GRASSLAND BYPASS PROJECT

8 Toxicity Testing for the Grassland Bypass Project

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Introduction

The objective of the laboratory toxicity-testing program is to evaluate the potential toxicity of waterborne contaminants within the GBP area using standardized bioassay protocols conducted under controlled environmental conditions. The laboratory toxicity tests evaluate one species within each of three trophic levels using short-term chronic testing procedures (7 or 4 days) and lethal (survival) and non-lethal (growth or reproduction) endpoints (USEPA 1987; 1994). The test species are *Selenastrum capricornutum* (alga), *Daphnia magna* (water flea), and *Pimephales promelas* (fathead minnow).

The testing is not specific for any single chemical exposure, but rather demonstrates the net effect of only waterborne contaminant exposures in the site waters on the selected test species. During toxicity testing, test species are fed a controlled diet that is unrelated to field sources of food. For this reason, toxicity testing is not expected to detect selenium toxicity in invertebrates and fish because the main route of exposure in these groups of organisms is through the food they eat. However, selenium toxicity in algae is through direct exposure from water and thus toxicity testing may detect selenium toxicity in algae.

Tests are conducted at the screening level, comparing the ambient water to 100% test water. If significant toxicity is observed, definitive tests (dilution series) may be conducted. Water samples are collected from Stations B, C, D, and F for each monthly testing period. The Delta Mendota Canal station is the control site. *In-situ* chronic toxicity testing using caged fathead minnows has been eliminated during the course of the program, as has measurement of selenium bioaccumulation in algae.

The toxicity program is conducted by Block Environmental Service's (BES) Bioassay Laboratory Division under contract with the San Luis & Delta-Mendota Water Authority. The U. S. Environmental Protection Agency (USEPA) provides technical assistance and program oversight. The toxicity program is carried out monthly.

WY 2001 represents the 5th and final year (Phase I) of the monitoring program. The Phase II monitoring program started on October 1, 2001 and continues through December 31, 2009. WY 2001 monthly data are presented in this chapter and are compared graphically with the previous 4 years.

Materials and Methods

Three species are used for 5 toxicity tests using the short-term chronic testing procedures (USEPA, 1987; 1994). The test species are the freshwater alga (*Selenastrum capricornutum*), the fathead minnow (*Pimephales promelas*), and the daphnid invertebrate *(Daphnia magna*). The 5 specific tests are 1. fathead minnow survival, 2. fathead minnow growth, 3. Daphnia magna survival, 4. Daphnia magna reproduction, and 5. freshwater algal growth. Grab samples are collected from Sites B, C, D, F, and the DMC each month. The toxicity tests uses 3 water samples (grab sample) collected on Day 0, Day 3, and Day 5 of the 7-day testing period. Each test is performed using 100% water from the 4 sites and compared to 100% water from the DMC. All toxicity test results are analyzed using the software program Toxicity Information Management System (TOXIS, Version 2. 5, EcoAnalysis, Inc.). TOXIS determines if there is a statistically significant reduction ($p<0.05$) between each of the 4 sites to the ambient DMC waters each month.

In order to assess independently the health of the test organisms and laboratory performance, a concurrent reference toxicant test is conducted for each of the test species during the monthly testing periods. The reference toxicant test is conducted using a dilution series of the toxicant in laboratory control water. The toxicity endpoints from the reference toxicant tests of each test method are plotted on a running control chart of the last 20 tests. The mean and upper and lower control limits (± 2 standard deviations) are recalculated with each successive test result. The outliers, which are values falling outside the upper and lower control limits, and trends of increasing or decreasing sensitivity, are identified. At the $p= 0.05$ probability level, 1 in 20 tests (5%) would be expected to fall outside of the control limits by chance alone.

Water samples for chemical analysis are collected during each sampling event. Selenium and sulfate parameters are analyzed by the U. S. Bureau of Reclamation's (USBR) contract laboratories. Other laboratory analyses (performed by BES) are temperature, dissolved oxygen (DO), pH, conductivity, salinity, ammonia, total chlorine, hardness, alkalinity, and total suspended solids. Field analyses are also made for DO, pH, conductivity and salinity during collection of the first of the three samples collected.

Sampling and testing protocols for each procedure are found in the Compliance Monitoring Program for Use and Operation of the Grassland Bypass Project

Figure 1
Site B Compared to Delta Mendota Canal—Chronic Endpoints

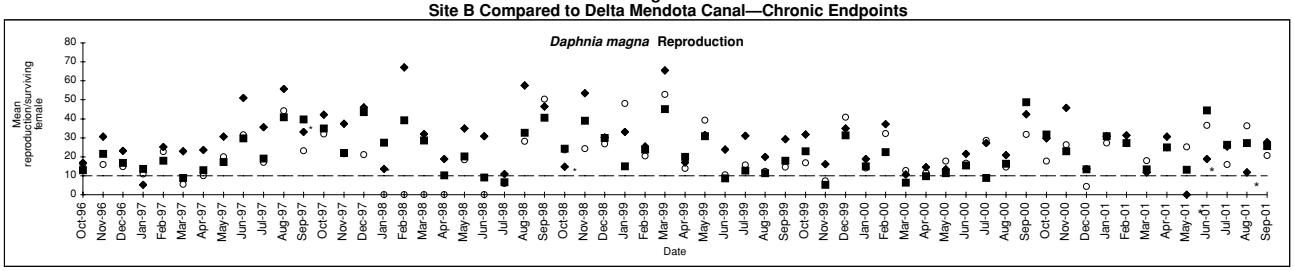


Figure 2
Site B Compared to Delta Mendota Canal—Chronic Endpoints

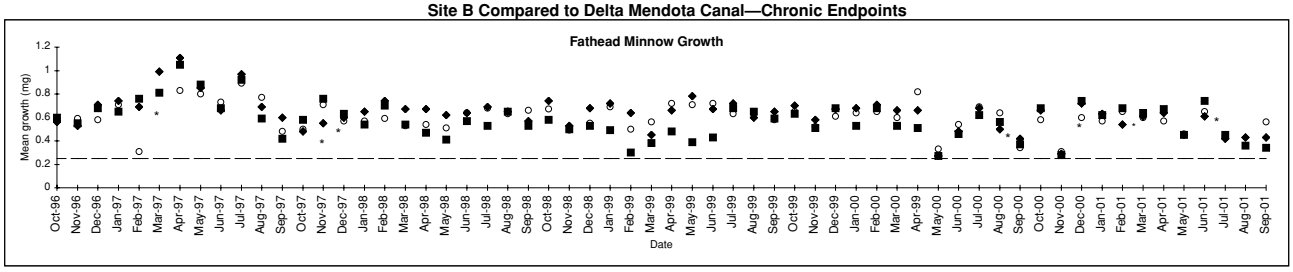


Figure 3
Site B Compared to Delta Mendota Canal—Chronic Endpoints

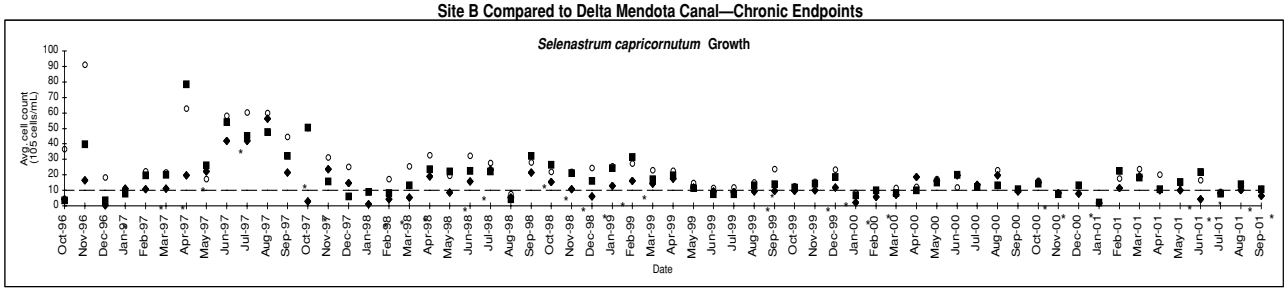


Figure 4
Site B Compared to Delta Mendota Canal—Acute Endpoints

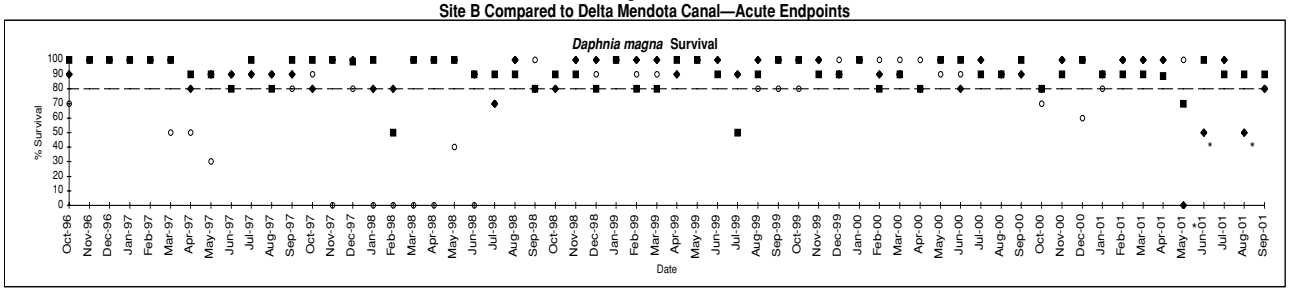
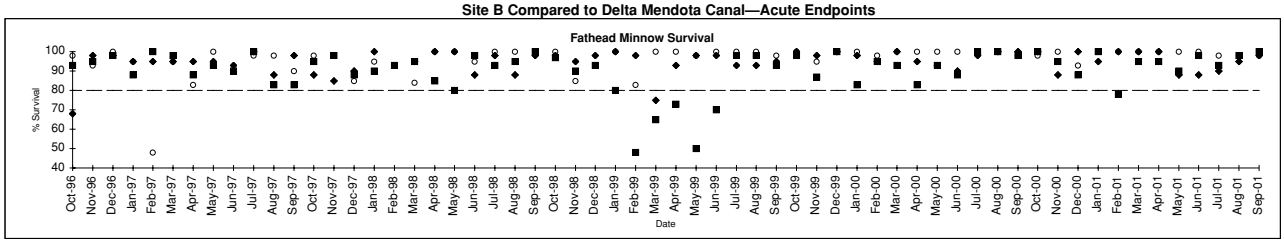


Figure 5
Site B Compared to Delta Mendota Canal—Acute Endpoints



■ Delta Mendota Canal (control)
◆ Site B
* Results statistically different from control
❍ Laboratory Control
-- Minimum test acceptability for control

(USBR et al. , 1996) and the Quality Assurance Project Plan (Entrix, Inc. , 1997).

Results

Toxicity testing, as described in the Compliance Monitoring Program for Use and Operation of the Grassland Bypass Project (USBR et al. , 1996) began in October 1996. Data for the 4 previous years may be found in the Annual Reports (USBR, 1998, 1999, 2000 and 2001). Toxicity results from the 5th year are presented in Tables 1 through 5. Figures 1 through 20 graphically present information for all 5 years.

Water chemistry data measured in the field are presented in Tables 6 through 9. Table 10 provides information on the sample collection depth. Tables 12-15 depict the statistical occurrences from all of the tests over the 5-year period. Laboratory water quality data are presented in Tables 16 through 27. Water quality data comparing each of the stations are found in Figures 21–30.

Laboratory Toxicity Testing

There were 12 monthly laboratory toxicity tests between October 2000 and September 2001.

Daphnia magna Short-Term Chronic Survival

The D. magna toxicity test survival results are presented in Table 1 and in Figures 4, 9, 14, and 19 (Tables and Figures are not sequential since data are

Table 1
***Daphnia magna* Survival (Percent)**

DATE	SITE LOCATION					
	B	C	D	F	Ambient (DMC)	Laboratory Control
Oct-00	80	80	60 *	80	80	70 **
Nov-00	100	100	100	100	90	100
Dec-00	80	80	80	100	100	60 **
Jan-01	90	70 *	100	100	90	80
Feb-01	100	100	90	100	90	100
Mar-01	100	100	90	90	90	90
Apr-01	100	100	100	100	89	89
May-01	0*	100	100	100	70**	100
Jun-01	50 *	70 *	70 *	90	100	100
Jul-01	100	100	60 *	80	90	90
Aug-01	50 *	100	30 *	100	90	90
Sep-01	80	100	90	100	90	80

* Statistically significant event (P=0.05). Statistics were computed between all site means and the DMC ambient water sample.

** DMC/Lab water failed to meet the survival (≥ 80%) acceptability criteria.

Table 2
***Daphnia magna* Mean Reproduction**
(Number of Neonates per Female + Standard Deviation)

DATE	SITE LOCATION					
	B	C	D	F	Ambient (DMC)	Laboratory Control
Oct-00	29.80 + 16.63	41.50 + 21.34	23.90 + 21.70	25.70 + 21.56	31.80 + 20.93	17.70 + 15.93
Nov-00	45.70 + 5.62	40.40 + 7.50	43.90 + 10.34	35.10 + 4.95	22.80 + 11.77	26.30 + 6.55
Dec-00	13.70 + 9.81	15.70 + 10.00	13.22 + 6.52	11.20 + 5.50	13.40 + 6.92	4.6 + 4.74 **
Jan-01	30.8 + 18.47	31.30 + 22.29	46.20 + 13.38	36.89 + 12.99	30.80 + 17.67	27.10 + 18.25
Feb-01	31.2 + 13.1	25.7 +8.4	25.1 + 12.02	29.9 +10.6	27.2 + 13.4	27.5 +10.4
Mar-01	11.70 + 3.56	21.90 + 9.89	19.30 + 9.02	15.60 + 8.15	13.40 + 6.28	17.80 + 9.99
Apr-01	30.70 + 12.27	28.60 + 7.82	36.50 + 12.45	26.20 + 9.07	24.89 + 13.46	24.78 + 12.08
May-01	0*	25.0 + 8.96	27.50 + 6.79	23.30 + 12.54	13.90 + 10.81	25.20 + 9.84
Jun-01	18.90 + 21.52 *	28.3 + 21.0*	27.6 + 19.16 *	47.90 + 19.72	44.50 + 11.05	36.40 + 8.36
Jul-01	25.33 + 4.58	28.50 + 5.58	16.80 + 14.76	17.70 + 12.27	26.20 + 11.70	15.90 + 9.79
Aug-01	11.7 + 28.3*	42.90 + 13.98	15.50 + 25.58 *	52.50 + 16.04	27.10 + 16.60	36.30 + 20.18
Sep-01	27.70 + 15.36	31.50 + 3.66	32.50 + 14.92	31.50 + 3.66	25.60 + 10.10	20.70 + 13.01

* Statistically significant event (P=0.05). Statistics were computed between all site means and the DMC ambient water sample.

** DMC/Lab Cl water failed to meet the reproduction (≥ 10) acceptability criteria.

presented by site designation and presented by species). Six months had statistically significant (p<0.05) reductions in survival of *D. magna* during the WY 2001: October (Site D), January (Site C), May (Site B), June (Sites B, C, and D), July (Site D) and August (Sites B and D), for a total of 9 tests.

All of the twelve concurrent *D. magna* reference toxicant survival endpoints for WY 2001 were within the control chart limitations.

The DMC ambient control data met the 80% minimum survival acceptability criterion for all sampling events except for May. Laboratory control met the survival acceptability criterion in all of the 12 sampling events except for December.

For the first 4 water years, *D. magna* survival results showed no significant reductions for survival for any of the stations, including the DMC ambient control.

Daphnia magna Short-Term Chronic Reproduction

The *D. magna* reproduction results are presented in Table 2 and in Figures 1, 6, 11, and 16. Three months showed statistically significant (p<0.05) reduced repro-

Table 3
***Pimephales promelas* (Fathead Minnow)**
Larval Survival (Percent + Standard Deviation)

DATE	SITE LOCATION					
	B	C	D	F	Ambient (DMC)	Laboratory Control
Oct-00	100 + 0	75 + 0.27 *	93 + 0.10	100 + 0	100 + 0	98 + 0.05
Nov-00	88 + 0.13	15 + 0.10 *	23 + 0.15 *	63 + 0.17 *	95 + 0.06	100 + 0
Dec-00	100 + 0	63 + 0.13 *	73 + 0.17	88 + 0.15	88 + 0.19	93 + 0.15
Jan-01	95 + 0.10	85 + 0.19	93 + 0.10	90 + 0.08	100 + 0	100 + 0
Feb-01	100 + 0	90 + 0.12	93 + 0.10	78 + 0.26	78 +0.32	100 + 0
Mar-01	100 + 0	93 + 0.05	93 + 0.1	90 + 0.08	95 + 0.06	100 + 0
Apr-01	100 + 0	100 + 0	95 + 0.06	93 + 0.10	95 + 0.06	100 + 0
May-01	88 + 0.13	97 + 0.06	90 + 0.08	90 + 0.12	90 + 0.08	100 + 0
Jun-01	88 + 0.10	98 + 0.05	98 + 0.05	98 + 0.05	98 + 0.05	100 + 0
Jul-01	90 + 0.14	93 + 0.10	98 + 0.05	100 + 0	93 + 0.10	98 + 0.05
Aug-01	95 + 0.10	95 + 0.06	98 + 0.05	95 + 0.06	98 + 0.05	98 + 0.05
Sep-01	98 + 0.05	100 + 0	90 + .08	100 + 0	100 + 0	100 + 0

* Statistically significant event (P=0.05). Statistics were computed between all site means and the DMC ambient water sample.

** Not a statistically significant event due to high variability in the response.
*** DMC water failed to meet the survival (≥ 80%) acceptability criteria.

Table 4
***Pimephales promelas* (Fathead Minnow) Mean Growth**
(In Milligrams + Standard Deviation)

DATE	SITE LOCATION					
	B	C	D	F	Ambient (DMC)	Laboratory Control
Oct-00	0.66 + 0.04	0.46 + 0.15 *	0.58 + 0.09 *	0.67 + 0.02	0.68 + 0.03	0.58 + 0.11
Nov-00	0.29 + 0.05	0.05 + 0.03 *	0.07 + 0.05 *	0.21 + 0.04 *	0.28 + 0.02	0.31 + 0.05
Dec-00	0.72 + 0.06	0.40 + 0.13 *	0.49 + 0.14 *	0.67 + 0.12	0.74 + 0.16**	0.60 + 0.17
Jan-01	0.63 + 0.09	0.50 + 0.08	0.59 + 0.08	0.55 + 0.03	0.58 + 0.05	0.57 + 0.04
Feb-01	0.54 +0.07 *	0.53 + 0.02 *	0.64 + 0.03	0.61 + 0.03	0.68 + 0.9	0.65 + 0.05
Mar-01	0.61 + 0.04	0.66 + 0.03	0.67 + 0.09	0.63 + 0.04	0.64 + 0.11	0.60 + 0.05
Apr-01	0.64 + 0.13	0.72 + 0.06	0.71 + 0.06	0.73 + 0.04	0.67 + 0.05	0.57 + 0.08
May-01	0.45 + 0.02	0.45 + 0.03	0.46 + 0.03	0.43 + 0.06	0.45 + 0.05	0.46 + 0.02
Jun-01	0.61 + 0.1 *	0.83 + 0.07	0.85 + 0.06	0.85 + 0.07	0.74 + 0.05	0.65 + 0.05
Jul-01	0.42 + 0.06	0.39 + 0.04	0.48 + 0.07	0.47 + 0.05	0.45 + 0.07	0.44 + 0.08
Aug-01	0.43 + 0.05	0.44 + 0.03	0.35 + 0.01	0.38 + 0.01	0.36 + 0.03	0.36 + 0.04
Sep-01	0.43 + 0.03	0.43 + 0.08	0.44 + 0.12	0.42 + 0.02	0.34 + 0.04	0.56 + 0.06

* Statistically significant event (P=0.05). Statistics were computed between all site means and the DMC ambient water sample.

** Not a statistically significant event due to high variability in the response.

duction for WY 2001: May (Site B), June (Sites B, C, and D) and August (Sites B and D).

All of the concurrent *D. magna* reference toxicant reproduction endpoints were within the control chart limitations.

The DMC ambient control data met the 10 neonates per surviving female minimum reproduction acceptability criterion in all 12 months. The laboratory control met the reproduction acceptability criterion in all but 1 of the months (December, 2000).

Previous significant tests included 2 in WY 1997, 4 in WY 1998, 2 in WY 1999, and none in WY 2000.

Chronic 7-Day Fathead Minnow (*Pimephales promelas*) Larval Survival

The fathead minnow toxicity test survival results are presented in Table 3 and in Figures 5, 10, 15, and 20. Three months showed statistically significantly ($p<0.05$) reduced fathead minnow larval survival results when compared to the DMC ambient control water. The reduced survival was observed during the October (Site C), November (Sites C, D, and F), and December (Site C) tests.

The survival data for the fathead minnow larvae indicate an adverse effect for Sites C, D and F from October to December. Site C had the greatest number of occurrences (3 events).

Each concurrent *P. promelas* reference toxicant survival endpoint was within the control chart limits.

Data for the DMC ambient control and the laboratory control met the minimum 80% acceptability criteria for 11 of the 12 months. The DMC failed the 80% acceptability criteria for February 2001, but the laboratory control met this criteria.

When the fathead minnow larval survival results for the 5 years are compared (Tables 12, 13, 14 and 15) it is evident that most statistically significant events occurred during the months of October through March.

During the 5-year period, 60 months, Site B showed no statistical effect on survival of fish. Site C had 16 sampling events of 60 indicating statistical reduction in fish survival, of which 14 were during the wet weather months. Site D had 12 sampling events of 60 indicating statistical reduction in survival of which 11 were during the wet weather months. Site F had 11 sampling events showing statistical reduction in fish survival, of which 8 occurred during the wet weather months.

Chronic 7-Day Fathead Minnow (Pimephales promelas) Larval Growth

The fathead minnow toxicity test growth results are presented in Table 4 and in Figures 2, 7, 12, and 17. During the 12 months of the final year, statistically significant ($p<0.05$) reduced growth rates were observed 10 times during October (Sites C and D), November (Sites C, D, and F), December (Sites C and D), February (Sites B and C) and June (Site B).

Each concurrent *P. promelas* reference toxicant growth endpoint was within the control chart limits. All

Table 5
***Selenastrum capricornutum* Cell Counts (cells/mL) with Variance (%)**
Cell count values expressed as the exponent 10^5.
(Selenate added)

DATE	SITE LOCATION											
	B	Var. (%)	C	Var. (%)	D	Var. (%)	F	Var. (%)	Ambient (DMC)	Var. (%)	Lab Control	Var. (%)
Oct-00	15.0	12.5	15.7	5.9	14.3	3.2	16.1	7.0	14.4	5.8	16.2	4.8
Nov-00	8.3	7.8	7.5	13.0	8.1	5.7	7.6	3.1	7.65 **	18.1	7.9 **	5.6
Dec-00	7.8 *	19.4	13.6	11.0	15.4	11.9	14.9	11.3	13.1	7.1	13.3	9.4
Jan-01	17.3	20.7	21.1	13.9	22.1	4.2	17.8	63.8	0.73 **	67.3	21.5	10.8
Feb-01	11.3 *	10.3	23.8	16.4	21.5	5.1	16.7 *	22.3	22.5	7.9	17.6	5.8
Mar-01	18.9	6.3	24.6	17.5	20.0	26.7	21.7	33.3	18.4	15.2	23.5	12.4
Apr-01	9.9	18.0	10.5	10.3	10.2	16.5	5.8 *	16.1	10.7	16.3	20.2	8.3
May-01	10.1 *	4.2	18.4	5.4	13.1	15.8	19.6	16.3	15.5	4.0	14.4	6.8
Jun-01	4.2 *	14.9	12.9 *	11.3	10.3 *	14.9	14.7 *	16.8	21.8	7.0	16.4	15.3
Jul-01	8.3	8.7	8.5	4.7	8.5	14.8	9.4	21.8	8.0 **	12.3	9.1 **	14.0
Aug-01	10.4 *	13.2	12.4	4.8	3.0 *	11.3	15.6	7.8	13.8	10.9	10.0	14.0
Sep-01	6.5 *	13.7	13.0	13.7	11.3	10.7	12.3	25.6	10.8	11.4	9.6	10.3

* Statistically significant event (P=0.05). Statistics were computed between all site means and the DMC ambient water sample.

** DMC/Control water failed to meet the growth ($\geq 1 \times 10^6$) acceptability criteria.

Figure 6
Site C Compared to Delta Mendota Canal—Chronic Endpoints

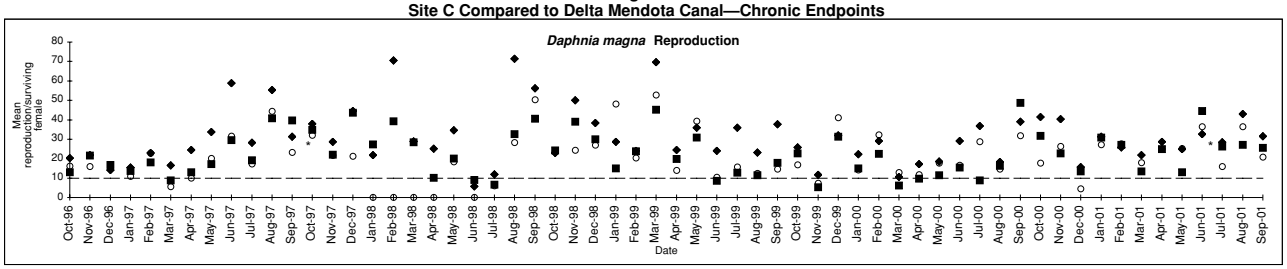


Figure 7
Site C Compared to Delta Mendota Canal—Chronic Endpoints

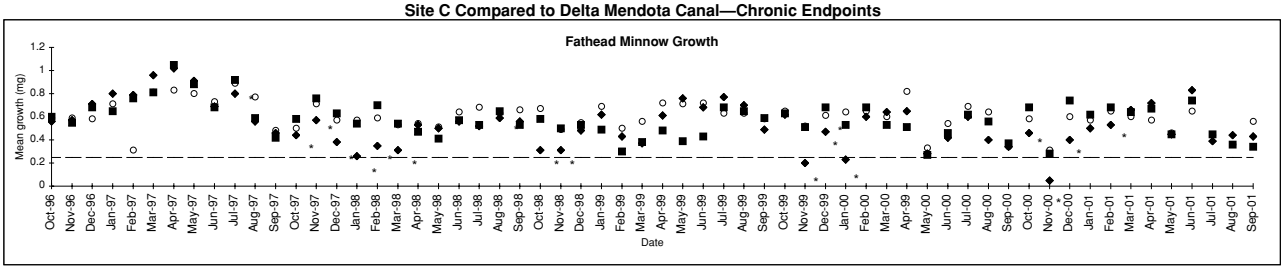


Figure 8
Site C Compared to Delta Mendota Canal—Chronic Endpoints

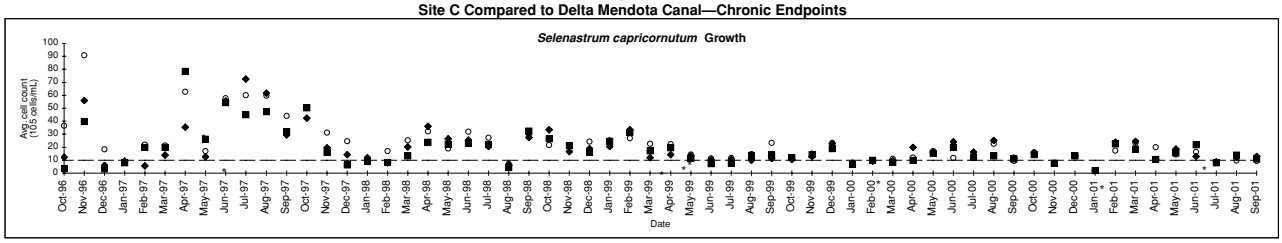


Figure 9
Site C Compared to Delta Mendota Canal—Acute Endpoints

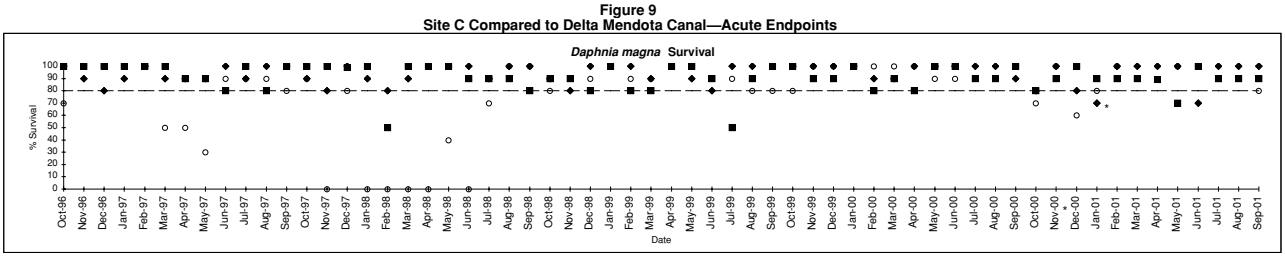
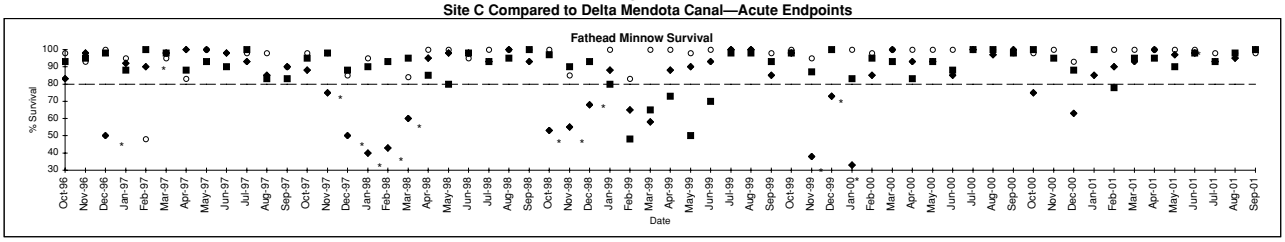


Figure 10
Site C Compared to Delta Mendota Canal—Acute Endpoints



■ Delta Mendota Canal (control)
◆ Site C
* Results statistically different from control
❍ Laboratory Control
-- Minimum test acceptability for control

Figure 11
Site D Compared to Delta Mendota Canal—Chronic Endpoints

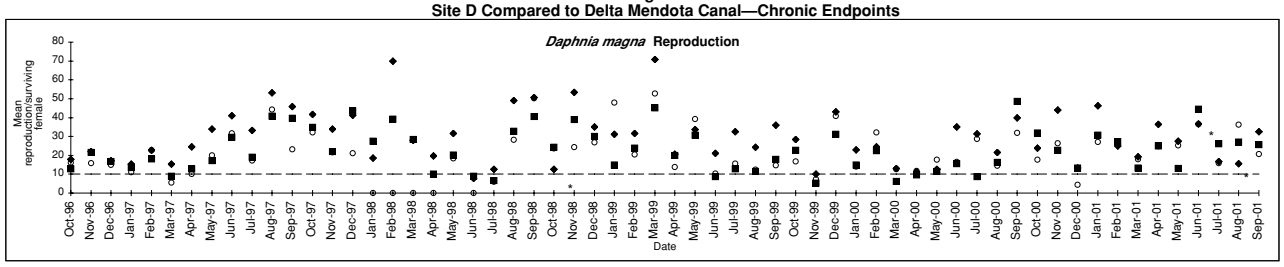


Figure 12
Site D Compared to Delta Mendota Canal—Chronic Endpoints

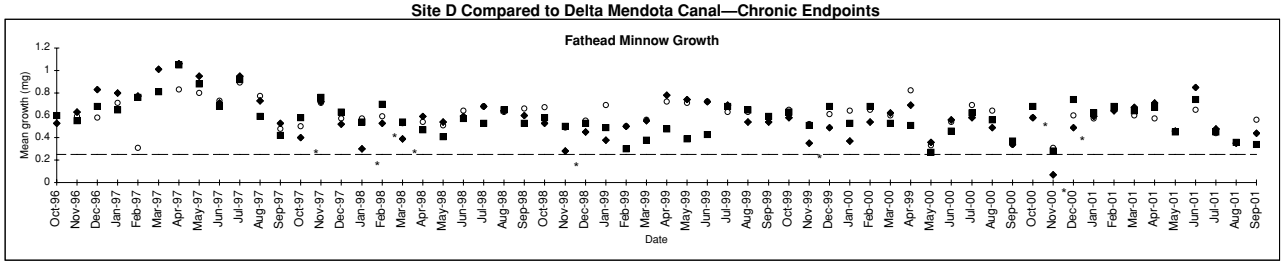


Figure 13
Site D Compared to Delta Mendota Canal—Chronic Endpoints

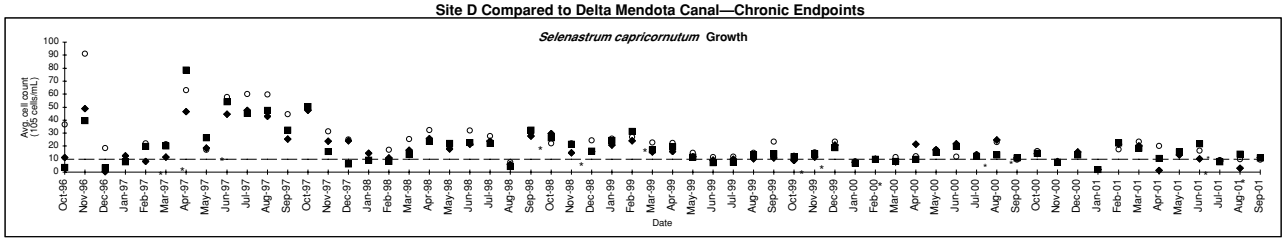


Figure 14
Site D Compared to Delta Mendota Canal—Acute Endpoints

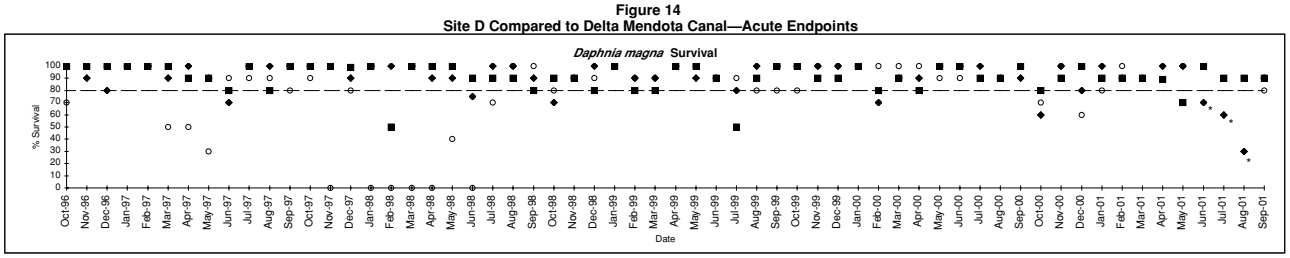
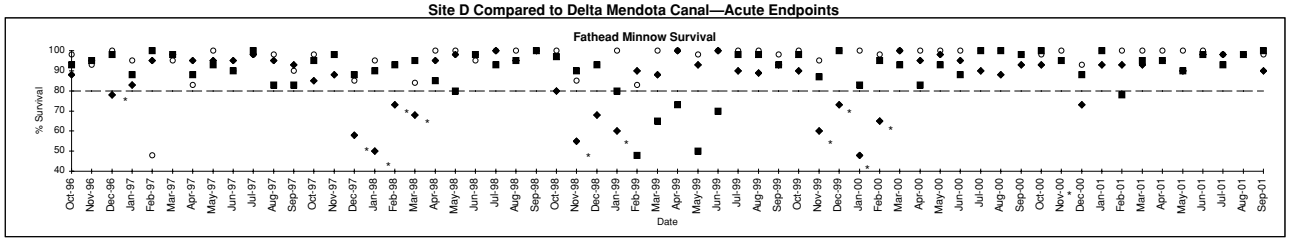


Figure 15
Site D Compared to Delta Mendota Canal—Acute Endpoints



■ Delta Mendota Canal (control)
◆ Site D
* Results statistically different from control
❍ Laboratory Control
-- Minimum test acceptability for control

data for the DMC ambient control and the laboratory control met the 0. 25 mg/surviving adult minimum growth acceptability criterion as shown in Table 4.

Over the 5 years, Site C had most statistically significant events, 17, for reduced fish growth. Most of these events, 12, were during the November-March wet weather season. Thirteen of these 17 events also coincided with reduced fish survival. Site F had 12 sampling events where reduced fish growth was statistically reduced; 9 of the 12 events occurred during the wet weather months. Fish survival was reduced during 10 of these events. Site B had 5 sampling events with signifi-

Table 6
Conductivity (uS) of Site Waters Measured in the Field, Day 1

	SITE LOCATION				
MONTH	**B**	**C**	**D**	**F**	**Ambient**
Oct-00	3120	1000	700	1150	400
Nov-00	3400	950	1330	1200	435
Dec-00	4350	1500	2120	1460	570
Jan-01	3970	1770	2400	1440	660
Feb-01	3016	1263	1775	964	422
Mar-01	6040	3180	3540	1580	590
Apr-01	3955	1774	3213	1095	655
May-01	4760	1273	3100	1217	416
Jun-01	5000	2010	4110	1410	6380
Jul-01	3975	2483	3714	1124	348
Aug-01	3569	2618	3884	1199	555
Sep-01	4030	930	2226	1274	657

Table 7
Dissolved Oxygen (in mg/L) of Site Waters Measured in the Field, Day 1

	SITE LOCATION				
MONTH	**B**	**C**	**D**	**F**	**Ambient**
Oct-00	13.8	6.8	6.2	12.9	9.5
Nov-00	13.5	8.8	8.9	11.2	10.3
Dec-00	10.8	8.6	9.1	9.4	10.5
Jan-01	10.5	10.5	10.6	10.4	11.3
Feb-01	12.2	12.3	10.2	11.7	12.4
Mar-01	12.6	8.8	9.8	10.1	9.8
Apr-01	14.7	13.1	12.4	9.2	10.5
May-01	9.2	8.3	8.4	6.3	10.0
Jun-01	11.7	11.2	9.0	7.8	8.7
Jul-01	11.1	9.4	9.5	5.8	8.2
Aug-01	11.5	10.1	9.4	7.3	9.1
Sep-01	10.3	8.3	8.0	7.7	8.3

Table 8
pH of Site Waters Measured in the Field, Day 1

	SITE LOCATION				
MONTH	**B**	**C**	**D**	**F**	**Ambient**
Oct-00	NT	NT	NT	NT	NT
Nov-00	8.3	7.3	7.5	7.8	7.6
Dec-00	7.7	7.4	7.2	7.8	7.5
Jan-01	7.6	7.2	7.1	8.1	7.6
Feb-01	7.4	7.2	7.3	7.6	7.3
Mar-01	8.0	7.9	7.8	7.4	7.6
Apr-01	NA	NA	NA	NA	NA
May-01	8.4	8.1	8.2	7.6	8.2
Jun-01	8.2	8.8	8.6	7.6	8.8
Jul-01	8.3	8.0	8.3	7.6	8.0
Aug-01	8.4	8.1	8.4	7.7	8.0
Sep-01	8.5	7.7	8.1	7.7	7.9

NA - Not Available
NT - Not Taken

Figure 16
Site F Compared to Delta Mendota Canal—Chronic Endpoints

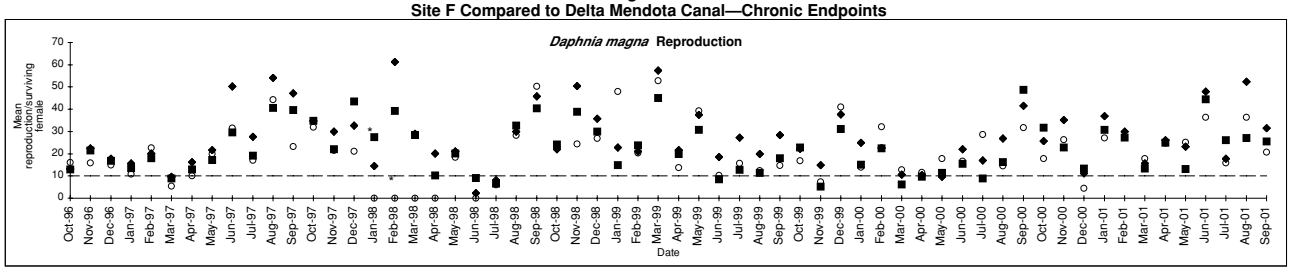


Figure 17
Site F Compared to Delta Mendota Canal—Chronic Endpoints

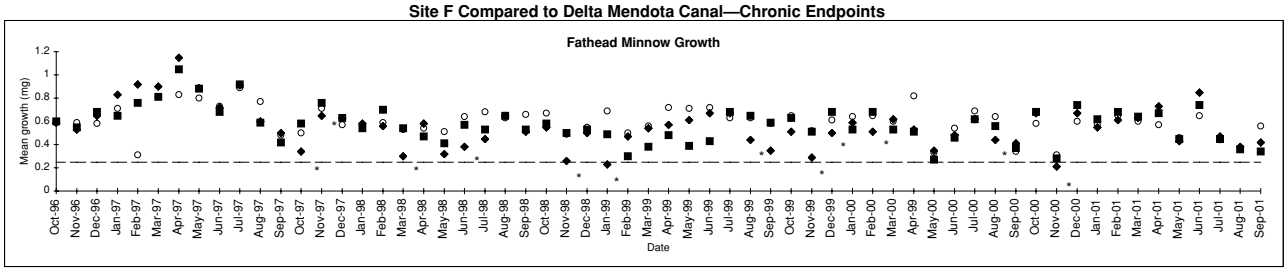


Figure 18
Site F Compared to Delta Mendota Canal—Chronic Endpoints

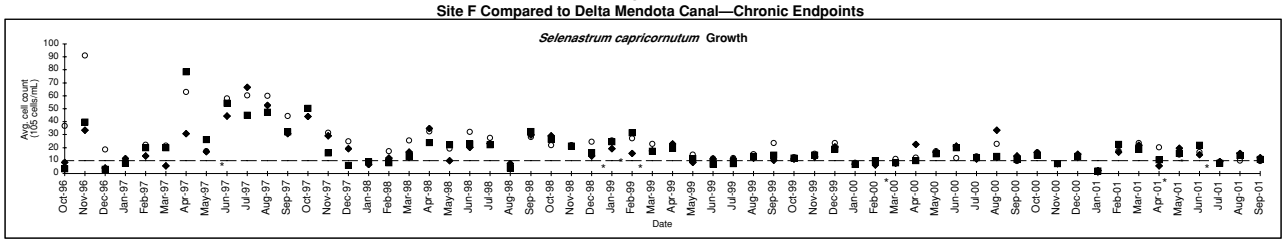


Figure 19
Site F Compared to Delta Mendota Canal—Acute Endpoints

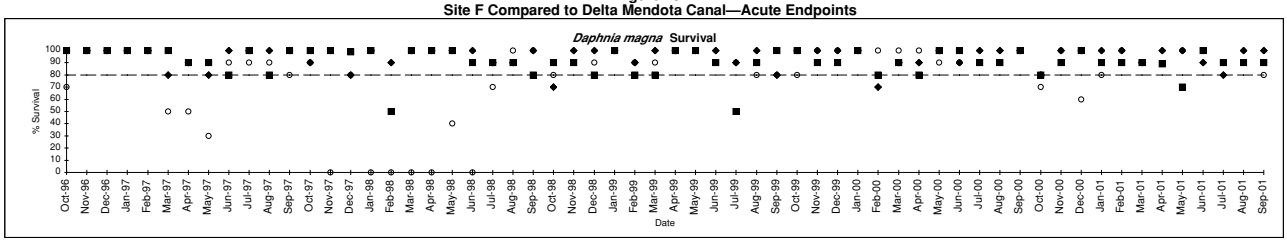
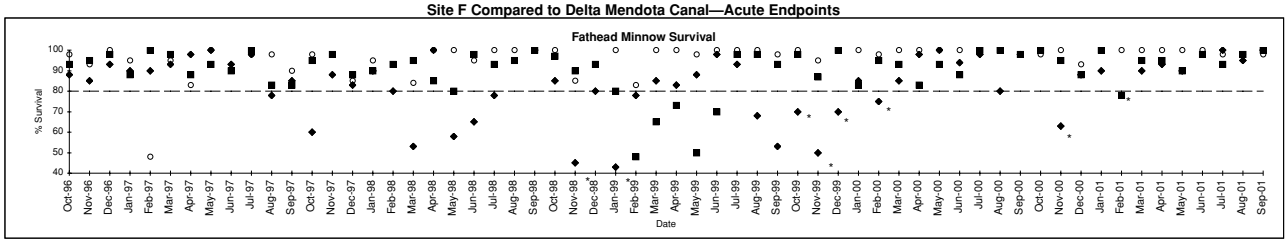


Figure 20
Site F Compared to Delta Mendota Canal—Acute Endpoints



■ Delta Mendota Canal (control)
◆ Site F
* Results statistically different from control
❍ Laboratory Control
-- Minimum test acceptability for control

cantly reduced growth (3 during the wet season). Site D had 10 sampling events in which fish growth was reduced. Seven of these sampling events were during the wet season and 6 sampling events had reduced fish survival.

Selenastrum capricornutum 96-Hour Growth Test

The algal growth results are presented in Table 5 and in Figures 3, 8, 13, and 18. Twelve tests during 6 months produced statistically significant ($p<0.05$)

Table 9
Temperature (deg. Celsius) of Site Waters Measured in the Field, Day 1

	SITE LOCATION				
MONTH	**B**	**C**	**D**	**F**	**Ambient**
Oct-00	22.5	22.0	21.5	21.0	22.0
Nov-00	11.4	10.2	10.1	10.6	12.8
Dec-00	12.5	12.6	12.4	12.5	10.9
Jan-01	9.4	10.2	9.8	9.0	9.8
Feb-01	9.1	9.6	8.8	9.0	9.7
Mar-01	14.8	15.8	14.6	15.0	13.8
Apr-01	13.2	13.5	13.4	12.3	14.3
May-01	22.2	22.5	22.2	19.9	16.8
Jun-01	24.0	24.0	24.0	22.5	21.5
Jul-01	27.0	26.2	26.5	25.4	25.3
Aug-01	24.4	24.8	24.7	23.1	25.1
Sep-01	21.0	22.5	22.3	20.8	23.4

Table 10
Depth of Sample Point (in feet), Day 1

	SITE LOCATION				
MONTH	**B**	**C**	**D**	**F**	**Ambient**
Oct-00	6.5	5.8	5.1	5.5	16.0
Nov-00	NT	NT	NT	NT	NT
Dec-00	NT	NT	NT	7.9	NT
Jan-01	6.6	5.5	5.5	7.5	17.5
Feb-01	7.0	6.5	6.5	6.8	15.0
Mar-01	7.1	7.8	7.8	5.5	15.0
Apr-01	6.8	5.0	5.0	6.8	15.0
May-01	6.7	5.0	5.0	6.5	15.5
Jun-01	7.0	4.8	4.8	7.5	16.0
Jul-01	7.0	4.5	4.5	7.0	17.0
Aug-01	6.9	4.5	4.5	7.5	16.0
Sep-01	7.5	4.8	4.8	7.2	13.0

NA - Not Available
NT - Not taken

reduced algal growth. The reduced growth was observed during December (Site B), February (Site B and F), April (Site F), May (Site B), June (Sites B, C, D and F), August (Sites B and D) and September (Site B). Site B had 6 statistically significant events. Site B also had the highest number of statistically significant events for the previous 4 water years. During June 2001 all sites had reduced algal growth.

Each concurrent *S. capricornutum* reference toxicant test had growth endpoints within the control chart limitations. However, the variability exceeded the suggested 20% acceptability criterion in 1 out of the 12 tests in March for the DMC control water. Three of the 12 DMC ambient control samples failed to meet the growth ($\geq 1x\ 10^6$) acceptability criteria in November, January and July sampling events.

The laboratory control met the minimum algal cell density on all events except three (December, July and September). These results are summarized in Table 5.

This is the 5th year that *S. capricornutum* tests have shown reduced growth in Sites B, D and F.

Definitive Bioassay Testing

Definitive bioassay testing was conducted on site B water samples for all 12 months of WY 2001 (Table 11). The definitive bioassay used a dilution series of the site water at 12. 5, 25, 50, 75, and 100 percent of the site water diluted with water from the DMC (ambient water). The results were compared to the DMC water. Laboratory control water was used as a second control to assure there was no toxicity in the DMC water.

The definitive bioassay method allowed for the determination of the No Observed Effect Concentration

Table 11
Statistical Analysis of Growth Endpoints for Algae at Station B

Test Month	IC 50	IC 25	NOEC	LOEC	Toxic Units
Feb-98	79.16	46.85	>100	>100	<1
Mar-98	83.62	58.83	50	100	2
Apr-98	>100	31.67	25	50	4
Oct-99	NA	NA	NA	NA	NA
Nov-99	>100	87.45	50	100	2
Dec-99	>100	54.44	<6.25	6.25	>16
Jan-00	72.98	38.58	25	50	4
Feb-00	>100	36.68	25	50	4
Mar-00	>100	100	>100	>100	<1
Apr-00	>100	>100	>100	>100	<1
May-00	>100	>100	>100	>100	<1
Jun-00	>100	>100	12.5	25	8
Jul-00	>100	>100	>100	>100	<1
Aug-00	>100	>100	>100	>100	<1
Sep-00	NA	NA	<6.25	6.25	>16
Oct-00	>100	>100	>100	>100	<1
Nov-00	>100	>100	>100	>100	<1
Dec-00	>100	40.91	25	50	4
Jan-01	3.67	1.84	<6.25	6.25	>16
Feb-01	>100	55.36	12.5	25	8
Mar-01	>100	>100	>100	>100	<1
Apr-01	>100	>100	>100	>100	<1
May-01	>100	81.72	50	100	2
Jun-01	75.53	12.82	<12.5	12.5	>8
Jul-01	>100	>100	50	75	2
Aug-01	>100	63.49	<12.5	12.5	>8
Sep-01	>100	23.29	>100	>100	<1

IC - Inhibition concentration: The toxicant concentration that would cause a given percent (i.e. 50% or 25%) reduction in a biological measurement (in this case, algal growth).

NOEC - No observed effect concentration: The highest concentration of toxicant to which organisms are exposed that causes no observable adverse effects.

LOEC - Lowest observed effect concentration: The lowest concentration of toxicant to which organisms are exposed which causes adverse effects.

Toxic Units: 100/NOEC. Toxicity units are used to standardize the results of toxicity tests regardless of the statistical endpoint used.

(NOEC). The NOEC is a statistically derived calculation of the amount of the test water dilution needed to eliminate those adverse effects that are measured by these tests. For example, in December 2000, the NOEC was 25 (Table 11). Therefore, a dilution of 25% of test water with 75% of ambient water was needed for the endpoint to not differ statistically from the control.

Results from the 12 monthly definitive tests for WY 2001 (Table 11) showed five samples that did not exhibit toxicity at full-strength test water (October, November, March, April, and September), two samples with a NOEC of 50 percent (May and July), one sample with a NOEC of 25 percent (December), one sample with a NOEC of 12. 5 percent (February), two samples with a NOEC less than 12. 5 (June and August) and one sample with a NOEC of less than 6. 5 percent (January).

These data also can be expressed in toxicity units (TU = 100/NOEC) (Table 11). In general, toxicity units are used to standardize the results of toxicity tests regardless of the statistical endpoint used. In the example given above for December 2000, the NOEC was 25, equivalent to 4 TU. A compilation of data for 26 months in which definitive bioassay testing of algae took place during the five years of the GBP (Table 11) showed

Table 12. Summary of Statistically Significant Results — Station B

Fathead Minnow Survival

WY	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Aug	Sept
1997												
1998												
1999												
2000												
2001												

Fathead Minnow Growth

WY	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Aug	Sept
1997					*							
1998	*	*										
1999												
2000												
2001					*				*			

Daphnia magna Survival

WY	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Aug	Sept
1997												
1998												
1999												
2000												
2001								*	*		*	

Daphnia magna Reproduction

WY	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Aug	Sept
1997												*
1998				*								
1999	*											
2000												
2001								*	*		*	

Algae Growth

WY	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Aug	Sept
1997			*		*	*	*		*			*
1998	*			*	*	*		*	*			*
1999	*	*	*	*	*						*	
2000		*	*	*	*							
2001			*		*			*	*		*	*

three months with greater than 16 TU (December 1999; September 2000; and January 2001). During this time, the drain water must be diluted more than sixteen to one to eliminate those toxic effects of the drain water that are measured by these tests. In addition, four episodes of toxicity occurred with TUs equal to or greater than 8 (June 2000; February, June, and August 2001) and four episodes of toxicity occurred with TUs of 4 (April 1998; January, February and December 2000).

Water Chemistry

Selenium

The selenium data are presented in Figure 21 and Table 16. As for the previous water years, Site B had the highest selenium concentrations with the months of March and April having the highest concentrations (>74 mg/L). The July and August 2001 sampling events had the lowest selenium concentrations of 32 to 39mg/L. As for the previous water year, Site D showed the same trends as site B with an approximate difference of 50-70% for the period October through April and then approaching the same concentrations as site B for the period June through August.

Sulfate

The sulfate results are presented in Figure 22 and Table 17. Sulfate concentrations followed similar trends as selenium concentrations for the same sites. Site B had the highest concentrations of sulfate with peaks up to 2000 mg/L in April 2001. High concentrations of sulfate were also observed in May and June. Site D followed the

Table 13. Summary of Statistically Significant Results — Station C

Fathead Minnow Survival

WY	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Aug	Sept
1997			*		*							
1998		*	*	*	*	*						
1999	*	*	*									
2000		*	*	*								
2001	*	*	*									

Fathead Minnow Growth

WY	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Aug	Sept
1997										*		
1998	*	*	*	*	*	*					*	
1999	*	*										
2000		*	*	*								
2001	*	*	*		*							

Daphnia magna Survival

WY	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Aug	Sept
1997												
1998												
1999												
2000												
2001				*					*			

Daphnia magna Reproduction

WY	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Aug	Sept
1997												*
1998												
1999												
2000												
2001									*			

Algae Growth

WY	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Aug	Sept
1997					*		*	*				
1998												
1999						*	*					
2000												
2001									*			

same trends as Site B and also showed the same relationship to Site B as the selenium concentrations.

Other Water Chemistry

The laboratory water chemistry data are presented in Figures 23–30 and Tables 18 through 27. All analyses were performed at the BES Laboratory, except for selenium and sulfate. Tables 6–9 provide water chemistry data collected in the field for conductivity, DO, pH, and temperature for the first day the sample set was collected. The conductivity was higher for Site B water for all months except July 2001. Site C and F had the lowest conductivity. The DO and pH of all stations were similar, with Site F showing the lowest pH on average. The Site B water is about three times greater in hardness than the other stations, exceeding 1000 mg/L (as $CaCO_3$) during January 2001 and March through June 2001. Total suspended solids were generally higher in Site C and F water and lowest in Site B water. Suspended solids remain higher from February through September at sites C, D and F. No trend in alkalinity was observed except that Site F is lower than the other stations sampled. The highest ammonia nitrogen concentration was observed in April 2001 at Site F (19. 52 mg/L). The total chlorine concentration ranged from non-detectable to 1. 0 mg/L for all sites sampled.

Conclusions

A total of 240 laboratory toxicity endpoints (4 sites, 12 months, and 5 tests from 3 species) compared waters from sites B, C, D, and F to the ambient control

Table 14. Summary of Statistically Significant Results — Station D

Fathead Minnow Survival

WY	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Aug	Sept
1997			*									
1998			*	*	*	*						
1999		*		*								
2000		*	*	*	*							
2001		*										

Fathead Minnow Growth

WY	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Aug	Sept
1997	*											
1998	*			*	*	*						
1999		*										
2000		*										
2001	*	*	*									

Daphnia magna Survival

WY	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Aug	Sept
1997												
1998												
1999												
2000												
2001	*								*	*	*	

Daphnia magna Reproduction

WY	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Aug	Sept
1997												
1998				*								
1999	*											
2000												
2001									*		*	

Algae Growth

WY	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Aug	Sept
1997			*		*	*		*				
1998												*
1999		*			*							
2000	*	*										
2001									*		*	

(DMC) between October 2000 and September 2001. Each set of tests included 5 toxicity endpoints (minnow survival, minnow growth, water flea survival, water flea reproduction, and algae growth). Of these tests, 42 of the 240 possible (17. 5 %) exhibited statistically significant reduced endpoints ($P<0.05$) compared to the ambient control tests (Site B = 14, Site C = 11, Site D = 12, and Site F = 5). Previous years had 25, 28, 44 and 24 for 2000, 1999, 1998 and 1997 water years, respectively.

The *Daphnia magna* was the least sensitive of the species tested, accounting for 5 significant responses for reproduction and 8 for survival during the WY 2001. For WY 1997 and 2000 there were no tests that showed significant reductions in survival of *D. magna*. During WY 1998, 1999 and 2000, there were 4, 2, and 0 responses, respectively to *D. magna* reproduction.

The algae exposed to Site B water exhibited reduced growth when compared to DMC ambient control water in 5 out of 12 months. Comparisons to previous years were 4 in WY 2000, 6 in WY 1999, 7 in WY 1998, 6 in WY 1997.

The larval fathead minnow test showed 15 significant responses, using survival and growth as the endpoint. The majority of these responses were during the winter months (October 2000 through February 2001) at Sites C, D, and F. Statistically significant events are summarized in Tables 12 through 15.

Table 15. Summary of Statistically Significant Results — Station F

Fathead Minnow Survival

WY	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Aug	Sept
1997												
1998	*				*	*			*			
1999		*		*								
2000	*	*	*		*							
2001		*										

Fathead Minnow Growth

WY	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Aug	Sept
1997												
1998	*	*			*	*			*			
1999		*		*							*	
2000		*	*		*							
2001		*										

Daphnia magna Survival

WY	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Aug	Sept
1997												
1998												
1999												
2000												
2001												

Daphnia magna Reproduction

WY	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Aug	Sept
1997												
1998				*	*							
1999												
2000												
2001												

Algae Growth

WY	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Aug	Sept
1997						*	*	*				
1998								*				
1999			*	*	*							
2000					*							
2001					*		*		*			

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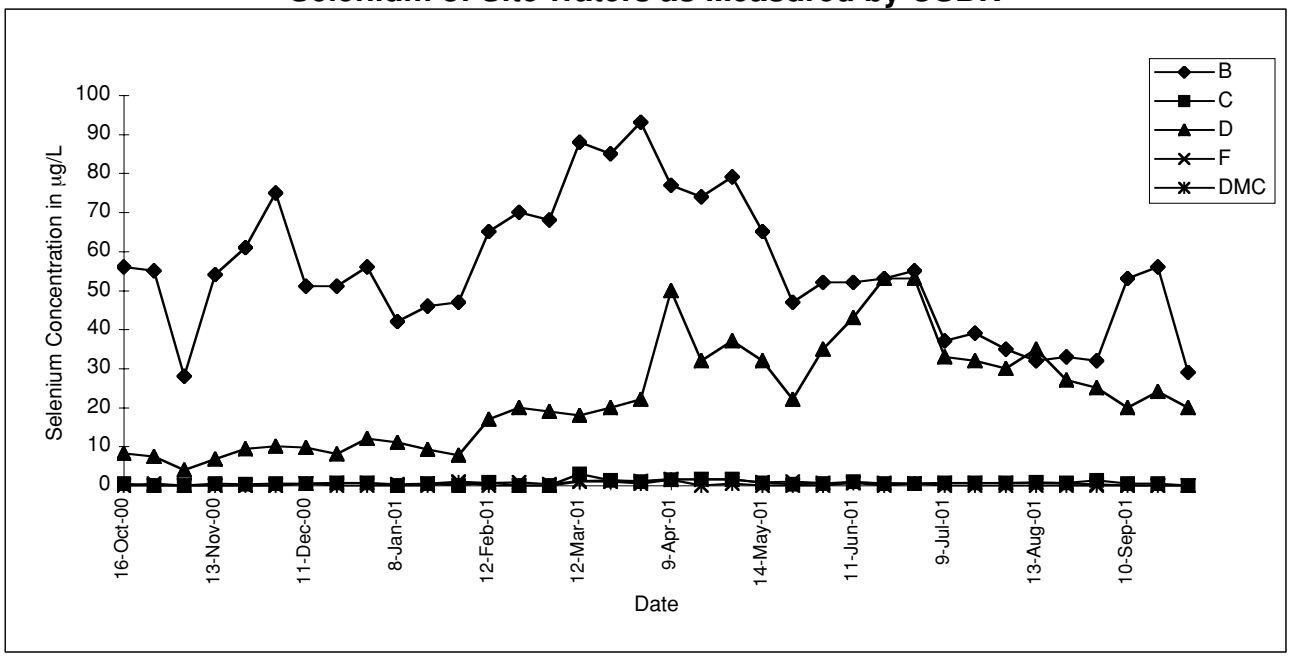
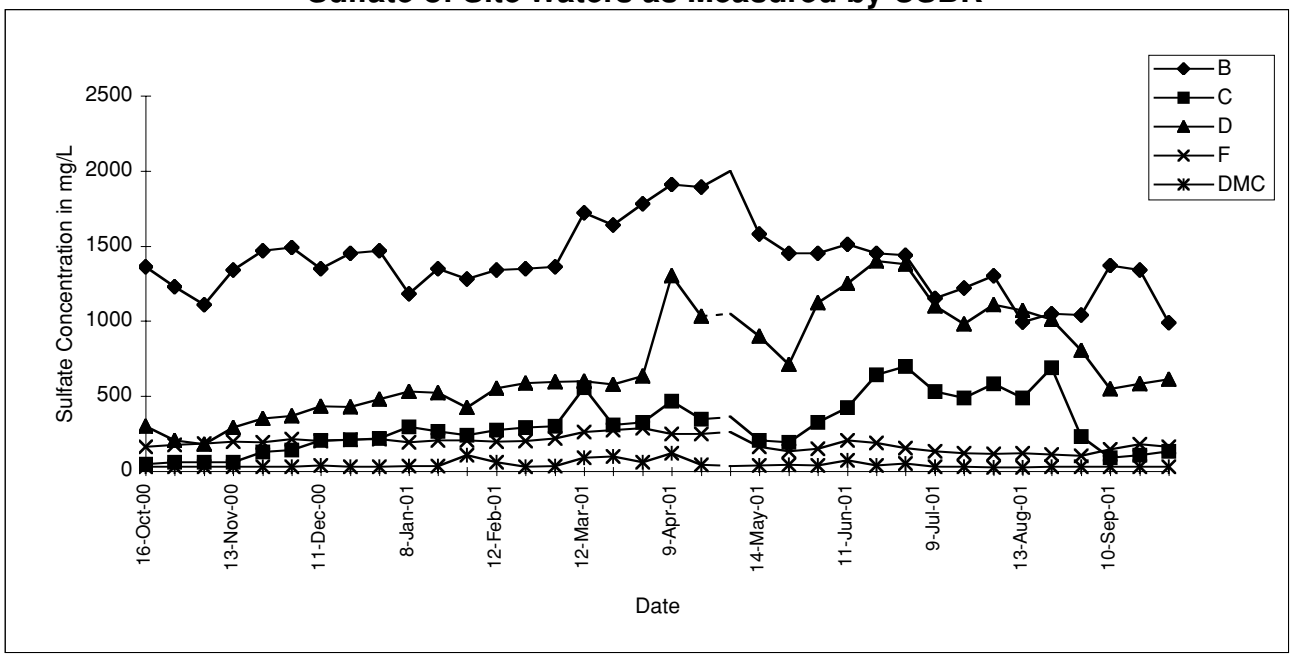
Figure 21
Selenium of Site Waters as Measured by USBR



Detection limit 0.40 µg/L for all tests

Figure 22
Sulfate of Site Waters as Measured by USBR



Data for April 7 not available

Figure 23
Conductivity of Site Waters as Measured at BES Laboratory

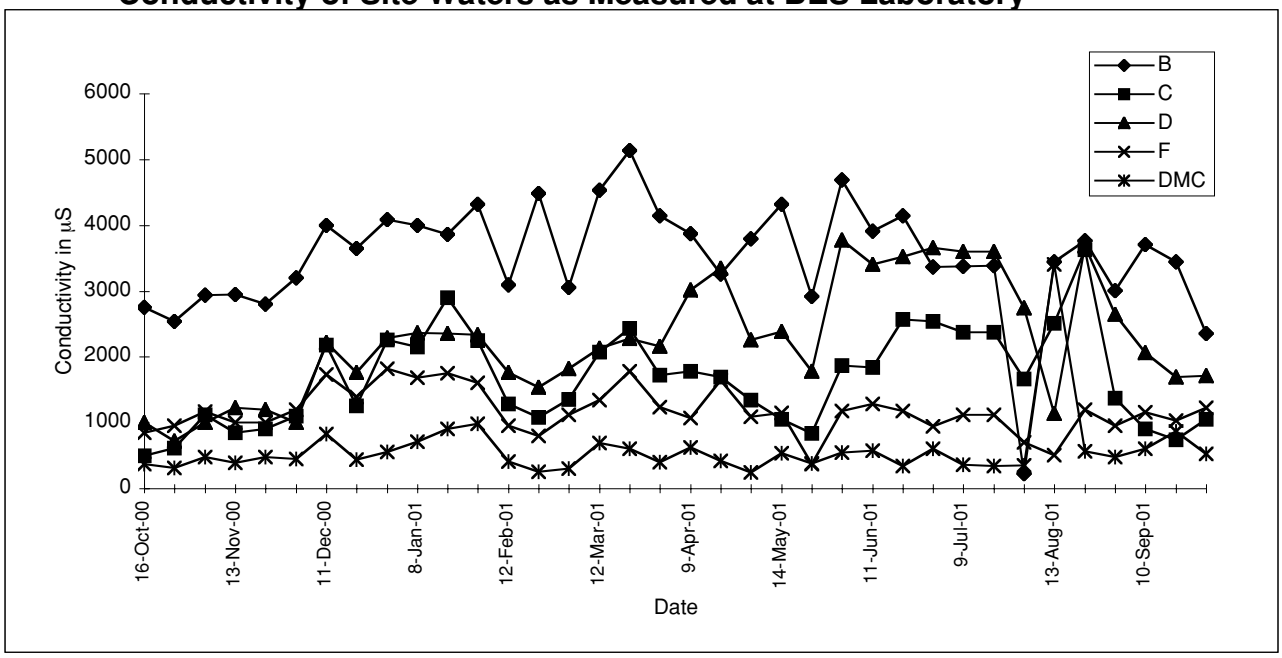


Figure 24
Total Suspended Solids of Site Waters as Measured at BES Laboratory

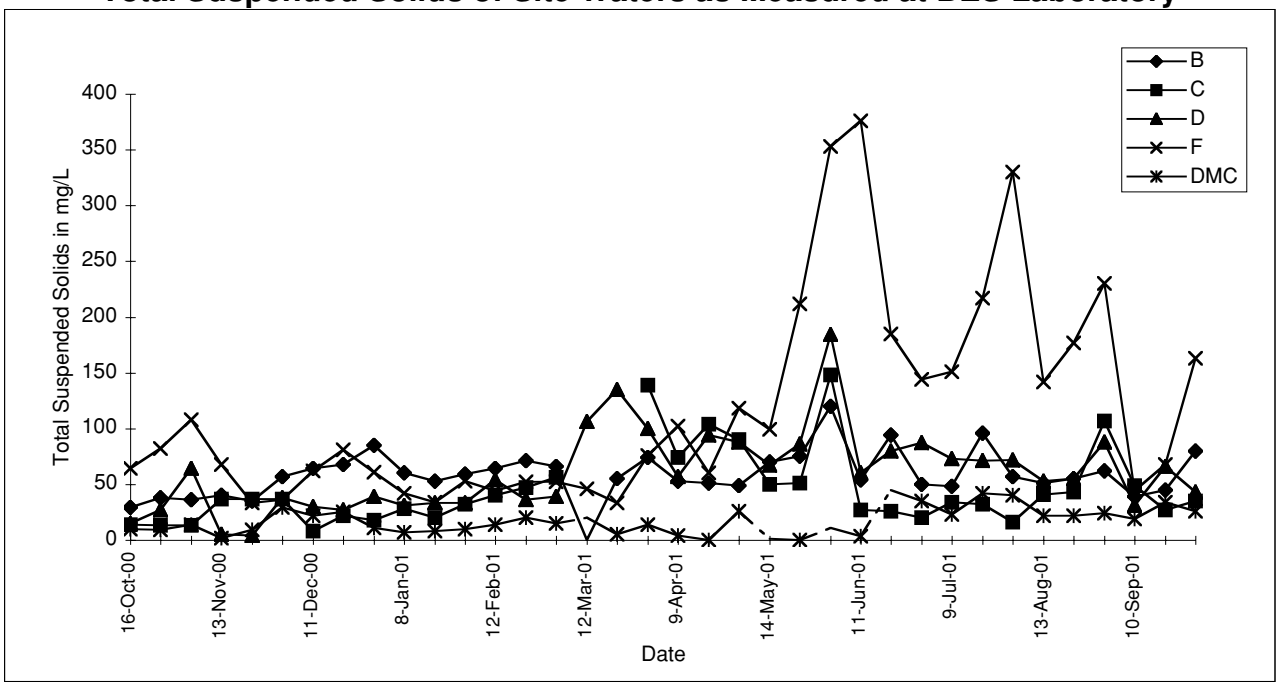


Figure 25
Dissolved Oxygen of Site Waters as Measured at the BES Laboratory

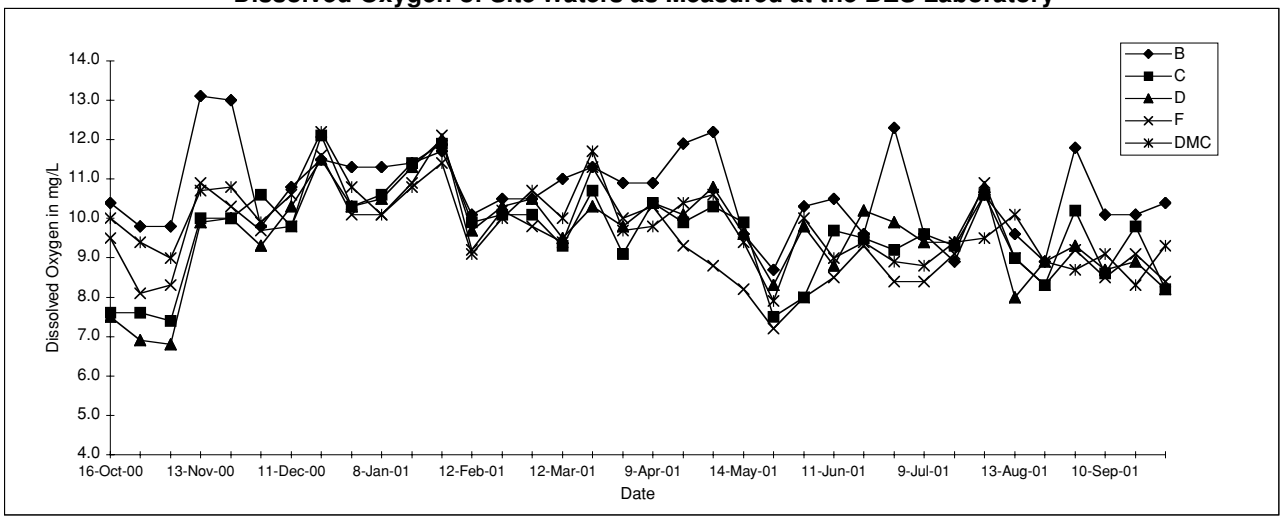


Figure 26
pH of Site Waters as Measured at the BES Laboratory

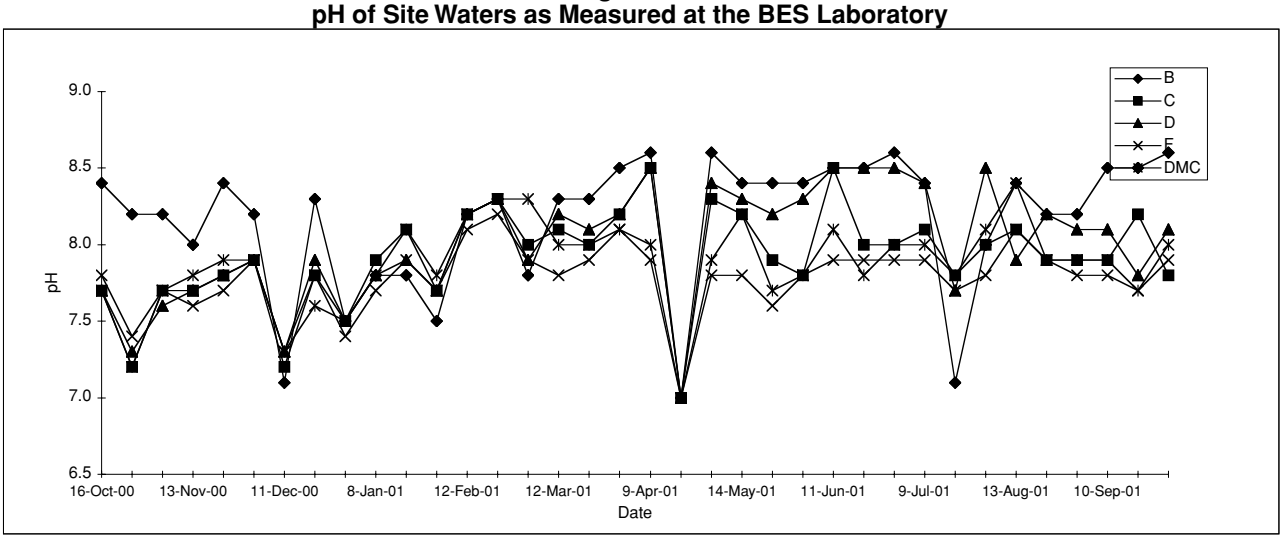
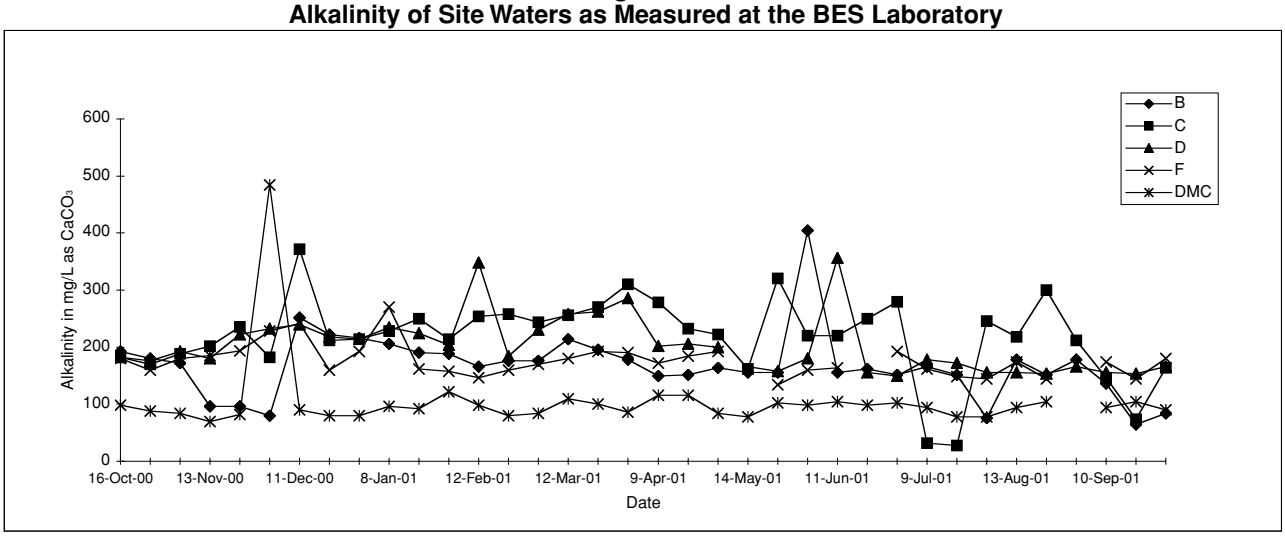


Figure 27
Alkalinity of Site Waters as Measured at the BES Laboratory



* Measurement Not Available (NA) for Site B

Figure 28
Hardness of Site Waters as Measured at the BES Laboratory

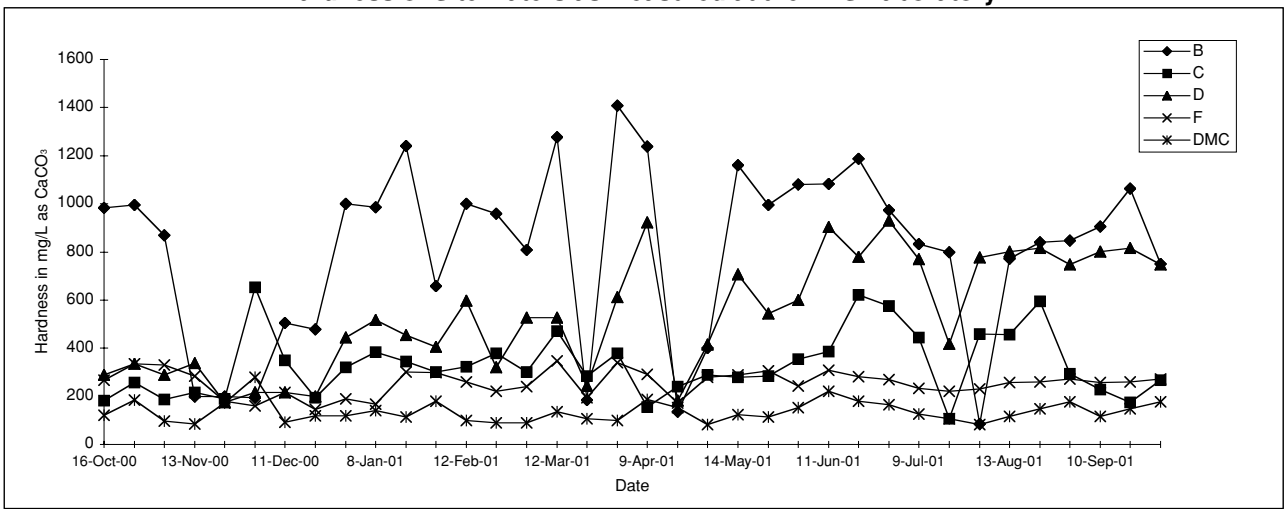


Figure 29
Ammonia of Site Waters as Measured at the BES Laboratory

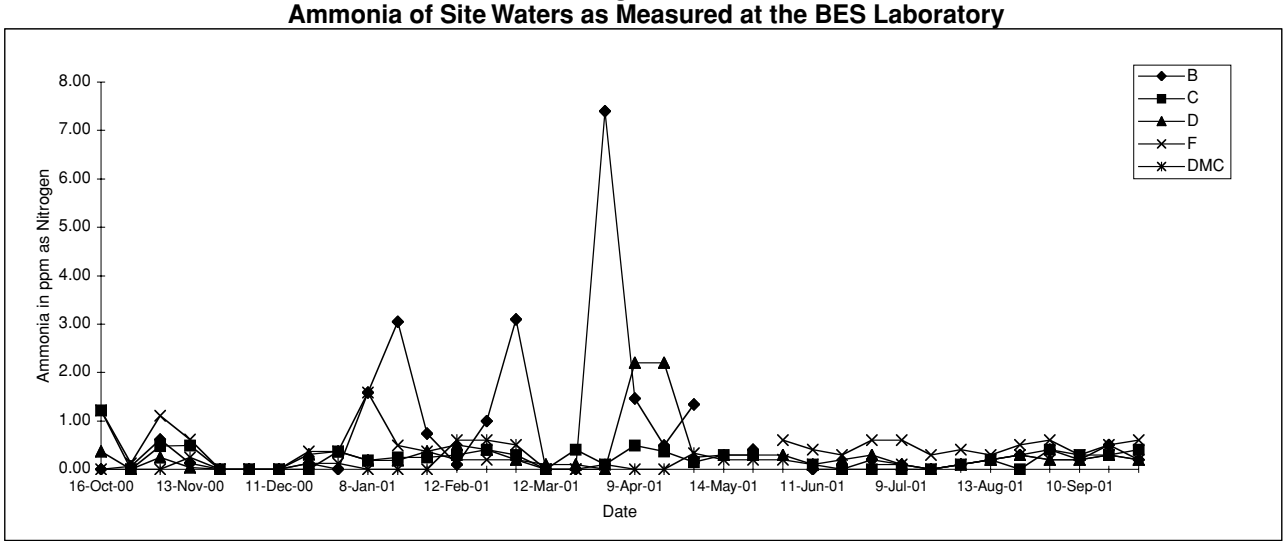
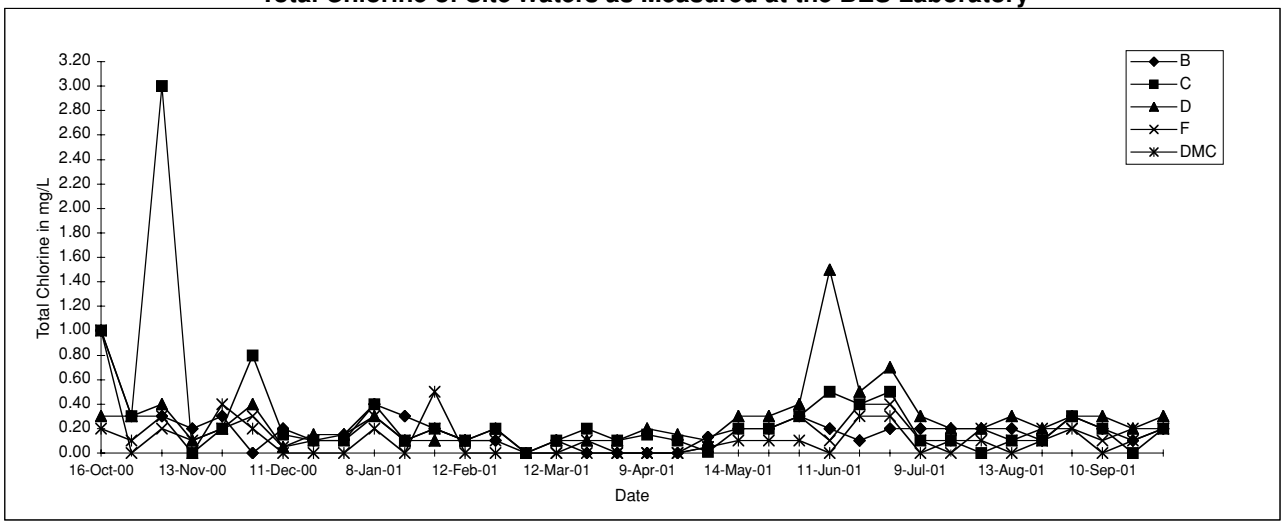


Figure 30
Total Chlorine of Site Waters as Measured at the BES Laboratory



0.0 Corresponds to a non-detectable concentration (i.e. <0.1)

TABLE 16. Selenium (µg/L) as Measured by the Bureau of Reclamation

MONTH	SAMPLE DATE	SITE LOCATION				
		B	C	D	F	DMC
Oct-00	**16-Oct-00**	56	0.5	8.3	<0.4	<0.4
	18-Oct-00	55	<0.4	7.4	0.5	<0.4
	20-Oct-00	28	<0.4	3.9	<0.4	<0.4
Nov-00	**13-Nov-00**	54	0.5	6.7	<0.4	<0.4
	15-Nov-00	61	0.4	9.4	<0.4	<0.4
	17-Nov-00	75	0.5	10	<0.4	<0.4
Dec-00	**11-Dec-00**	51	0.5	9.8	0.5	0.5
	13-Dec-00	51	0.6	8.1	0.7	<0.4
	15-Dec-00	56	0.6	12	0.6	<0.4
Jan-01	**8-Jan-01**	42	<0.4	11	0.4	<0.4
	10-Jan-01	46	0.5	9.3	0.5	<0.4
	12-Jan-01	47	<0.4	7.7	1	0.8
Feb-01	**12-Feb-01**	65	0.8	17	0.6	<0.4
	14-Feb-01	70	<0.4	20	0.8	<0.4
	16-Feb-01	68	<0.4	19	0.4	<0.4
Mar-01	**12-Mar-01**	88	2.9	18	1.2	1
	14-Mar-01	85	1.3	20	1.3	1
	16-Mar-01	93	1	22	1.2	0.5
Apr-01	**9-Apr-01**	77	1.5	50	1.7	1.5
	11-Apr-01	74	1.7	32	1.5	<0.4
	13-Apr-01	79	1.7	37	1.5	0.5
May-01	**14-May-01**	65	0.7	32	0.8	<0.4
	16-May-01	47	0.4	22	1	<0.4
	18-May-01	52	0.5	35	0.6	<0.4
Jun-01	**11-Jun-01**	52	1	43	0.6	0.6
	13-Jun-01	53	0.5	53	0.7	<0.4
	15-Jun-01	55	0.5	53	0.5	0.5
Jul-01	**9-Jul-01**	37	0.7	33	0.6	<0.4
	11-Jul-01	39	0.7	32	0.6	<0.4
	13-Jul-01	35	0.6	30	0.7	<0.4
Aug-01	**13-Aug-01**	32	0.9	35	0.6	<0.4
	15-Aug-01	33	0.6	27	0.5	<0.4
	17-Aug-01	32	1.3	25	0.4	<0.4
Sep-01	**10-Sep-01**	53	0.5	20	<0.4	<0.4
	12-Sep-01	56	0.5	24	<0.4	<0.4
	14-Sep-01	29	<0.4	20	<0.4	<0.4

TABLE 17. Sulfate (mg/L) as Measured by the Bureau of Reclamation

MONTH	SAMPLE DATE	SITE LOCATION				
		B	C	D	F	DMC
Oct-00	**16-Oct-00**	1360	47	299	162	28
	18-Oct-00	1230	60	205	175	28
	20-Oct-00	1110	61	180	185	28
Nov-00	**13-Nov-00**	1340	61	293	196	29
	15-Nov-00	1470	130	352	192	30
	17-Nov-00	1490	142	367	213	28
Dec-00	**11-Dec-00**	1350	207	432	201	39
	13-Dec-00	1450	209	426	209	29
	15-Dec-00	1470	219	481	213	29
Jan-01	**8-Jan-01**	1180	297	532	193	34
	10-Jan-01	1350	267	521	205	36
	12-Jan-01	1280	239	423	205	105
Feb-01	**12-Feb-01**	1340	276	553	199	60
	14-Feb-01	1350	290	588	202	31
	16-Feb-01	1360	299	595	220	33
Mar-01	**12-Mar-01**	1720	555	599	263	90
	14-Mar-01	1640	307	576	274	98
	16-Mar-01	1780	326	635	286	59
Apr-01	**9-Apr-01**	1910	465	1300	247	122
	11-Apr-01	1890	346	1030	250	44
	13-Apr-01	2000	366	1050	263	34
May-01	**14-May-01**	1580	204	898	162	40
	16-May-01	1450	191	709	132	41
	18-May-01	1450	324	1120	148	40
Jun-01	**11-Jun-01**	1510	423	1250	204	74
	13-Jun-01	1450	640	1400	187	37
	15-Jun-01	1440	698	1380	153	53
Jul-01	**9-Jul-01**	1150	529	1100	134	28
	11-Jul-01	1220	489	980	120	28
	13-Jul-01	1300	583	1110	115	26
Aug-01	**13-Aug-01**	995	490	1070	122	26
	15-Aug-01	1050	691	1010	113	28
	17-Aug-01	1040	231	804	102	30
Sep-01	**10-Sep-01**	1370	90	547	144	30
	12-Sep-01	1340	108	581	178	32
	14-Sep-01	988	131	614	164	32

TABLE 18. Conductivity (μS) of Site Waters as Received at the BES Laboratory

MONTH	SAMPLE DATE	SITE LOCATION				
		B	C	D	F	DMC
Oct-00	16-Oct-00	2750	500	1000	850	370
	18-Oct-00	2540	610	720	950	310
	20-Oct-00	2940	1120	1000	1170	480
Nov-00	13-Nov-00	2950	850	1230	1000	390
	15-Nov-00	2800	900	1200	1000	480
	17-Nov-00	3200	1100	1000	1200	450
Dec-00	11-Dec-00	4000	2180	2220	1730	830
	13-Dec-00	3650	1250	1760	1390	440
	15-Dec-00	4080	2260	2290	1820	550
Jan-01	8-Jan-01	4000	2150	2360	1680	710
	10-Jan-01	3860	2900	2350	1750	900
	12-Jan-01	4320	2250	2330	1600	980
Feb-01	12-Feb-01	3097	1287	1756	950	413
	14-Feb-01	4480	1080	1540	800	250
	16-Feb-01	3051	1356	1819	1121	297
Mar-01	12-Mar-01	4535	2073	2127	1340	686
	14-Mar-01	5131	2434	2273	1779	599
	16-Mar-01	4141	1717	2158	1235	401
Apr-01	9-Apr-01	3875	1777	3010	1071	625
	11-Apr-01	3254	1690	3343	1643	415
	13-Apr-01	3791	1344	2257	1090	239
May-01	14-May-01	4316	1046	2379	1147	530
	16-May-01	2916	836	1780	372	379
	18-May-01	4683	1863	3775	1173	545
Jun-01	11-Jun-01	3906	1835	3406	1285	571
	13-Jun-01	4145	2565	3521	1175	338
	15-Jun-01	3363	2540	3654	944	606
Jul-01	9-Jul-01	3375	2372	3595	1117	363
	11-Jul-01	3380	2370	3595	1117	340
	13-Jul-01	226	1667	2744	700	349
Aug-01	13-Aug-01	3446	2506	1133	510	3408
	15-Aug-01	3765	3632	3690	1192	566
	17-Aug-01	3005	1367	2643	957	476
Sep-01	10-Sep-01	3709	905	2057	1155	606
	12-Sep-01	3438	740	1692	1030	868
	14-Sep-01	2357	1053	1713	1224	529

TABLE 19. Total Suspended Solids (mg/L) of Site Waters as Received at the BES Laboratory

MONTH	SAMPLE DATE	SITE LOCATION				
		B	C	D	F	DMC
Oct-00	**16-Oct-00**	29	14	15	64	10
	18-Oct-00	38	13	27	82	9
	20-Oct-00	36	13	64	108	14
Nov-00	**13-Nov-00**	40	37	5	68	2
	15-Nov-00	35	37	4	33	9
	17-Nov-00	57	37	38	36	29
Dec-00	**11-Dec-00**	64	8	30	62	22
	13-Dec-00	68	22	27	81	25
	15-Dec-00	85	18	39	61	11
Jan-01	**8-Jan-01**	60	28	31	42	7
	10-Jan-01	53	20	33	34	8
	12-Jan-01	59	32	33	53	10
Feb-01	**12-Feb-01**	64	40	54	44	14
	14-Feb-01	71	47	36	52	20
	16-Feb-01	66	56	39	52	15
Mar-01	**12-Mar-01**	NA	296	106	46	20
	14-Mar-01	55	229	135	33	5
	16-Mar-01	74	139	100	76	14
Apr-01	**9-Apr-01**	53	74	57	102	4
	11-Apr-01	51	104	94	60	NA*
	13-Apr-01	49	90	88	118	26
May-01	**14-May-01**	70	50	67	99	1
	16-May-01	75	51	86	212	ND
	18-May-01	120	148	184	353	11
Jun-01	**11-Jun-01**	54	27	60	376	3.2
	13-Jun-01	94	26	80	185	45
	15-Jun-01	50	20	87	144	35
Jul-01	**9-Jul-01**	48	34	73	151	23
	11-Jul-01	96	32	71	217	42
	13-Jul-01	57	16	72	330	40
Aug-01	**13-Aug-01**	51	41	53	142	22
	15-Aug-01	55	43	55	177	22
	17-Aug-01	62	107	88	230	24
Sep-01	**10-Sep-01**	39	49	31	44	19
	12-Sep-01	45	27	66	68	34
	14-Sep-01	80	35	43	163	26

NA=Not available
*=All water consumed in bioassay

TABLE 20. Dissolved Oxygen (mg/L) of Site Waters as Received at the BES Laboratory

MONTH	SAMPLE DATE	SITE LOCATION				
		B	C	D	F	DMC
Oct-00	16-Oct-00	10.4	7.6	7.5	9.5	10.0
	18-Oct-00	9.8	7.6	6.9	8.1	9.4
	20-Oct-00	9.8	7.4	6.8	8.3	9.0
Nov-00	13-Nov-00	13.1	10.0	9.9	10.9	10.7
	15-Nov-00	13.0	10.0	10.0	10.3	10.8
	17-Nov-00	9.8	10.6	9.3	9.7	9.9
Dec-00	11-Dec-00	10.8	9.8	10.3	9.8	10.6
	13-Dec-00	11.5	12.1	11.5	11.6	12.2
	15-Dec-00	11.3	10.3	10.3	10.1	10.8
Jan-01	8-Jan-01	11.3	10.6	10.5	10.1	10.1
	10-Jan-01	11.4	11.4	11.3	10.9	10.8
	12-Jan-01	11.7	11.9	12.0	12.1	11.4
Feb-01	12-Feb-01	10.1	9.9	9.7	9.2	9.1
	14-Feb-01	10.5	10.1	10.3	10.2	10.0
	16-Feb-01	10.5	10.1	10.5	9.8	10.7
Mar-01	12-Mar-01	11.0	9.3	9.5	9.4	10.0
	14-Mar-01	11.3	10.7	10.3	11.3	11.7
	16-Mar-01	10.9	9.1	9.8	10.0	9.7
Apr-01	9-Apr-01	10.9	10.4	10.4	10.3	9.8
	11-Apr-01	11.9	9.9	10.1	9.3	10.4
	13-Apr-01	12.2	10.3	10.8	8.8	10.6
May-01	14-May-01	9.6	9.9	9.6	8.2	9.4
	16-May-01	8.7	7.5	8.3	7.2	7.9
	18-May-01	10.3	8.0	9.8	8.0	10.0
Jun-01	11-Jun-01	10.5	9.7	8.8	8.5	9.0
	13-Jun-01	9.6	9.5	10.2	9.3	9.4
	15-Jun-01	12.3	9.2	9.9	8.4	8.9
Jul-01	9-Jul-01	9.6	9.6	9.4	8.4	8.8
	11-Jul-01	8.9	9.3	9.4	9.1	9.4
	13-Jul-01	10.6	10.6	10.8	10.9	9.5
Aug-01	13-Aug-01	9.6	9.0	8.0	9.0	10.1
	15-Aug-01	8.9	8.3	8.9	8.3	8.9
	17-Aug-01	11.8	10.2	9.3	9.2	8.7
Sep-01	10-Sep-01	10.1	8.6	8.7	8.5	9.1
	12-Sep-01	10.1	9.8	8.9	9.1	8.3
	14-Sep-01	10.4	8.2	8.2	8.4	9.3

TABLE 21. pH of Site Waters as Received at the BES Laboratory

MONTH	SAMPLE DATE	SITE LOCATION				
		B	C	D	F	DMC
Oct-00	16-Oct-00	8.4	7.7	7.7	7.8	7.7
	18-Oct-00	8.2	7.2	7.3	7.4	7.2
	20-Oct-00	8.2	7.7	7.6	7.7	7.7
Nov-00	13-Nov-00	8.0	7.7	7.7	7.6	7.8
	15-Nov-00	8.4	7.8	7.8	7.7	7.9
	17-Nov-00	8.2	7.9	7.9	7.9	7.9
Dec-00	11-Dec-00	7.1	7.2	7.3	7.3	7.3
	13-Dec-00	8.3	7.8	7.9	7.8	7.6
	15-Dec-00	7.5	7.5	7.5	7.4	7.5
Jan-01	8-Jan-01	7.8	7.9	7.8	7.7	7.8
	10-Jan-01	7.8	8.1	7.9	7.9	8.1
	12-Jan-01	7.5	7.7	7.7	7.7	7.8
Feb-01	12-Feb-01	8.2	8.2	8.2	8.1	8.2
	14-Feb-01	8.3	8.3	8.3	8.2	8.3
	16-Feb-01	7.8	8.0	7.9	7.9	8.3
Mar-01	12-Mar-01	8.3	8.1	8.2	7.8	8.0
	14-Mar-01	8.3	8.0	8.1	7.9	8.0
	16-Mar-01	8.5	8.2	8.2	8.1	8.1
Apr-01	9-Apr-01	8.6	8.5	8.5	7.9	8.0
	11-Apr-01	7.0	7.0	7.0	7.0	7.0
	13-Apr-01	8.6	8.3	8.4	7.8	7.9
May-01	14-May-01	8.4	8.2	8.3	7.8	8.2
	16-May-01	8.4	7.9	8.2	7.6	7.7
	18-May-01	8.4	7.8	8.3	7.8	7.8
Jun-01	11-Jun-01	8.5	8.5	8.5	7.9	8.1
	13-Jun-01	8.5	8.0	8.5	7.9	7.8
	15-Jun-01	8.6	8.0	8.5	7.9	8.0
Jul-01	9-Jul-01	8.4	8.1	8.4	7.9	8.0
	11-Jul-01	7.1	7.8	7.7	7.7	7.8
	13-Jul-01	8.0	8.0	8.5	7.8	8.1
Aug-01	13-Aug-01	8.4	8.1	7.9	8.1	8.4
	15-Aug-01	8.2	7.9	8.2	7.9	7.9
	17-Aug-01	8.2	7.9	8.1	7.8	7.9
Sep-01	10-Sep-01	8.5	7.9	8.1	7.8	7.9
	12-Sep-01	8.5	8.2	7.8	7.7	7.7
	14-Sep-01	8.6	7.8	8.1	7.9	8.0

TABLE 22. Salinity (ppt) of Site Waters as Received at the BES Laboratory

MONTH	SAMPLE DATE	SITE LOCATION				
		B	C	D	F	DMC
Oct-00	16-Oct-00	1.5	ND	0.5	0.5	0.1
	18-Oct-00	1.2	0.2	0.3	0.5	0.1
	20-Oct-00	1.5	0.3	0.5	0.8	0.2
Nov-00	13-Nov-00	1.7	0.6	0.7	0.6	0.3
	15-Nov-00	1.8	0.7	0.8	0.7	0.3
	17-Nov-00	5.0	5.0	5.0	5.0	0.1
Dec-00	11-Dec-00	2.0	1.0	1.0	1.0	ND
	13-Dec-00	2.0	1.0	1.0	ND	ND
	15-Dec-00	2.0	1.0	1.0	1.0	ND
Jan-01	8-Jan-01	2.0	1.0	2.0	1.0	1.0
	10-Jan-01	4.0	2.0	2.0	1.0	1.0
	12-Jan-01	3.0	2.0	2.0	1.0	1.0
Feb-01	12-Feb-01	2.4	0.9	1.3	0.7	0.3
	14-Feb-01	2.4	0.9	1.4	0.7	0.2
	16-Feb-01	2.4	1.0	1.4	0.8	0.2
Mar-01	12-Mar-01	3.0	1.5	1.4	0.8	0.3
	14-Mar-01	3.0	1.5	1.5	0.8	0.3
	16-Mar-01	3.0	1.2	1.6	0.9	0.3
Apr-01	9-Apr-01	27.0	1.2	2.2	0.7	0.4
	11-Apr-01	2.7	0.9	1.7	0.8	0.2
	13-Apr-01	2.9	0.9	1.7	0.8	0.2
May-01	14-May-01	2.7	0.7	1.7	0.7	0.3
	16-May-01	2.3	0.7	1.4	0.5	0.3
	18-May-01	2.0	1.0	2.0	0.3	0.3
Jun-01	11-Jun-01	2.6	1.0	2.2	0.8	0.3
	13-Jun-01	2.5	1.6	2.4	0.7	0.2
	15-Jun-01	2.4	1.7	2.4	0.6	0.4
Jul-01	9-Jul-01	0.2	1.2	1.9	0.6	0.2
	11-Jul-01	0.2	1.2	1.8	0.6	0.2
	13-Jul-01	0.2	1.3	2.0	0.5	0.2
Aug-01	13-Aug-01	1.9	1.3	0.6	0.3	2.0
	15-Aug-01	3.6	2.1	1.9	0.6	0.3
	17-Aug-01	3.5	0.8	1.7	0.6	0.3
Sep-01	10-Sep-01	2.2	0.5	1.2	0.7	0.3
	12-Sep-01	2.2	0.4	1.2	0.8	0.5
	14-Sep-01	1.8	0.7	1.3	0.8	0.4

ND=Not Detected

TABLE 23. Alkalinity (as mg/L $CaCO_3$) of Site Waters as Received at the BES Laboratory

MONTH	SAMPLE DATE	SITE LOCATION				
		B	C	D	F	DMC
Oct-00	**16-Oct-00**	192	182	182	180	98
	18-Oct-00	180	170	176	160	88
	20-Oct-00	172	188	192	180	84
Nov-00	**13-Nov-00**	96	202	180	185	70
	15-Nov-00	96	236	222	194	82
	17-Nov-00	80	182	232	228	484
Dec-00	**11-Dec-00**	252	372	240	242	90
	13-Dec-00	222	212	218	160	80
	15-Dec-00	216	214	214	192	80
Jan-01	**8-Jan-01**	206	228	234	270	96
	10-Jan-01	190	250	224	162	92
	12-Jan-01	188	214	204	158	122
Feb-01	**12-Feb-01**	166	254	348	146	98
	14-Feb-01	176	258	184	160	80
	16-Feb-01	176	244	230	170	84
Mar-01	**12-Mar-01**	214	256	258	180	110
	14-Mar-01	196	270	262	192	100
	16-Mar-01	178	310	286	190	86
Apr-01	**9-Apr-01**	150	278	202	172	116
	11-Apr-01	152	232	206	184	116
	13-Apr-01	164	222	200	192	84
May-01	**14-May-01**	156	162	166	158	78
	16-May-01	156	320	158	134	102
	18-May-01	404	220	180	160	98
Jun-01	**11-Jun-01**	156	220	356	164	104
	13-Jun-01	162	250	156	166	98
	15-Jun-01	152	280	150	192	102
Jul-01	**9-Jul-01**	166	32	178	162	94
	11-Jul-01	152	28	172	148	78
	13-Jul-01	76	246	156	144	78
Aug-01	**13-Aug-01**	178	218	156	174	94
	15-Aug-01	152	300	154	144	104
	17-Aug-01	178	212	166	180	90
Sep-01	**10-Sep-01**	136	146	156	174	94
	12-Sep-01	64	74	154	144	104
	14-Sep-01	84	164	166	180	90

NA=Not Available

TABLE 24. Hardness (as mg/L $CaCO_3$) of Site Waters as Received at the BES Laboratory

MONTH	SAMPLE DATE	SITE LOCATION				
		B	C	D	F	DMC
Oct-00	16-Oct-00	984	182	288	268	122
	18-Oct-00	996	258	336	336	184
	20-Oct-00	868	186	290	330	96
Nov-00	13-Nov-00	200	216	338	284	86
	15-Nov-00	200	190	176	180	172
	17-Nov-00	194	652	216	160	280
Dec-00	11-Dec-00	504	350	216	216	92
	13-Dec-00	478	194	200	146	118
	15-Dec-00	1000	320	444	190	118
Jan-01	8-Jan-01	986	384	516	168	142
	10-Jan-01	1240	344	454	300	114
	12-Jan-01	658	300	406	298	180
Feb-01	12-Feb-01	1000	324	598	260	100
	14-Feb-01	960	378	320	220	90
	16-Feb-01	808	300	528	240	90
Mar-01	12-Mar-01	1278	470	526	346	136
	14-Mar-01	184	284	242	194	106
	16-Mar-01	1408	378	612	340	100
Apr-01	9-Apr-01	1238	156	922	292	188
	11-Apr-01	136	240	182	172	154
	13-Apr-01	400	290	414	280	82
May-01	14-May-01	1160	278	706	290	124
	16-May-01	996	284	544	306	114
	18-May-01	1080	354	600	244	154
Jun-01	11-Jun-01	1082	386	902	308	220
	13-Jun-01	1188	622	780	282	180
	15-Jun-01	974	576	930	270	166
Jul-01	9-Jul-01	832	444	770	234	126
	11-Jul-01	798	108	418	222	108
	13-Jul-01	86	458	776	230	82
Aug-01	13-Aug-01	772	456	802	258	116
	15-Aug-01	840	596	816	260	148
	17-Aug-01	848	294	748	272	178
Sep-01	10-Sep-01	906	228	802	258	116
	12-Sep-01	1064	174	816	260	148
	14-Sep-01	750	266	748	272	178

NA=Not Available

TABLE 25. Temperature (°C) of Site Waters as Received at the BES Laboratory

MONTH	SAMPLE DATE	SITE LOCATION				
		B	C	D	F	DMC
Oct-00	16-Oct-00	12.0	5.0	6.0	5.0	12.0
	18-Oct-00	6.2	7.1	5.9	6.2	6.2
	20-Oct-00	4.0	5.0	5.0	9.0	11.0
Nov-00	13-Nov-00	4.3	4.3	3.6	3.8	7.0
	15-Nov-00	4.0	4.0	4.0	4.0	4.0
	17-Nov-00	6.0	6.0	6.0	6.0	6.0
Dec-00	11-Dec-00	8.0	10.0	10.8	10.0	10.0
	13-Dec-00	2.3	3.4	2.8	3.2	3.0
	15-Dec-00	2.0	2.0	2.0	2.0	2.0
Jan-01	8-Jan-01	9.2	9.4	8.2	8.7	8.4
	10-Jan-01	10.0	8.9	9.0	9.0	6.0
	12-Jan-01	5.5	5.5	5.5	5.5	8.5
Feb-01	12-Feb-01	9.1	9.2	8.7	9.5	9.6
	14-Feb-01	2.7	2.8	3.2	3.3	3.3
	16-Feb-01	3.2	2.5	2.9	4.6	3.2
Mar-01	12-Mar-01	16.3	10.0	15.0	15.7	16.0
	14-Mar-01	5.0	6.5	11.5	5.5	5.0
	16-Mar-01	6.0	3.0	4.2	4.5	6.0
Apr-01	9-Apr-01	12.0	13.1	11.0	10.9	13.1
	11-Apr-01	3.0	3.9	4.0	3.5	3.9
	13-Apr-01	6.5	9.1	5.3	6.0	6.1
May-01	14-May-01	15.0	8.0	7.0	13.5	18.0
	16-May-01	4.9	5.0	5.0	4.9	11.8
	18-May-01	6.5	8.7	6.5	9.0	8.0
Jun-01	11-Jun-01	14.5	15.1	21.3	17.0	16.9
	13-Jun-01	15.4	8.9	6.3	6.2	3.9
	15-Jun-01	6.0	9.5	10.2	10.0	10.1
Jul-01	9-Jul-01	19.7	17.9	22.5	24.0	22.2
	11-Jul-01	15.0	18.0	15.0	15.0	15.0
	13-Jul-01	6.7	5.7	11.5	8.3	11.0
Aug-01	13-Aug-01	23.7	22.8	24.0	21.7	21.8
	15-Aug-01	14.9	13.6	13.7	13.9	13.9
	17-Aug-01	10.3	12.5	12.0	11.9	10.5
Sep-01	10-Sep-01	18.0	17.2	17.4	14.6	16.7
	12-Sep-01	8.0	8.5	8.5	9.1	8.5
	14-Sep-01	7.5	14.8	6.4	7.4	8.4

TABLE 26. Ammonia (ppm as Nitrogen) of Site Waters as Received at the BES Laboratory

MONTH	SAMPLE DATE	SITE LOCATION				
		B	C	D	F	DMC
Oct-00	16-Oct-00	ND	1.22	0.37	1.22	ND
	18-Oct-00	0.06	ND	ND	0.12	ND
	20-Oct-00	0.61	0.48	0.24	1.10	ND
Nov-00	13-Nov-00	0.12	0.49	0.04	0.61	0.24
	15-Nov-00	ND	ND	ND	ND	ND
	17-Nov-00	ND	ND	ND	ND	ND
Dec-00	11-Dec-00	ND	ND	ND	ND	ND
	13-Dec-00	0.12	ND	0.31	0.37	0.12
	15-Dec-00	ND	0.37	0.37	0.37	0.12
Jan-01	8-Jan-01	1.59	0.18	0.18	1.59	ND
	10-Jan-01	3.05	0.24	0.18	0.49	ND
	12-Jan-01	0.73	0.24	0.37	0.37	ND
Feb-01	12-Feb-01	0.10	0.30	0.50	0.20	0.60
	14-Feb-01	1.00	0.40	0.40	0.20	0.60
	16-Feb-01	3.10	0.30	0.20	0.20	0.50
Mar-01	12-Mar-01	ND	ND	0.10	ND	ND
	14-Mar-01	ND	0.40	0.10	ND	ND
	16-Mar-01	7.40	0.10	ND	ND	0.10
Apr-01	9-Apr-01	1.46	0.49	2.20	19.52	ND
	11-Apr-01	0.49	0.37	2.20	19.52	ND
	13-Apr-01	1.34	0.15	0.24	0.18	0.33
May-01	14-May-01	0.40	0.30	0.30	0.80	0.20
	16-May-01	0.40	0.30	0.30	0.80	0.20
	18-May-01	0.30	0.20	0.30	0.60	0.20
Jun-01	11-Jun-01	ND	0.10	0.10	0.40	0.10
	13-Jun-01	ND	ND	0.20	0.30	0.20
	15-Jun-01	0.20	ND	0.30	0.60	0.10
Jul-01	9-Jul-01	0.10	ND	0.10	0.60	0.10
	11-Jul-01	ND	ND	ND	0.30	ND
	13-Jul-01	0.10	0.10	0.10	0.40	0.10
Aug-01	13-Aug-01	0.20	0.20	0.20	0.30	0.20
	15-Aug-01	0.30	ND	0.30	0.50	0.30
	17-Aug-01	0.40	0.40	0.20	0.60	0.20
Sep-01	10-Sep-01	0.20	0.30	0.20	0.30	0.20
	12-Sep-01	0.50	0.30	0.30	0.50	0.30
	14-Sep-01	0.20	0.40	0.20	0.60	0.20

NA=Not Available
ND=Not Detected

TABLE 27. Total Chlorine (mg/L) of Site Waters as Received at the BES Laboratory

MONTH	SAMPLE DATE	SITE LOCATION				
		B	C	D	F	DMC
Oct-00	**16-Oct-00**	1.00	1.00	0.30	1.00	0.20
	18-Oct-00	0.30	0.30	0.30	ND	0.10
	20-Oct-00	0.30	3.00	0.40	0.20	0.30
Nov-00	**13-Nov-00**	0.20	ND	0.10	0.10	ND
	15-Nov-00	0.30	0.20	0.20	0.20	0.40
	17-Nov-00	ND	0.80	0.40	0.30	0.20
Dec-00	**11-Dec-00**	0.20	0.15	0.05	0.05	ND
	13-Dec-00	0.10	0.10	0.15	0.10	ND
	15-Dec-00	0.15	0.10	0.15	0.10	ND
Jan-01	**8-Jan-01**	0.40	0.40	0.30	0.30	0.20
	10-Jan-01	0.30	0.10	0.10	0.10	ND
	12-Jan-01	0.20	0.20	0.10	0.20	0.50
Feb-01	**12-Feb-01**	0.10	0.10	0.10	0.10	ND
	14-Feb-01	0.10	0.20	0.20	0.10	ND
	16-Feb-01	ND	ND	ND	ND	ND
Mar-01	**12-Mar-01**	0.10	0.10	0.10	ND	ND
	14-Mar-01	ND	0.20	0.10	ND	0.10
	16-Mar-01	ND	0.10	0.10	ND	ND
Apr-01	**9-Apr-01**	ND	0.15	0.20	ND	ND
	11-Apr-01	ND	0.10	0.15	ND	ND
	13-Apr-01	0.13	0.01	0.10	0.05	0.05
May-01	**14-May-01**	0.20	0.20	0.30	0.10	0.10
	16-May-01	0.20	0.20	0.30	0.10	0.10
	18-May-01	0.30	0.30	0.40	0.30	0.10
Jun-01	**11-Jun-01**	0.20	0.50	1.50	0.10	ND
	13-Jun-01	0.10	0.40	0.50	0.40	0.30
	15-Jun-01	0.20	0.50	0.70	0.40	0.30
Jul-01	**9-Jul-01**	0.20	0.10	0.30	0.10	ND
	11-Jul-01	0.20	0.10	0.20	ND	0.10
	13-Jul-01	0.20	ND	0.20	0.20	0.10
Aug-01	**13-Aug-01**	0.20	0.10	0.30	0.10	ND
	15-Aug-01	0.10	0.10	0.20	0.20	0.10
	17-Aug-01	0.30	0.30	0.30	0.20	0.20
Sep-01	**10-Sep-01**	0.20	0.20	0.30	0.10	ND
	12-Sep-01	0.10	ND	0.20	0.20	0.10
	14-Sep-01	0.20	0.20	0.30	0.20	0.20

NA=Not Available
ND=Not Detected
* =Chlorine level measured at 2.5 mg/l, which is believed to be erroneous data