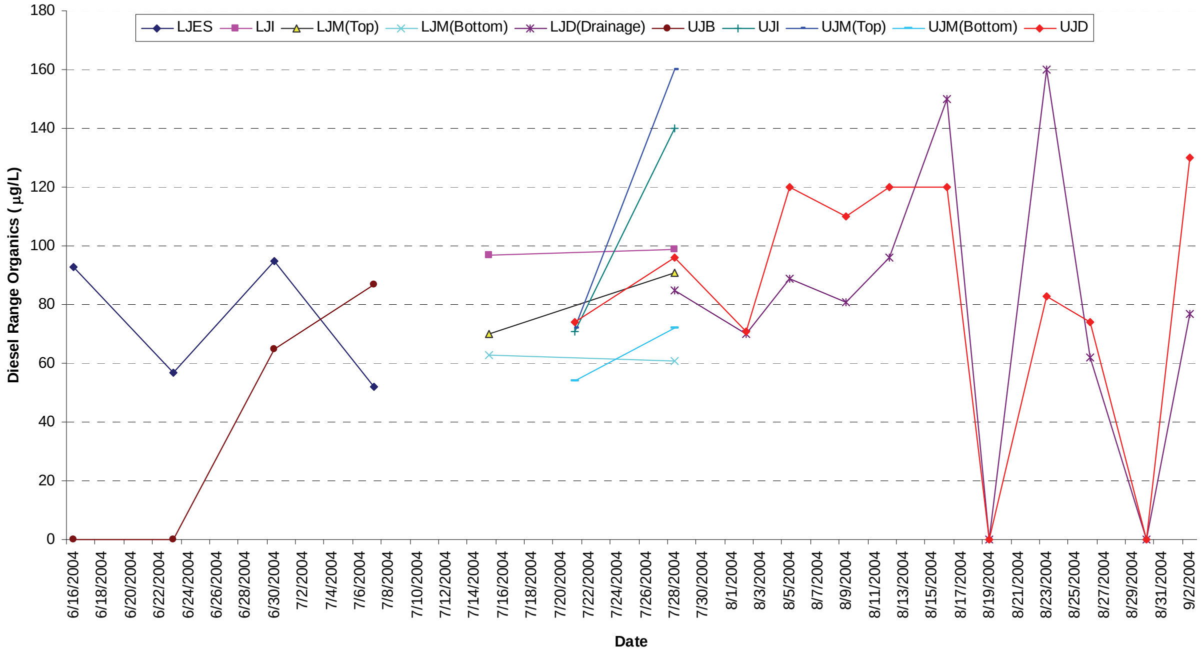


Figure 3.8.1b Average diesel range organics at Jones Tract (Contract Lab), July 28–Sep 2, 2004

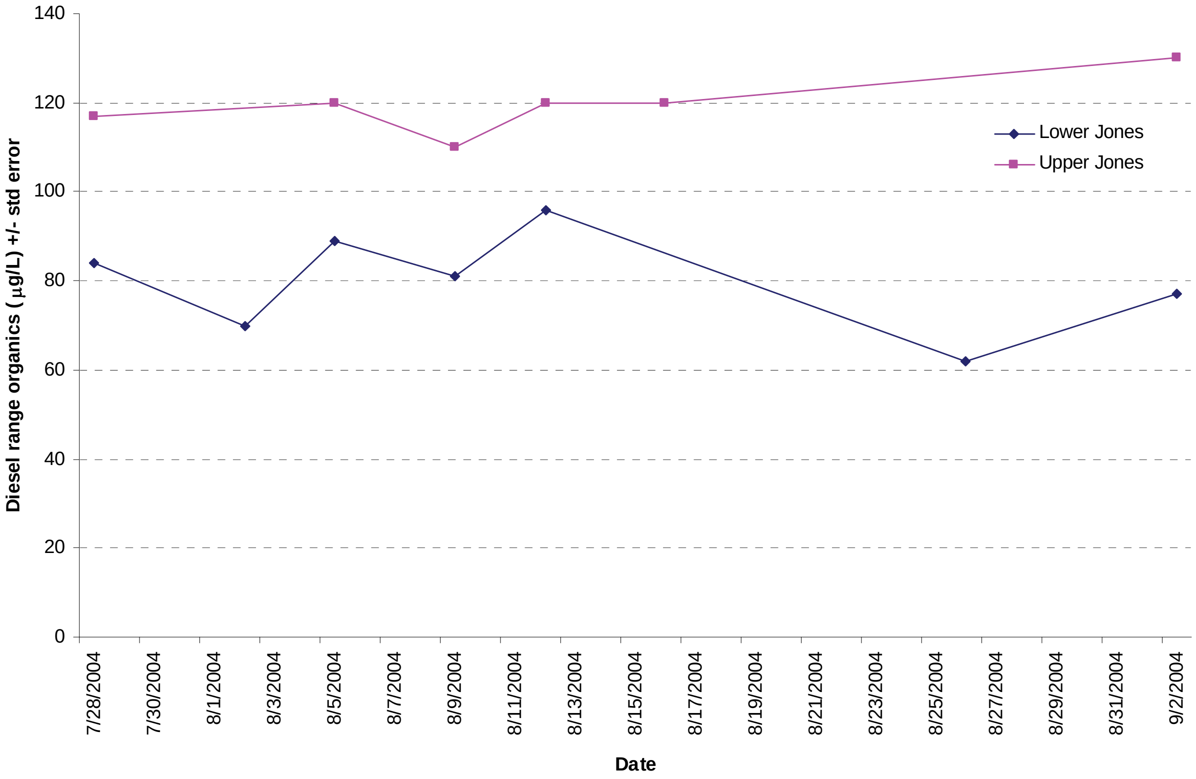


Table 3.7.1 Metolachlor pesticide concentrations

	Average ± std. dev Lower Jones	Average ± std. dev Upper Jones	Metolachlor MR
6/4/2004	0	0	
6/10/2004	0.1	0	< 0.05
6/16/2004	0.2	0.1	< 0.05
6/23/2004	0.1	0	< 0.05
6/30/2004	0.1	0.1	< 0.05
7/7/2004	0.1	0.1	< 0.05
7/15/2004	0.1		
7/21/2004		0.175 ± 0.05	
7/28/2004	0.125 ± 0.05	0.275 ± 0.05	
8/2/2004	0.1	0.1	
8/3/2004			
8/5/2004	0.1	0.3	
8/9/2004	0.1	0.3	
8/12/2004	0.2	0.4	
8/16/2004	0.2	0.4	
8/19/2004	0.2	0.3	
8/23/2004	0.2	0.5	
8/26/2004	0.1	0.4	
8/30/2004	0.1	0.3	
9/2/2004	0.2	0.2	
9/7/2004	0.2	0.2	
9/9/2004			
9/14/2004	0.2	0.4	
9/15/2004			
9/21/2004	0.1	0.3	
9/28/2004	0.1	0.2	
10/5/2004	0.2	0.2	
10/12/2004	0.1		
10/19/2004	0.1		
10/26/2004	0.2	0.1	
11/2/2004	0.2		
11/8/2004	0.1		
11/15/2004	0.1		
11/22/2004	0.1		

Table 3.7.2 Diazinon concentrations

N.D. indicates not detected

	Average Lower Jones	Average Upper Jones	MR
6/4/2004	N.D.	N.D.	
6/10/2004	0.01	N.D.	N.D.
6/16/2004	N.D.	N.D.	N.D.
6/23/2004	N.D.	N.D.	N.D.
6/30/2004	N.D.	N.D.	N.D.
7/7/2004	N.D.	N.D.	N.D.
7/15/2004	N.D.		
7/21/2004		N.D.	
7/28/2004	N.D.	N.D.	
8/2/2004	N.D.	N.D.	
8/5/2004	N.D.	N.D.	
8/9/2004	N.D.	N.D.	
8/12/2004	N.D.	N.D.	
8/16/2004	N.D.	N.D.	
8/19/2004	N.D.	N.D.	
8/23/2004	N.D.	N.D.	
8/26/2004	N.D.	N.D.	
8/30/2004	N.D.	N.D.	
9/2/2004	N.D.	N.D.	

Table 3.7.3 Molinate concentrations at Jones Tract

	Average Lower Jones	Average Upper Jones	Molinate MR
6/4/2004	0	0.04	
6/10/2004	0.03	0.05	0.05
6/16/2004	0.02	0.04	0.04
6/23/2004	0.02	0.02	0.03
6/30/2004	< 0.02	< 0.02	0.02
7/7/2004	< 0.02	< 0.02	< 0.02
7/15/2004	< 0.02		
7/21/2004		< 0.02	
7/28/2004	< 0.02	< 0.02	
8/2/2004	< 0.02	< 0.02	
8/3/2004			
8/5/2004	< 0.02	< 0.02	
8/9/2004	< 0.02	< 0.02	
8/12/2004	< 0.02	< 0.02	
8/16/2004	< 0.02	< 0.02	
8/19/2004	< 0.02	< 0.02	
8/23/2004	< 0.02	< 0.02	
8/26/2004	< 0.02	< 0.02	
8/30/2004	< 0.02	< 0.02	
9/2/2004	< 0.02	< 0.02	

Chapter 3 Results and Discussion

3.9 Bacteria

Table

Table 3.9.1 Total coliforms at Jones Tract by multiple tube fermentation technique (MPN/100ml)

Date sampled	Middle River	Upper Jones (bottom)	Lower Jones East Side	Upper Jones Discharge	Low Jones Discharge
6/16/2004	220	2800	16000		
6/23/2004	110	230	20		
6/30/2004	300	500	170		
7/28/2004				240	80
8/9/2004				>1600	240
8/12/2004					
8/16/2004					
8/23/2004				1600	1600

Table 3.9.2 Fecal coliforms at Jones Tract by multiple tube fermentation technique (MPN/100ml)

Date sampled	Middle River	Upper Jones (bottom)	Lower Jones East Side	Upper Jones Discharge	Low Jones Discharge
6/16/2004	20	1700	5000		
6/23/2004	20	20	20		
6/30/2004	130	20	40		
7/28/2004				8	8
8/9/2004				>1600	<2
8/16/2004					
8/23/2004				4	8

Table 3.9.3 *E. coli* at Jones Tract by multiple tube fermentation technique (MPN/100ml)

Date sampled	Middle River	Upper Jones (bottom)	Lower Jones East Side
6/16/2004	20	1100	9000
6/23/2004	20	ND	ND
6/30/2004	40	20	40

Table 3.9.4 Total coliforms at Jones Tract by membrane filter technique CFU/100ml

Date Sampled	Middle River	Upper Jones (bottom)	Lower Jones East Side
6/16/2004	4000	40000	33000
6/23/2004	880	3350	ND
6/30/2004	6750	2530	2620

Table 3.9.5 Fecal coliforms at Jones Tract by membrane filter technique (CFU/100ml)

Date Sampled	Middle River	Upper Jones (bottom)	Lower Jones East Side
6/16/2004	4000	36000	29700
6/23/2004	ND	1340	ND
6/30/2004	5400	ND	1750

Table 3.9.6 *E. coli* at Jones Tract by membrane filter technique (CFU/100ml)

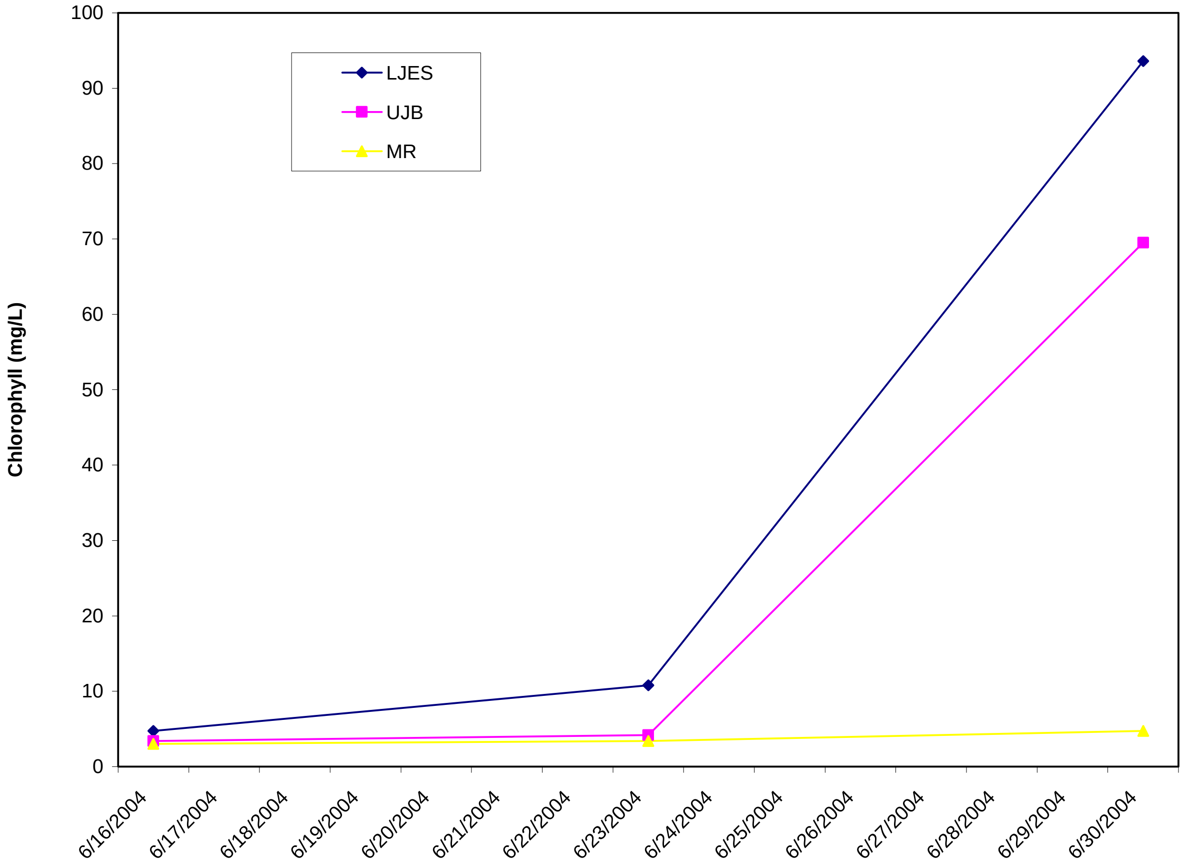
Date Sampled	Middle River	Upper Jones (bottom)	Lower Jones East Side
6/16/2004	2860	28000	23100
6/23/2004	ND	ND	ND
6/30/2004	5400	ND	ND

Chapter 3 Results and Discussion

3.10 Chlorophyll and Pheophytin

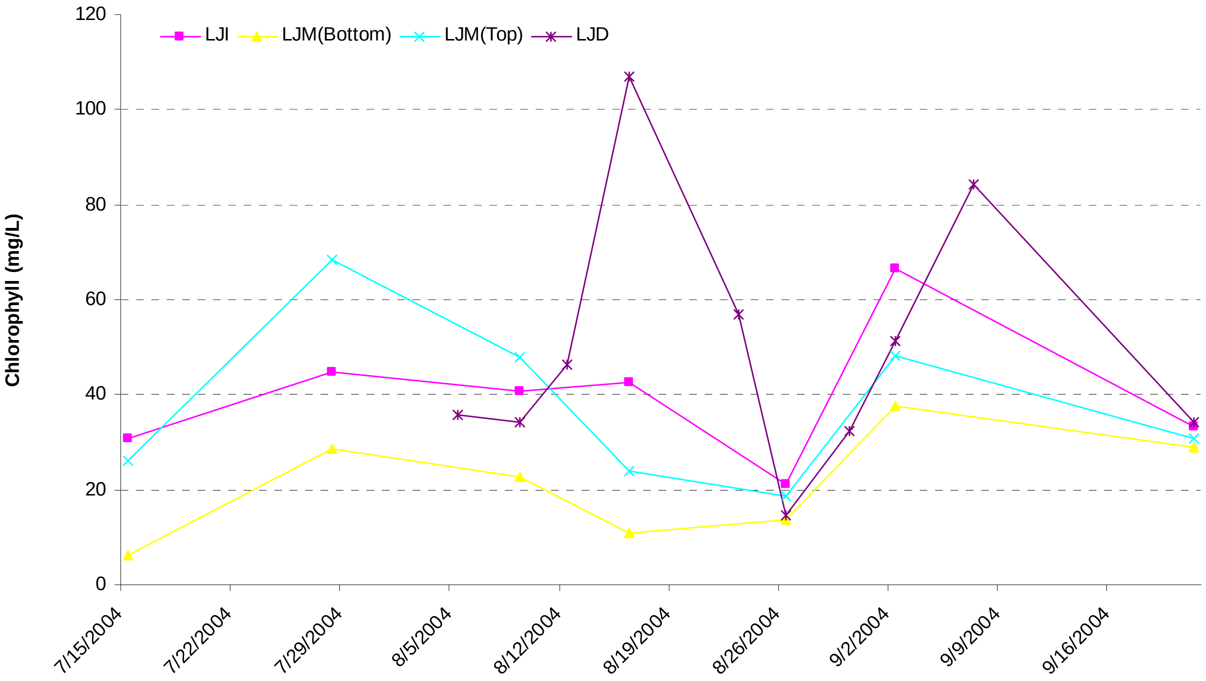
Figures

Figure 3.10.1 Chlorophyll concentration at Lower Jones East Side, Upper Jones (bottom), and Middle River (June 16, 23, 30, 2004)



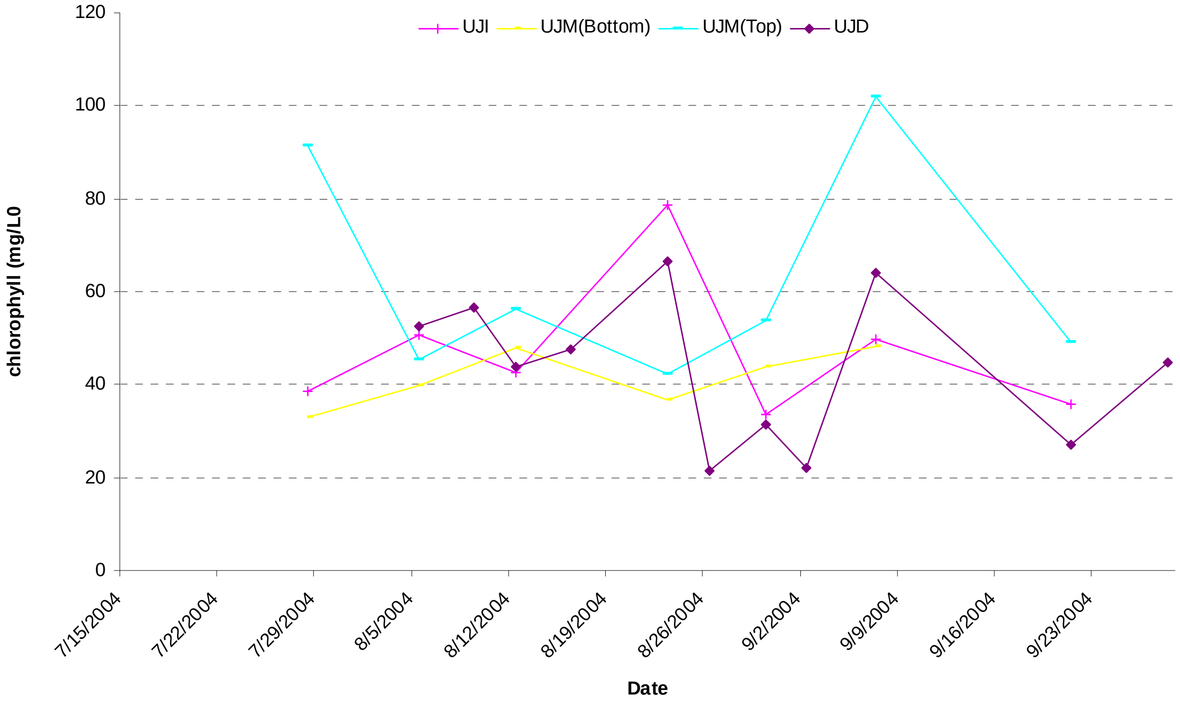
LJES = Lower Jones East Side
UJB = Upper Jones (bottom)
MR = Middle River

Figure 3.10.2 Chlorophyll concentration at Lower Jones Tract (Bryte Lab data), July–Sep 2004



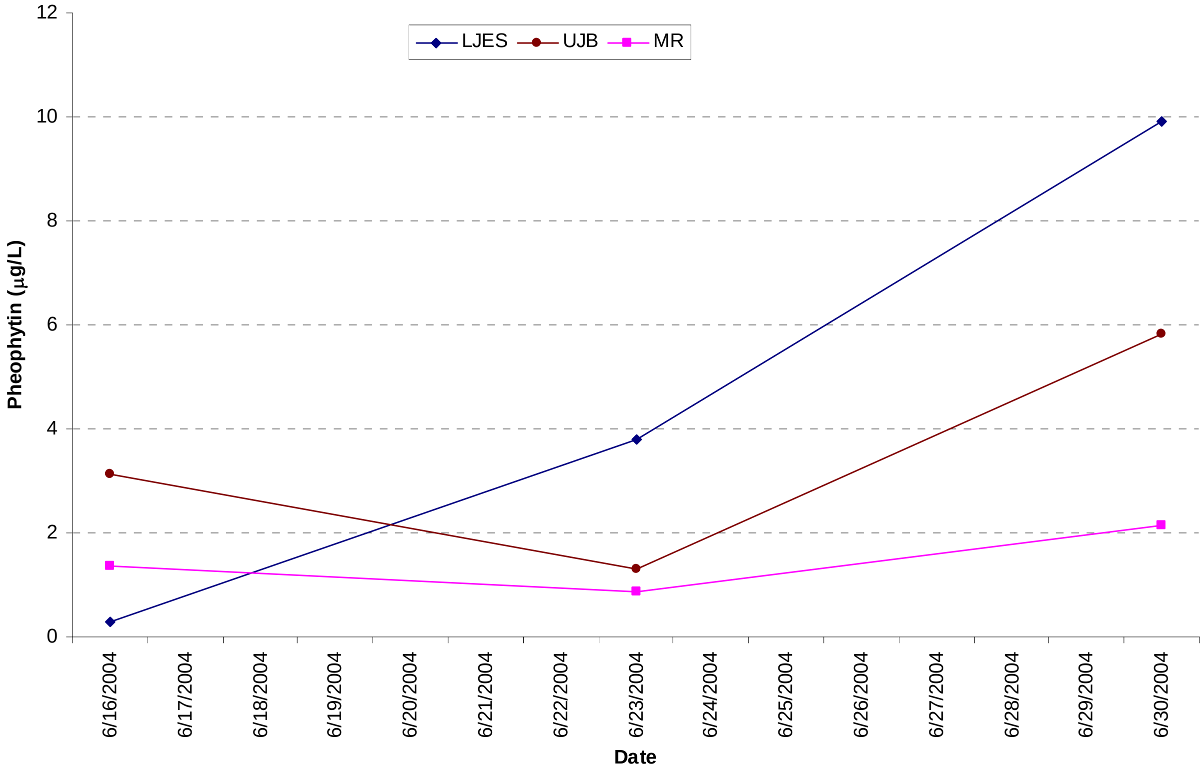
LJI = Lower Jones Intake
LJM = Lower Jones Middle
LJD = Lower Jones Discharge

Figure 3.10.3 Chlorophyll concentration at Upper Jones Tract (Bryte Lab data), July–Sep 2004



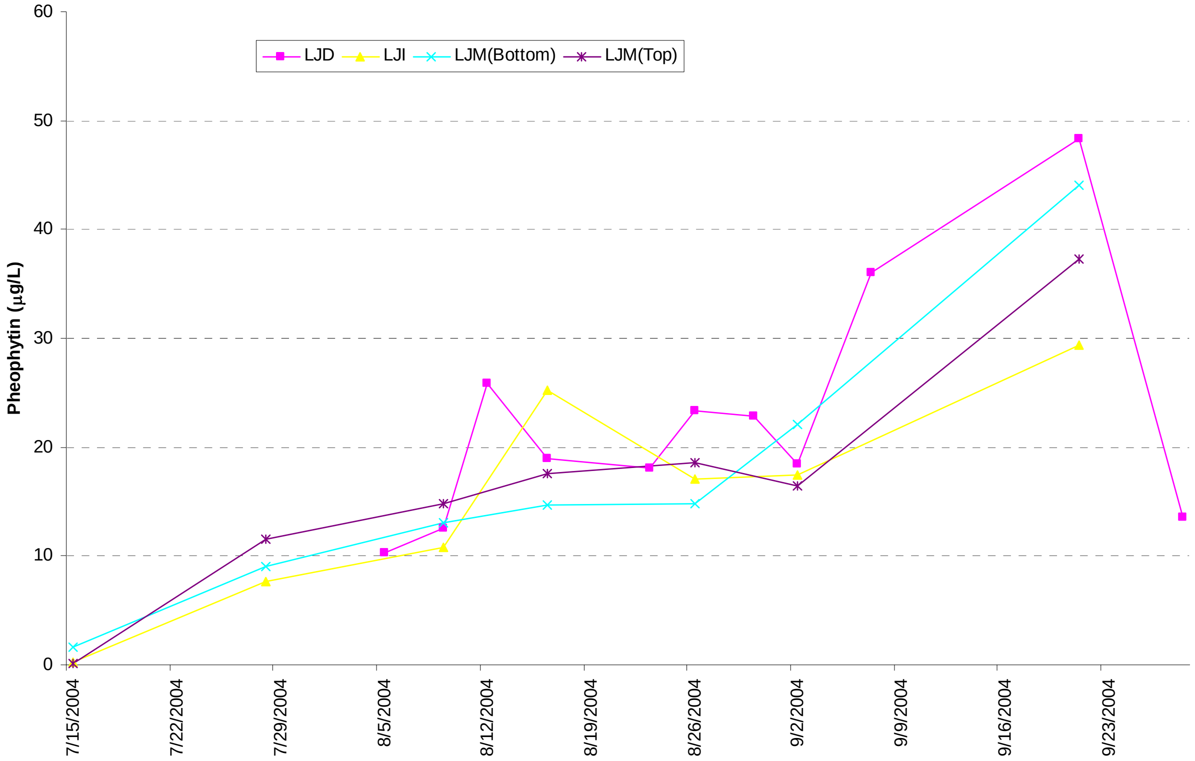
UJI = Upper Jones Intake
UJM = Upper Jones Middle
UJD = Upper Jones Discharge

Figure 3.10.4 Pheophytin concentration in Jones Tract (Bryte Lab data), June 16, 23, 30, 2004



LJES = Lower Jones East Side
UJB = Upper Jones (bottom)
MR= Middle River

Figure 3.10.5 Pheophytin concentration in Lower Jones Tract (Bryte Lab data), July–Nov 2004



LJD = Lower Jones Tract
LJI = Lower Jones Intake
LJM = Lower Jones Middle River

Figure 3.10.6 Pheophytin concentration in Upper Jones Tract (Bryte Lab data), July–Nov 2004

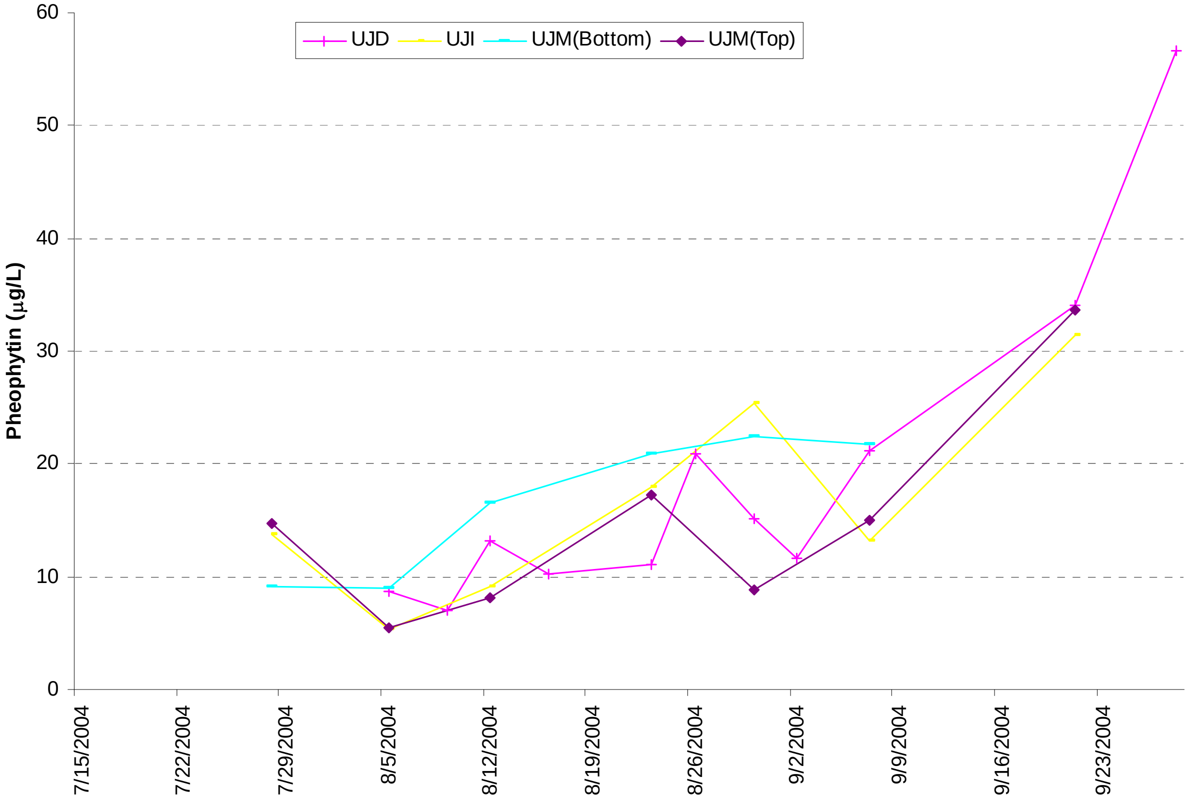


Figure 3.10.7 Average daily chlorophyll concentration at Jones Tract (July–Nov 2004)

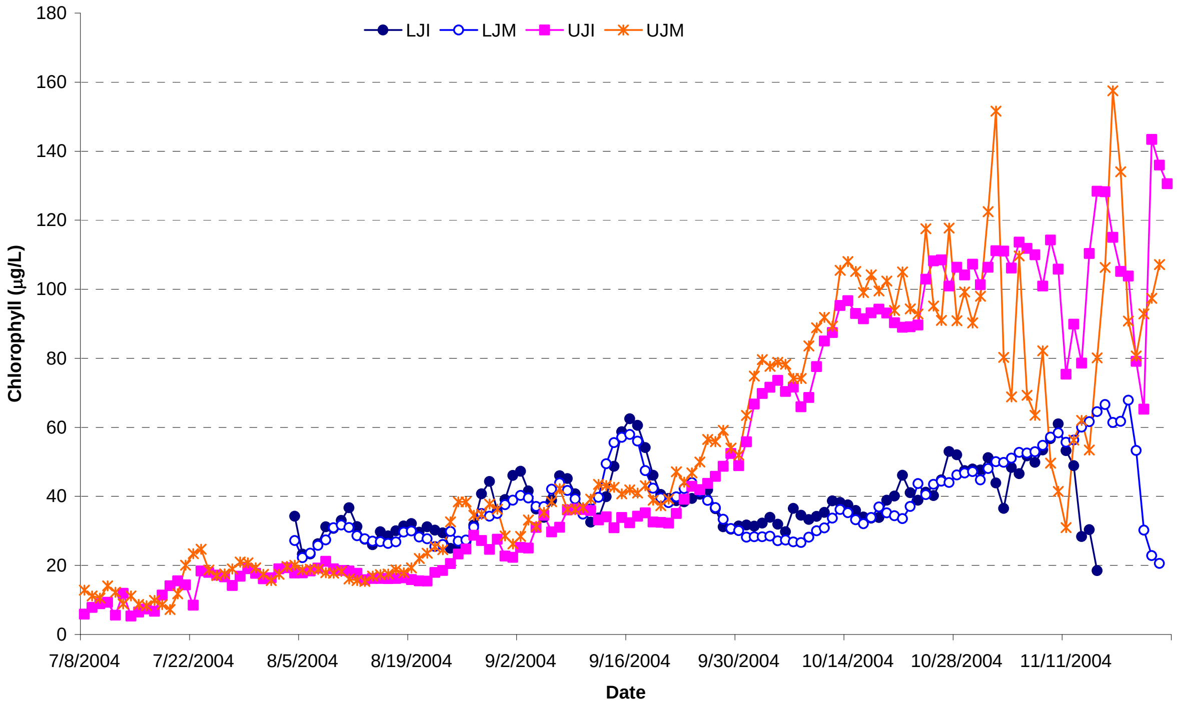


Figure 3.10.8 Chlorophyll concentration on a typical 24-hour day (Lower Jones Intake)

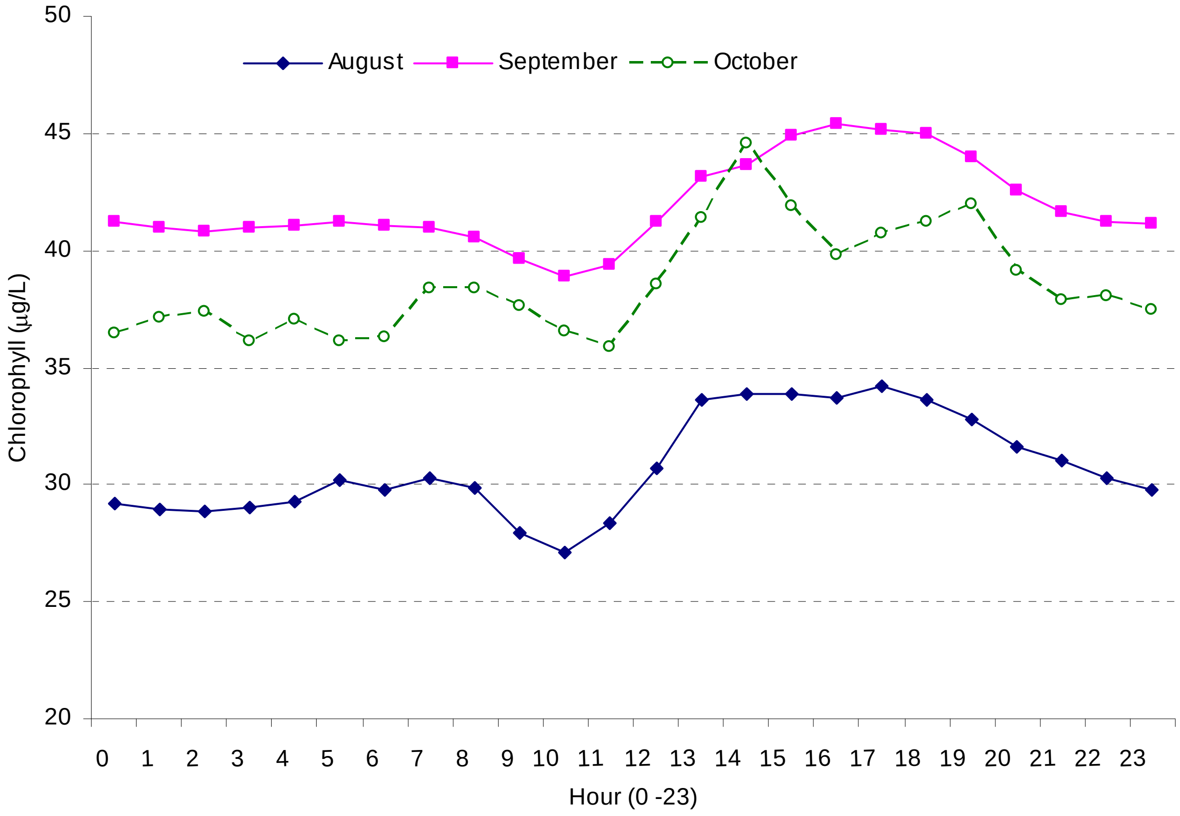


Figure 3.10.9 Chlorophyll concentration on a typical 24-hour day (Lower Jones Middle)

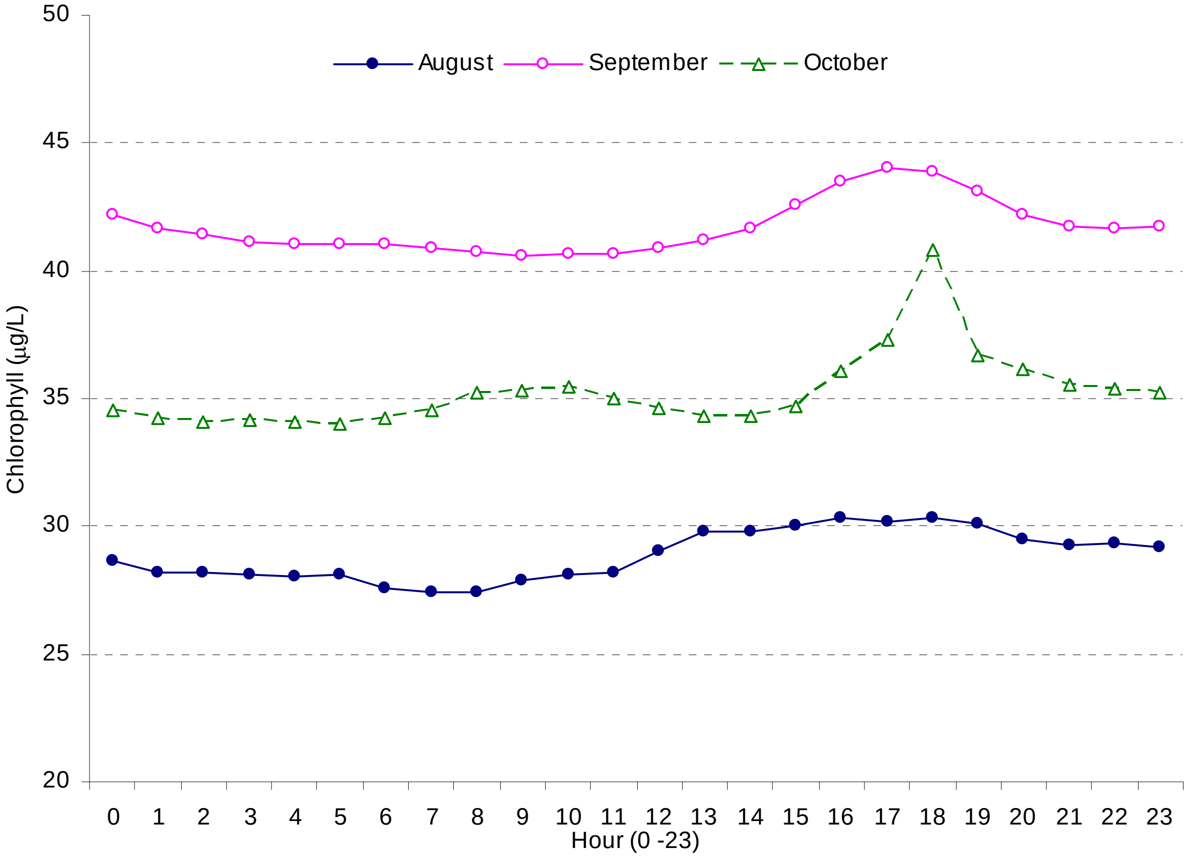


Figure 3.10.10 Chlorophyll concentration on a typical 24-hour day (Upper Jones Intake)

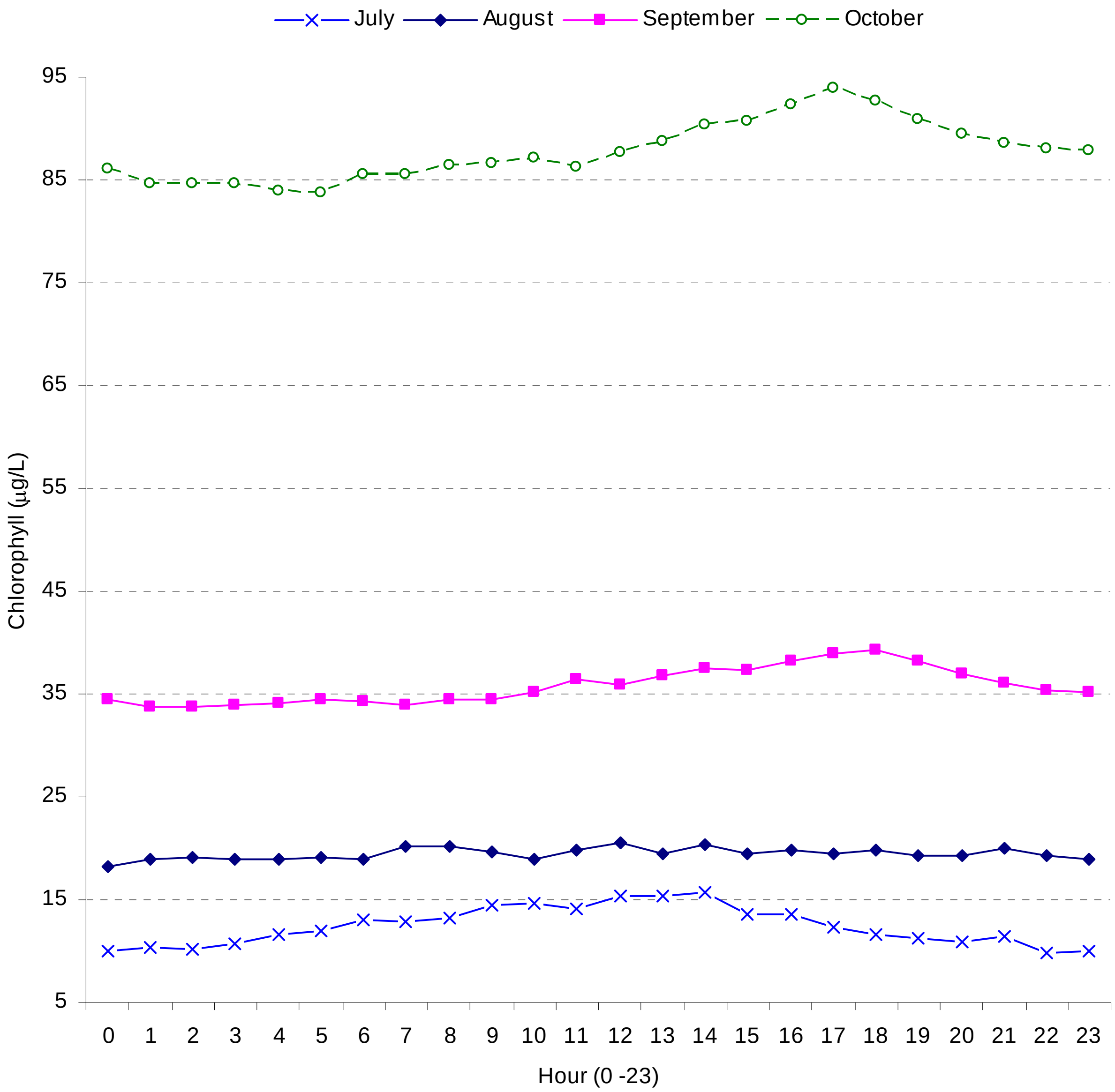
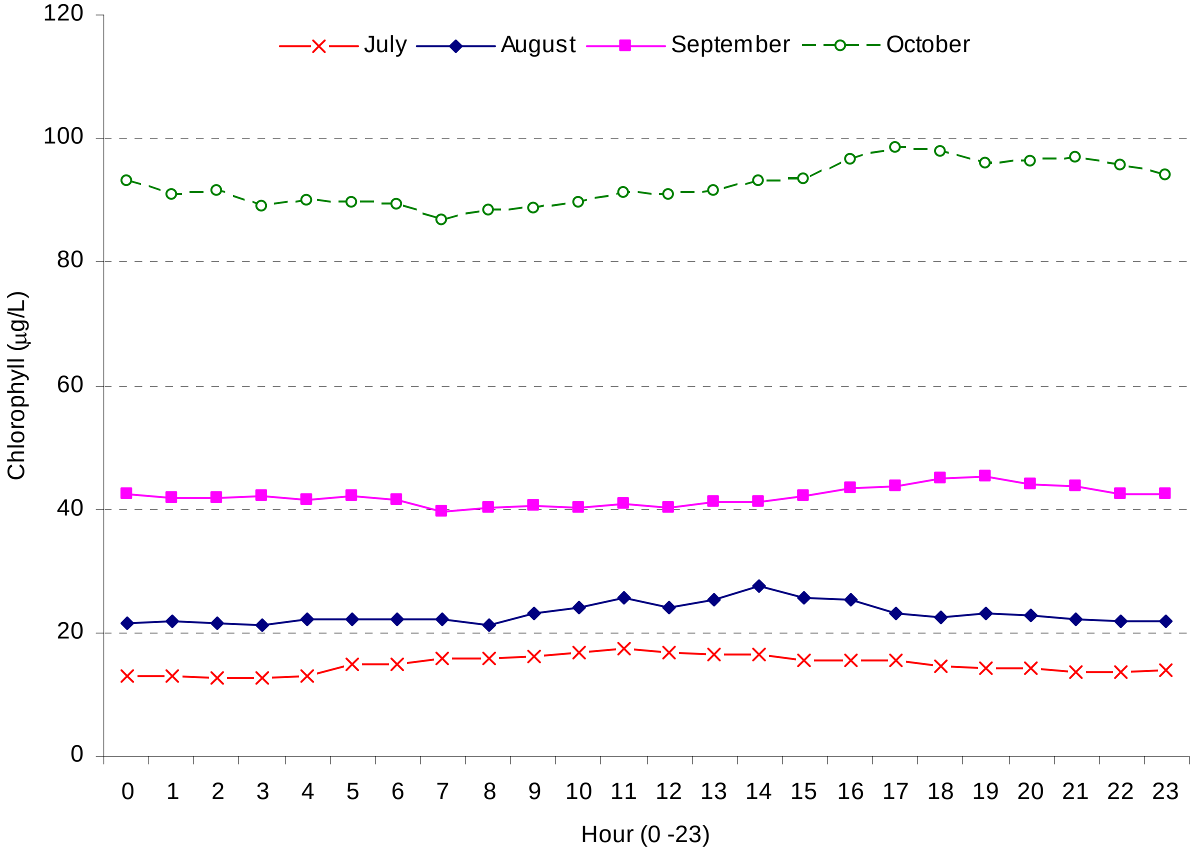


Figure 3.10.11 Chlorophyll concentration on a typical 24-hour day (Upper Jones Middle)



Chapter 3 Results and Discussion

3.11 Acute Toxicity Tests

Tables

Table 3.11.1 *Ceriodaphnia dubia* acute toxicity percent survival

	07/15/04	07/21/04	07/28/04	08/02/04	08/09/04	08/16/04	08/23/04	08/30/04	09/07/04	09/14/04
Middle River Control	55%									
Middle River Control Retest	100%									
Middle River	90%									
Middle River Retest	100%									
Upper Jones Intake Control	55%	90%								
Upper Jones Intake Control Retest	100%									
Upper Jones Intake	100%	95%								
Upper Jones Intake Retest	100%									
Upper Jones Discharge Control		95%	100%		100%	95%	95%	90%	95%	100%
Upper Jones Discharge		100%	100%		100%	100%	90%	35%*	100%	100%
Lower Jones Discharge Control			100%		100%	95%	95%	90%	95%	100%
Lower Jones Discharge			90%		100%	100%	90%	50%	80%	100%

Note 1: Blank spaces represent no sample / no analysis.
Note 2: Results reported for the 7/15/2004 *Ceriodaphnia* test include an immediate re-test because of 45% mortality in the control.
* Significantly less than control

Table 3.11.2 Fathead minnow acute toxicity percent survival

	7/15/2004	7/21/2004	7/28/2004	8/2/2004	8/9/2004	8/16/2004	8/23/2004	8/30/2004	9/7/2004	9/14/2004
Middle River Control	95%									
Middle River	100%									
Upper Jones Intake Control	95%	100%								
Upper Jones Intake	95%	100%								
Upper Jones Discharge Control		100%	95%	100%	95%	90%	100%	100%	95%	100%
Upper Jones Discharge		95%	100%	95%	90%	60%	100%	75%	90%	100%
Lower Jones Discharge Control			95%	100%	95%	90%	100%	100%	95%	100%
Lower Jones Discharge			90%	100%	100%	80%	95%	85%	95%	90%

Note: Blank spaces represent no sample/no analysis.

Chapter 4 Conclusions

Contents

Chapter 4 Conclusions

4.1 The Jones Tract Flood: Water Quality Monitoring Project purposes

Within the overall DWR goal of recovering Jones Tract from the levee breech and flood, the Municipal Water Quality Investigations Branch of the Division of Environmental Services of DWR undertook the water quality monitoring with 3 project purposes:

1 Evaluate the water quality of pump discharge as required by the Regional Water Quality Control Board to meet water quality objectives;
2 Evaluate water quality at the pump-out site to determine possible water quality effects to delta waters used for municipal purposes; and
3 Gather and analyze data that might help assess potential water quality of future island storage projects.

4.2 Monitoring to meet Regional Board requirements

The monthly monitoring reports delivered to the Regional Board kept the Board apprised of changes in water quality. With the exception of a positive fish toxicity test which, when repeated, came up negative, Regional Board staff did not express concerns with the levels or concentrations of the monitored water quality parameters.

DWR worked closely with the Regional Board to meet water quality objectives. The Trapper Slough levee, on the southeast side of Jones tract, was initially raised with material purchased from the Port of Stockton. DWR worked with the Central Valley Regional Water Quality Control Board and the Port of Stockton to determine the effect of these materials on water quality in the Delta. Tests were conducted in response to concerns that this material was acidic and contained elevated levels of several metals. There was a concern that under acidic conditions these materials could dissolve and leach into Delta waterways. Lime was applied and incorporated to raise the pH level (counteract the acidity) of the fill material. The levee road was reshaped so that runoff from precipitation would flow toward the inward side of the levee, and fill material was pulled back from contact with the slough.

4.3 Evaluation of pump-out on Delta municipal source water quality

While the changes in water quality directly outside of Jones Tract due to the pump-out did not rise to the level of concern that would have threatened the environment or the continued pump-out operations, the study did find many potential effects of interest regarding Delta water as a source of drinking water. These included changes in dissolved organic carbon, algae concentration and type, potential for the formation of disinfection byproducts, nutrient loading, production of unpleasant taste and odor compounds, and anoxia in the bottom waters leading to elevated dissolved manganese and iron concentrations.

The most dramatic water quality change, and the one probably of greatest concern to drinking water quality, was the high concentration (or loading) of dissolved organic carbon (DOC) from the peat soils. When chlorinated, such as in a drinking water treatment plant, DOC can react with chlorine to form disinfection byproducts (DBPs), several of which are regulated by the US EPA as potential carcinogens. With increasing DOC concentration, water treatment plant operators are required to use successively more expensive treatment processes in an effort to reduce the DOC and DBP concentrations in the finished water. By a combination of comparing 2004 values to historical averages, and numerical modeling, it is possible to conclude that it is quite likely that the Jones Tract flood contributed to elevated concentrations of DOC of 0.5 to 1 mg/L at the Delta water export facilities during pump-out operations. This has water quality implications for any similar flooded island.

The flooded island provided a sudden new habitat for algae growth, and measurements of overall chlorophyll concentration, as well as photographs, provided an indication that algae grew quite well in Jones Tract flood waters. This has direct and indirect implications for drinking water for future events or projects. Among the effects, the growth and decay of algae can produce unpleasant taste and odor compounds (e.g., 2-methylisoborneol (MIB) and geosmin) that make otherwise safe water unpalatable to drink. Routine water quality sampling by the DWR O&M Water Quality branch observed a significant increase in MIB concentration at Clifton Court and, downstream, in the South Bay Aqueduct, coinciding with the Jones Tract pump-out. While MIB and geosmin had been observed in previous years, concentrations during the Jones Tract pump-out were among the highest observed. The cyanobacterial algal species, *Planktothrix perornata* was identified as the main producer of MIB, and it has subsequently been found in the State Water Project and reservoirs downstream. Among the indirect effects, decaying algae are another source of DOC and thus DBPs. Certain species of algae also tend to clog water filtration apparatus.

Jones flood waters appear to have been a source of nutrient loading, specifically of phosphate. While concentrations of nutrients are not in themselves a direct concern in drinking water (high nitrate are an exception), nutrients carried from the Delta can cause algal blooms in downstream reservoirs under the right conditions. These subsequent blooms can, in turn, produce taste and odor problems and increased DOC concentrations. The presence or absence of a needed nutrient can strongly influence the kind of algae that succeeds. For example, ready availability of phosphorus and a relative lack of nitrogen can provide a competitive advantage to blue-green algae (cyanobacteria), because cyanobacteria are capable of fixing the necessary nitrogen themselves.

The high organic matter content of Jones Tract peat soils, along with nutrients and water, provided ideal growing conditions for a microbial community at the sediment-water interface. The aerobic portion of this community used oxygen for sustenance and growth. This oxygen demand tended to produce anoxic conditions at depths some distance from the bottom. Anoxia in the bottom waters would have implications for drinking water as anoxia was observed to lead to elevated dissolved manganese and iron concentrations. Anoxia has ecological implications for what kinds of organisms could live, and where, in a flooded island such as Jones Tract.

4.4 Potential water quality effects of a future island water storage project

It is very likely that flooding a Delta island similar to Jones Tract would exhibit most or all of the effects discussed in section 4.2 above. How these and other effects evolve over time would likely vary according to how the island water storage project were operated, but the fundamental controlling mechanisms would be approximately the same.

The CALFED Record of Decision states that the goal of the Water Quality Program is to provide "safe, reliable, and affordable drinking water in a cost-effective way," with a target to "achieve either: (a) average concentrations at Clifton Court Forebay and other southern and central Delta drinking water intakes of 50 µg/L bromide and 3.0 mg/L total organic carbon, or (b) an equivalent level of public health protection using a cost effective combination of alternative source waters, source control, and treatment technologies."

At present, TOC at the Banks Pumping Plant (immediately downstream from Clifton Court Forebay) exceeds 3.0 mg/L approximately 80% of the time on an annual basis (MWQI real-time carbon data at Banks Sept 2001 to May 2009). The median is 3.78 mg/L; the TOC concentration is greater than 3.78 mg/L half the time. TOC tends to be highest in winter due to inputs from the tributary rivers and in-Delta island drainage, and lowest in the summer and fall, from approximately July to the onset of winter rains in October and November.

The close agreement between TOC and DOC loading rates found by the SMARTS tank mesocosm study (see 3.2.1), by independent researchers elsewhere (e.g., Aguilar and Thibodeaux, 2005), and observed in the large-scale "natural experiment" of Jones Tract suggest that organic carbon loading model developed in section 3.2 is valid. TOC/DOC concentrations in an island storage project would depart rapidly from the desired low organic carbon concentration.

The Jones Tract flood provided an unexpected opportunity for a natural experiment. However, since Jones Tract itself was returned to the state of a drained, reclaimed island, the Jones Tract data by themselves do not tell us as much as we might like about the likely carbon loading on multi-year time scales. Here, the results of the SMARTS study and the theoretical work of Aguilar and Thibodeaux may provide insight. They suggest that the microbially-mediated production of DOC will tend to continue indefinitely after an initial rapid DOC release mechanism fades. This presumes that the island soils remain essentially submerged. If the island is managed such that soils are repeatedly exposed to air (the island completely drained), the return of the initial rapid DOC release upon re-flooding should not be unexpected.

The potential water quality effects of an island water storage project would depend substantially on the seasonal timing of water movement into and out of the storage island. One likely scenario is that the island would be filled in the winter when river stages are high and water is relatively plentiful, and drained during the summer when water is relatively scarce. A likely water quality implication of this scenario is that the island would be filled with water containing seasonally elevated TOC/DOC concentrations. The stored water would receive additional DOC through the spring and summer, with increasing temperatures likely to increase the rate of DOC loading. Finally, the resultant high-TOC/DOC water would be released into the Delta during the months in which TOC/DOC is generally lowest and closest to reaching the CALFED water quality goal. From a drinking water standpoint, the net effect would be to move Delta waters even further from the CALFED water quality TOC goal.

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Appendix A Organic Carbon Production Model for Jones Tract

The goal of the organic carbon production model is to estimate the production and concentration of dissolved organic carbon as a function of mass flux from the peat soils, the total volume of water in the reservoir, and the discharge of water from the reservoir due to pumping. The model is expressed as a differential equation of the rate of change in the total mass of total organic carbon or dissolved organic carbon (TOC / DOC) in the system as a function of time. The following quantities were measured at Jones Tract or can be directly calculated from measured quantities:

- reservoir depth and area
- total or initial volume of water
- TOC and/or DOC concentrations

We define

M_{tot}	the total mass of DOC
b	the total mass of DOC that enters from the entire area of the island bottom (with units of gC day^{-1})
F_{out}	the rate of pump-out (m^{-3} day^{-1})
$V(t)$	the reservoir volume (m^{3}) at a given time t
A	the total area of the island (m^{2})
ε	the areal rate of carbon production (with units of gC m^{-2} day^{-1}) given by b divided by the total area A of the island

To find the total mass of DOC (or TOC) at any time *t*, we define the following ordinary differential equation:

$$\frac{dM_{tot}}{dt} = b(t) - \frac{M_{tot}}{V(t)} F_{out} \qquad \text{A.0}$$

In words, the rate of increase or decrease in total DOC mass is equal to the amount of carbon that enters from the bottom minus the amount pumped out.

We can calculate $V(t)$ at any time t as the initial volume V_0 minus the volume pumped out at rate F_{out} over time t:

$$V(t) = V_0 - F_{out}\, t \qquad \text{A.1}$$

Equation 1.1 is valid so long as the pump-out rate F_{out} is constant over a suitable interval.

The differential equation then becomes:

$$\frac{dM_{tot}}{dt} = b(t) - \left(\frac{M_{tot} F_{out}}{V_0 - F_{out}\ t} \right)$$

Or, in standard form

$$\frac{dM_{tot}}{dt}+\left(\frac{M_{tot}F_{out}}{V_0-F_{out}\ t}\right)=b(t) \qquad \text{A.2}$$

Equation 1.2 is exact for any short time interval during which F_{out} can be treated as constant. Equation 1.2 can be solved using the method of *integrating factors*, as follows.

First, we multiply the entire equation by a function $\mu(t)$ that will be determined later:

$$\mu(t)\frac{dM_{tot}}{dt}+\mu(t)\left(\frac{M_{tot}F_{out}}{V_0-F_{out}\ t}\right)=\mu(t)b(t) \qquad \text{A.3}$$

We then chose $\mu(t)$ such that the left side of the equation is recognizable as the derivative of some particular expression or function. We can thus integrate without (yet) knowing the form of the function $M_{tot}(t)$ that we seek. Using the chain rule of differentiation we recognize the parts of the equation:

$$\frac{d}{dt}\left[\mu(t)M_{tot}\right]=\mu(t)\frac{dM_{tot}}{dt}+M_{tot}\frac{d\mu(t)}{dt} \qquad \text{A.4}$$

The first term to the right of the equals sign agrees with the first term of Equation 1.X, and the second will agree if we choose $\mu(t)$ to satisfy the equation

$$\frac{d\mu(t)}{dt}=\frac{F_{out}\mu(t)}{V_0-F_{out}\ t} \qquad \text{A.5}$$

Dividing by $\mu(t)$ and recognizing that $-F_{out}$ is the derivative of $-F_{out}\,t$ with respect to time, we integrate:

$$\int\frac{d\mu(t)}{\mu(t)}=\int\frac{F_{out}}{V_0-F_{out}\ t}dt \qquad \text{A.6}$$

$$\ln\left|\mu(t)\right|=-\ln\left|V_0-(F_{out}\ t)\right|+C=\ln\left|\frac{1}{V_0-(F_{out}\ t)}\right|+C \qquad \text{A.7}$$

Volume, expressed as $(V_o - F_{out}\ t)$, can always be expected to be non-zero positive number, so without loss of generality we can remove the absolute value bars and write

$$\mu(t)=\frac{1}{V_0-(F_{out}\ t)}+C \qquad \text{A.8}$$

Since we do not need C to be the most general integrating factor, we choose C =0:

$$\mu(t)=\frac{1}{V_0-(F_{out}\ t)} \qquad \text{A.9}$$

Returning to equation 1.3 and multiplying through with equation 1.9 we obtain

$$\left(\frac{1}{V_0-(F_{out}\ t)}\right)\frac{dM_{tot}}{dt}+\left(\frac{1}{V_0-(F_{out}\ t)}\right)\left(\frac{M_{tot}F_{out}}{V_0-F_{out}\ t}\right)=\left(\frac{1}{V_0-(F_{out}\ t)}\right)b(t) \qquad \text{A.10}$$

Using the Chain Rule for differentiation, the left hand side can be simplified:

$$\frac{d}{dt}\left(\frac{M_{tot}}{V_0-F_{out}\ t}\right)=\frac{b(t)}{V_0-(F_{out}\ t)} \qquad \text{A.11}$$

Assuming that *b(t)* and F_{out} are constant for some reasonably small time step, we integrate both sides to obtain

$$\frac{M_{tot}}{V_0-F_{out}\ t}=\frac{-b(t)}{F_{out}}\ln\left|V_0-(F_{out}\ t)\right|+C_2 \qquad \text{A.12}$$

Constant C_2 can be anything, so choose it to be ln|ß| with units of volume (m^3). Solving for M_{tot} we arrive at:

$$M_{tot}=(V_0-F_{out}t)[\frac{b(t)}{F_{out}}]\ln(\frac{\beta}{V_0-F_{out}t}) \quad \text{A.13}$$

$$M_{tot}=(V_0-F_{out}t)[\frac{b(t)}{F_{out}}]\left(\ln\left|\frac{1}{V_0-F_{out}t}\right|+\ln|\beta|\right) \qquad \text{A.14}$$

To determine ß we use the initial condition of M_0 at $t = 0$

$$M_{tot}(t=0)=M_0=[\frac{V_0b(t)}{F_{out}}]\left(-\ln|V_0|+\ln|\beta|\right) \quad \text{A.15}$$

$$\frac{M_0F_{out}}{V_0b(t)}=\left(-\ln|V_0|+\ln|\beta|\right) \qquad \text{A.16}$$

$$\frac{M_0F_{out}}{V_0b(t)}+\ln|V_0|=\ln|\beta| \qquad \text{A.17}$$

$$\exp\left(\frac{M_0F_{out}}{V_0b(t)}+\ln|V_0|\right)=\beta \qquad \text{A.18}$$

$$V_0\exp\left(\frac{M_0F_{out}}{V_0b(t)}\right)=\beta \quad \text{A.19}$$

Substituting ß back into Equation 1.14 we have the specific solution of our differential equation.

$$M_{tot} = (V_0 - F_{out}t)[\frac{b(t)}{F_{out}}]\ln\left(\frac{V_0 \exp\left(\frac{M_0 F_{out}}{V_0 b(t)}\right)}{V_0 - F_{out}t}\right) \qquad \text{A.20}$$

$$M_{tot} = (V_0 - F_{out}t)\frac{b(t)}{F_{out}}\left(\ln(\frac{V_0}{V_0 - F_{out}t}) + \ln\left(\exp\left(\frac{M_0 F_{out}}{V_0 b(t)}\right)\right)\right) \qquad \text{A.21}$$

$$M_{tot} = (V_0 - F_{out}t)\frac{b(t)}{F_{out}}\left(\ln(\frac{V_0}{V_0 - F_{out}t}) + \frac{M_0 F_{out}}{V_0 b(t)}\right) \qquad \text{A.22}$$

$$M_{tot} = (V_0 - F_{out}t)\left[\frac{b(t)}{F_{out}}\ln(\frac{V_0}{V_0 - F_{out}t}) + \frac{M_0}{V_0}\right] \qquad \text{A.23}$$

We note that the equation behaves at $t = 0$, where $M_{tot}(t = 0) = M_0$.

Recall that

Mass/Volume = Concentration A.24

and in particular, initial dissolved mass M_0 divided by volume V_0 is concentration C_0,

$$M_{tot} = (V_0 - F_{out}t)\left[C_0 + \frac{b(t)}{F_{out}}\ln(\frac{V_0}{V_0 - F_{out}t})\right] \qquad \text{A.25}$$

Note that $(V_0 - F_{out}*t)$ in equation 1.23 is the volume $V(t)$ for any time t, therefore, recalling equation 1.24, the quantity in brackets is the concentration $C(t)$:

$$C(t) = \frac{M_{tot}(t)}{(V_0 - F_{out}t)} = C_0 + \frac{b(t)}{F_{out}}\ln(\frac{V_0}{V_0 - F_{out}t}) \qquad \text{A.26}$$

Solving for the areal flux rate in terms of measured quantities

$$\varepsilon(t) = \frac{b(t)}{A} = \frac{(C(t) - C_0)F_{out}}{A\ln(\frac{V_0}{V_0 - F_{out}\,t})} \qquad \text{A.27}$$

This solution for $C(t)$ is valid for any sufficiently small step where we can assume that the rate of pump-out was approximately constant. Figure 2-3 shows that despite a wide range in depth estimates depending on the source of the data, all data and information suggest a consistent, linear decrease in depth throughout most of the pump out. The κ' rate of carbon yield in $gCm^{-2}d^{-1}$ was calculated for each time step by using the measured TOC or DOC concentration $C(t)$ at any time t and the corresponding previous concentration for the initial concentration $C(0)$.