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# Strawberry Sill Water Quality Analysis

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*March 19, 2004*

# 1 Summary


- The purpose of this report is to analyze the available water quality data from Strawberry Sill, comparing the sill to water quality at the Intake and at Site 3. For the purpose of these analyses, $\Rightarrow$ only depths $\leq$40 m from Site 3 were included.

- Strawberry Sill stratifies at about the same depth as Site 3. Water temperatures along the sill were similar to those at Site 3, and surface water temperatures along the sill were similar to Site 3 and the Intake.

- Because the sill stratifies, its water quality was often more similar to Site 3 than the Intake (which doesn't stratify).

- Hypolimnetic oxygen deficits of about 1–3 mg/L were common along the sill during late summer and early fall.

- Sill alkalinity, turbidity, and phosphorus concentrations were usually very low, similar to both Site 3 and the Intake. Nitrate/nitrite followed typical patterns for Lake Whatcom.

- The total organic carbon concentrations may be slightly higher along the sill compared to Site 3 and the Intake.

  – Because of the importance of this parameter to drinking water treatment, additional TOC samples should be collected to characterize sill water quality.

- Chlorophyll samples were not collected from the sill.

  – Because of the importance of this parameter to drinking water treatment, chlorophyll samples should be collected to characterize sill water quality.

- The metals data were fairly similar between all sites, and there were no consistent seasonal patterns evident in the data. There were a number of outlier points (at all sites), but most concentrations were at or below detection.

# 2 Background Information

## 2.1 Sill Sampling Objectives and Site Descriptions

The Strawberry Sill sampling program was included as part of the long-term Lake Whatcom monitoring program. Five lake sites are included in the long-term monitoring program: Sites 1–4, located at the deepest points in their respective basins, and the Intake site (Figure 1, page 12). Beginning in October 1996, three sampling sites were added along the 40-meter contour of Strawberry Sill (Sites s1–s3 on Figure 2, page 13). The sill sampling effort was limited to monthly Hydrolab measurements and biannual water quality analyses. In October 2000, the sampling effort along the sill was reduced to a single site (s2), and all sampling was discontinued after September 2002.

## 2.2 Field Sampling and Analytical Methods

The Strawberry Sill sites were sampled less frequently than the long-term monitoring sites (see Matthews, et al., 2004 for a complete description of the current lake monitoring program). In addition, because of the time required to sample basin 3, the sill sites were not always sampled on the same dates as the long-term monitoring sites. Table 1 (page 8) lists the sampling dates of the sill and long-term monitoring sites.

A Surveyor IV Hydrolab was used to measure temperature, pH, dissolved oxygen, and conductivity. All water samples collected in the field were stored on ice and in the dark until they reached the laboratory, and were analyzed as described in Table 2 on page 9 (APHA, 1998; Hydrolab, 1997; Lind, 1985). Total metals analyses (arsenic, cadmium, chromium, copper, iron, mercury, nickle, lead, and zinc) and total organic carbon analyses were done by AmTest.[1] Unless otherwise noted, all other analyses were done by WWU personnel.

[1] AmTest, 14603 N.E. 87th St., Redmond, WA, 98052.

## 2.3 Results of the Water Quality Analysis

### 2.3.1 Hydrolab parameters

The sill stratified during the summer at approximately the same depth as Site 3 (Figures 3–5, pages 14–16). Because of this, Site 3 and Strawberry Sill had very similar water temperature patterns, with clearly developed epilimnions and hypolimnions, compared to the Intake, which does not stratify. As a result of the stratification, the median water temperatures along the sill and at Site 3 were lower than at the Intake (Table 3, page 10). However, if the cooler hypolimnetic temperatures are excluded, the near-surface water temperatures at all of the sites, including the Intake, are not significantly different (pairwise Wilcoxon rank sum tests with Holm's p-value correction, $p \leq 0.05$).

Although none of the sill sites developed severe hypolimnetic oxygen deficits, there was more variation in hypolimnetic oxygen in the sill samples than at Site 3 or the Intake (Figure 6, page 17). Oxygen deficits of $\sim$1–3 mg/L were common in hypolimnetic samples from the sill during late summer or early fall, and the two sill sites located nearest to the lake shore (s1 and s3) had significantly lower summer[2] oxygen concentrations compared to the Intake.

The pH values along the sill and at Site 3 pH were more variable than at the Intake (Figure 7, page 18). The higher pH values at the Intake were caused by algal photosynthesis in the epilimnion, which raises the pH due to removal of dissolved $CO_2$. The maximum depth at the Intake is only $\sim$10–12 meters, so all sampling depths are within the well-mixed photic zone of the epilimnion. Although there are seasonal changes in pH that reflect changing lake productivity (higher pH in the summer and lower pH in the winter), on any particular sampling date, the pH at the Intake is relatively uniform. The deeper sample from Site 3 and along the sill are within the hypolimnion, which is below the photic zone, and isolated from mixing with the epilimnion. As a result, the pH levels diverge during stratification and become more uniform when the lake is mixing (winter).

The conductivity values (Figure 8, page 19) showed the same temporal trend that has been discussed in the annual Lake Whatcom Monitoring Reports. This trend was caused by changes in sampling equipment, specifically the addition of a more

[2]The "summer" period for Strawberry Sill was defined as the months when basin 3 is normally stratified: June through November.

sensitive Hydrolab conductivity probe. The appearance of decreasing conductivity is not a real change in water quality, but rather an indicator of more accurate equipment. As with the other Hydrolab measurements, the conductivities at the sill were more similar to Site 3 than the Intake.

### 2.3.2 Water quality parameters

Because of the small sample size for the water quality analyses, statistical tests were omitted, and the following description is based on observations of the data plotted in Figures 9–15 (pages 20–26) and summarized in Table 4 (page 11).

Seasonal patterns in alkalinity were apparent at Site 3, where the effects of photosynthesis in the epilimnion caused alkalinities to increase near the surface, but remain low in the deeper samples (Figure 9, page 20). Higher near-surface alkalinity were also present at the Intake during stratification, resulting in a higher median alkalinity at the Intake (Table 4). The sill alkalinities were more variable, and did not always follow the same pattern established by the other sites. The differences were minor, however, and all sites (all of Lake Whatcom, for that matter), could be characterized as having very low alkalinities.

Turbidity concentrations at all sites were usually below 2.0 NTU (Figure 10, page 21), and the median turbidity values for all sites were $\leq$0.6 NTU (Table 4). The Site 3 turbidities appeared to follow a seasonal pattern similar to alkalinity, but this pattern was not very clear at the other sites (sill and Intake). The Intake and two of the sill sites (s1 and s3) are closer to shore than Site 3 and Site s2, and could easily be affected by turbidity in surface runoff. This might explain the occasional turbidity spike seen in winter (e.g., Jan 2000).

The phosphorus concentrations along the sill were similar to those measured at Site 3 and the Intake (Figures 11–12 and Table 4, pages 22–23 and 11). Although the data are not sufficient for trend analysis, there appears to be a small increase in total phosphorus over time at all sites. If so, the pattern would be consistent with similar trends observed in the 1988–2003 Lake Whatcom data.

The ammonia data from Site 3 follow a seasonal pattern, with spikes occurring more frequently in late summer and early fall (Figure 13, page 24). The is typical for Lake Whatcom, particularly in basins 1 and 2. The ammonia concentrations along the sill and at the Intake did not follow any specific pattern and were often below detection.

Nitrate/nitrite concentrations followed predictable seasonal patterns at all sites (Figure 14, page 25). Epilimnetic nitrate/nitrite concentrations dropped due to algal uptake (epilimnetic samples from Sites 3, s1–s3, and all samples from the Intake), but remained high in hypolimnetic samples. Following overturn, nitrate/nitrite concentrations increased at all sites. Other than the absence of hypolimnetic patterns at the Intake, there were no apparent differences between the sill, the Intake, or Site 3.

Total nitrogen concentrations followed roughly the same pattern as nitrate/nitrite, but was much more variable at all sites (Figure 15, page 26). Total nitrogen consists of ammonia, nitrate, nitrite, and organic nitrogen, with the largest fraction usually being nitrate. Accordingly, it is not surprising that the total nitrogen pattern resembled the nitrate/nitrite patterns.

### 2.3.3 Metals and TOC

Total organic carbon and metals were sampled infrequently at all sites, usually only once or twice each year from surface and bottom depths. Because of the infrequent sampling, significance tests were not calculated. The descriptive figures show minimum, median, and maximum ranges only if there were more than three samples collected on that date; when three or fewer samples were collected, each point is plotted separately (Figures 16–25 (pages 27–36) .

The total organic carbon concentrations appeared to be slightly higher along the sill compared to the Intake and Site 3 (Figure 16, page 27). The median TOC values were very low at all sites (1.0–1.3 mg/L), and most of the TOC concentrations were at or below the detection level (1.0 mg/L). The TOC concentrations along the sill should be investigated more thoroughly, particularly since chlorophyll concentrations were not measured along the sill. The occasional spikes in total organic carbon concentrations could be a concern for drinking water treatment.

Although the Lake Whatcom monitoring project is only required to analyze 9 metals (arsenic, cadmium, chromium, copper, iron, mercury, nickle, lead, and zinc), AmTest reports results for 33 metals (including the 9 above) because the data are generated automatically during sample analysis. Many of the sill metals data were at or below detection. Metals that were rarely or never above detection were not plotted in this report, and include the following:

| | | | |
|---|---|---|---|
| lead | dl = 0.001 mg/L | selenium | dl = 0.03/0.01 mg/L |
| lithium | dl = 0.02/0.005 mg/L | silver | dl = 0.01 mg/L |
| mercury | dl = 0.01 mg/L | tin | dl = 0.02/0.005 mg/L |
| molybdenum | dl = 0.01/0.005 mg/L | titanium | dl = 0.01/0.001 mg/L |
| nickle | dl = 0.01/0.005 mg/L | vanadium | dl = 0.005/0.002 mg/L |
| phosphorus | dl = 0.05/0.01 mg/L | yttrium | dl = 0.001/0.0005 mg/L |

(Some AmTest detection limits (dl) changed during sampling period.)

Figures 17–25 (pages 28–36) summarize the results for those metals that were detected in at least 80% of the sill samples. Most showed no clear seasonal or site-specific patterns. The Strawberry Sill iron concentrations were usually higher than Site 3, but were about the same as at the Intake. Silica concentrations were slightly higher in the sill samples compared to the Intake (Figure 23, page 34). On October 9, 2001, the deep water sample (35 m) from Site s2 had unusually high concentrations of iron (0.12 mg/L), manganese (0.22 mg/L), total organic carbon (6.5 mg/L). The turbidity levels on the same date were not particularly high, so the results were probably not due to contamination by bottom sediment. Lead was also detected on that date at Site s2 (0.019 mg/L in the surface sample and 0.010 mg/L at 35 m). There is no apparent reason for these high values at s2, and they could represent bottle contamination or analytical error.

### 2.3.4 General statistical information

The data analysis included all sill samples, plus samples collected at the Intake and Site 3 between October 1996 and September 2002. Site 3 data was limited to samples collected from 0–40 meters.

Most variables were not normally distributed (Kolmogorov-Smirnov test, $p < 0.05$, SPSS Version 12.0.0) and did not have homogeneous variances within sites (Levene Statistic, $p < 0.05$, SPSS Version 12.0.0), so significance tests were based on nonparametric techniques. Descriptive plots were created to show minimum, maximum, and median values for all variables that were above the analytical detection limit for at least 80% of the samples. Kruskal-Wallis rank sum tests and Pairwise Wilcoxon rank sum tests (Holm's p-value correction) were used to identify significant differences between sites for the Hydrolab samples. No pairwise testing was done for the other analyses (water quality, total organic carbon, and metals analyses) because of the small, unbalanced sample size for the sill sites.

Most of the data were *not* censored to remove values below analytical detection limits. This preserves the variance associated with low concentrations and reduces problems associated with tied ranks in nonparametric statistics. Detection limits are indicated on appropriate figures, and statistical cautions have been included in figure and table captions. Total organic carbon and metals data from AmTest were censored by the analytical laboratory.

For a summary of nonparametric statistical procedures, see *Nonparametric Statistical Methods, Second Edition* by M. Hollander and D. Wolfe, John Wiley & Sons, New York, NY, 1999. Additional information about sampling, quality control, or Lake Whatcom water quality can be found in the annual Lake Whatcom Monitoring Reports, available from the City of Bellingham Public Works Department.

| | Sill | | Lake | | Sill | | Lake | | Sill | | Lake |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | hl | wq | hl/wq | Date | hl | wq | hl/wq | Date | hl | wq | hl/wq |
| Oct 8 1996 | | | • | Jan 20 1999 | • | • | | Jan 18 2001 | • | • | |
| Oct 22 1996 | • | • | | Feb 23 1999 | | | • | Feb 13 2001 | | | • |
| Nov 12 1996 | | | • | Apr 7 1999 | • | | | Apr 12 2001 | • | | |
| Dec 3/12 1996 | | | • | Apr 6/7 1999 | | | • | Apr 10/12 2001 | | | • |
| | | | | May 4/5 1999 | | | • | May 8 2001 | • | | |
| Jan 16 1997 | • | • | | Jun 9 1999 | • | | | May 8/10 2001 | | | • |
| Feb 10 1997 | • | | | Jun 8/9 1999 | | | • | Jun 62001 | • | | |
| Feb 12 1997 | | | • | Jul 7/8 1999 | | | • | Jun 5/6 2001 | | | • |
| Apr 29 1997 | • | | | Aug 4 1999 | • | | | Jul 10 2001 | • | | |
| Apr 22 1997 | | | • | Aug 4/5 1999 | | | • | Jul 10/11 2001 | | | • |
| May 21 1997 | • | | | Sep 2 1999 | • | | | Aug 1 2001 | • | | |
| May 15/21 1997 | | | • | Sep 1 1999 | | | • | Aug 1/2 2001 | | | • |
| Jun 12 1997 | • | | | Oct 12 1999 | • | • | | Sep 6 2001 | • | | |
| Jun 10/12 1997 | | | • | Oct 5-12 1999 | | | • | Sep 4/6 2001 | | | • |
| Jul 14 1997 | • | | | Nov 4 1999 | • | | | Oct 9 2001 | • | • | |
| Jul 10/14 1997 | | | • | Nov 2/4 1999 | | | • | Oct 2 2001 | | | • |
| Aug 13/21 1997 | | | • | Dec 2 1999 | • | | | Nov 8 2001 | • | | |
| Sep 18 1997 | • | | | Dec 1/2 1999 | | | • | Nov 6/8 2001 | | | • |
| Sep 10/18 1997 | | | • | | | | | Dec 4/5 2001 | | | • |
| Oct 16 1997 | • | | | Jan 4 2000 | • | • | | | | | |
| Oct 16 1997 | | | • | Feb 3 2000 | • | | | Jan 10 2002 | • | • | |
| Nov 6 1997 | • | • | | Feb 3/4 2000 | | | • | Feb 14 2002 | • | | |
| Nov 17 1997 | | | • | Apr 4 2000 | • | | | Feb 12/14 2002 | | | • |
| Dec 4 1997 | • | | | Apr 4/6 2000 | | | • | Apr 2 2002 | • | | |
| Dec 4/11 1997 | | | • | May 2/4 2000 | | | • | Apr 2/4 2002 | | | • |
| | | | | May 2/4 2000 | • | | | May 9 2002 | • | | |
| Feb 3 1998 | • | • | | Jun 6 2000 | • | | | May 7/9 2002 | | | • |
| Feb 26 1998 | | | • | Jun 6/8 2000 | | | • | Jun 6 2002 | • | | |
| Apr 21 1998 | • | | | Jul 12 2000 | • | | | Jun 4/14 2002 | | | • |
| Apr 7/14 1998 | | | • | Jul 12/13 2000 | | | • | Jul 1 2002 | • | | |
| May 20 1998 | • | | | Aug 8 2000 | • | | | Jul 1/2 2002 | | | • |
| May 5/6 1998 | | | • | Aug 8/10 2000 | | | • | Aug 8 2002 | • | | |
| Jun 10/11 1998 | | | • | Sep 6 2000 | • | | | Aug 6/8/13 2002 | | | • |
| Jul 7-9 1998 | | | • | Sep 6/7 2000 | | | • | Sep 12 2002 | • | | |
| Jul 7 1998 | • | | | Oct 5 2000 | • | • | | Sep 3/5 2002 | | | • |
| Aug 4 1998 | • | | | Oct 3/10 2000 | | | • | | | | |
| Aug 4/5 1998 | | | • | Nov 7 2000 | • | | | | | | |
| Sep 3 1998 | • | | | Nov 7/9 2000 | | | • | | | | |
| Sep 1/2 1998 | | | • | Dec 7 2000 | • | | | | | | |
| Oct 15 1998 | | | | Dec 6/7 2000 | | | • | | | | |
| Oct 6/7 1998 | | | • | | | | | | | | |
| Nov 3 1998 | • | | | | | | | | | | |
| Nov 3/4 1998 | | | • | | | | | | | | |
| Dec 2/3 1998 | | | • | | | | | | | | |

Table 1: Sampling dates for Strawberry Sill and long-term monitoring sites, October 1996 – September 2002.

| Parameter | Method | Historic DL[†] | Sensitivity or Confi dence limit |
|---|---|---|---|
| Conductivity | Hydrolab (1997), fi eld meter | – | $\pm$ 2 $\mu$S/cm |
| Dissolved oxygen | Hydrolab (1997), fi eld meter | – | $\pm$ 0.1 mg/L |
| pH | Hydrolab (1997), fi eld meter | – | $\pm$ 0.1 pH unit |
| Temperature | Hydrolab (1997), fi eld meter | – | $\pm$ 0.1$^{\circ}$ C |
| Alkalinity | APHA (1998) #2320, low level, SOP-IWS-15 | – | $\pm$ 0.5 mg/L |
| Turbidity | APHA (1998) #2130, nephelometric, SOP-LW-11 | – | $\pm$ 0.2 NTUs |
| Ammonia | APHA (1998) #4500-$NH_3$ F., phenate, SOP-LW-21 | 10 $\mu$g-N/L | $\pm$ 2.9 $\mu$g-N/L |
| Nitrite/nitrate | APHA (1998) #4500-$NO_3$ I., Cd reduction, SOP-IWS-19 | 20 $\mu$g-N/L | $\pm$ 9.2 $\mu$g-N/L |
| T. nitrogen | APHA (1998) #4500-N C., persulfate digestion, SOP-IWS-19 | 100 $\mu$g-N/L | $\pm$ 18.1 $\mu$g-N/L |
| Sol. phosphate | APHA (1998) #4500-P G., ascorbic acid, SOP-IWS-19 | 5 $\mu$g-P/L | $\pm$ 1.3 $\mu$g-P/L |
| T. phosphorus | APHA (1998) #4500-P H., persulfate digestion, SOP-IWS-19 | 5 $\mu$g-P/L | $\pm$ 3.3 $\mu$g-P/L |

[†] Historic detection limits (DL) are higher than current method detection limits. Sensitivity is based on 2002/2003 Lake Whatcom Monitoring Report (Matthews, et al., 2004). See report for complete QA/QC discussion.

Table 2: Summary of IWS analytical methods used to water quality at Strawberry Sill.

| | Site | Min. | Med. | Mean | Max. | N |
|---|---|---|---|---|---|---|
| Alkalinity | Intake | 15.9 | 18.5 | 18.5 | 20.5 | 158 |
| (mg/L as $CaCO_3$) | 3 | 16.3 | 17.9 | 18.0 | 19.9 | 259 |
| | s1 | 15.5 | 17.9 | 18.1 | 20.8 | 64 |
| | s2 | 15.4 | 17.9 | 18.0 | 19.4 | 96 |
| | s3 | 17.1 | 17.9 | 18.1 | 19.3 | 64 |
| Conductivity | Intake | 51.8 | 57.4 | 57.8 | 63.0 | 621 |
| ($\mu$S/cm) | 3 | 45.5 | 56.4 | 56.8 | 63.0 | 978 |
| | s1 | 53.2 | 57.4 | 57.9 | 63.0 | 534 |
| | s2 | 46.5 | 56.4 | 56.7 | 63.0 | 838 |
| | s3 | 53.1 | 57.4 | 57.8 | 63.0 | 535 |
| Dissolved Oxygen | Intake | 8.4 | 9.9 | 10.2 | 13.9 | 621 |
| (mg/L) | 3 | 7.8 | 10.0 | 10.1 | 13.0 | 978 |
| | s1 | 7.4 | 9.8 | 9.9 | 12.1 | 534 |
| | s2 | 7.5 | 9.9 | 10.0 | 13.4 | 837 |
| | s3 | 7.7 | 9.7 | 9.8 | 12.5 | 535 |
| pH | Intake | 7.1 | 7.8 | 7.8 | 8.5 | 605 |
| | 3 | 6.8 | 7.6 | 7.6 | 8.6 | 952 |
| | s1 | 7.0 | 7.6 | 7.7 | 8.4 | 534 |
| | s2 | 6.6 | 7.6 | 7.6 | 8.6 | 806 |
| | s3 | 6.9 | 7.6 | 7.7 | 8.5 | 536 |
| Temperature | Intake | 5.8 | 13.9 | 13.6 | 22.6 | 629 |
| ($^\circ$C) | 3 | 6.1 | 9.6 | 11.7 | 22.2 | 979 |
| | s1 | 6.1 | 10.7 | 12.0 | 22.2 | 542 |
| | s2 | 5.9 | 10.4 | 11.8 | 22.5 | 847 |
| | s3 | 6.0 | 10.5 | 11.9 | 22.6 | 544 |
| Turbidity | Intake | 0.4 | 0.6 | 0.6 | 1.8 | 159 |
| (NTU) | 3 | 0.2 | 0.4 | 0.5 | 1.2 | 264 |
| | s1 | 0.2 | 0.5 | 0.5 | 1.2 | 64 |
| | s2 | 0.2 | 0.4 | 0.5 | 1.2 | 88 |
| | s3 | 0.2 | 0.5 | 0.5 | 1.4 | 64 |

Table 3: Water quality comparison between Strawberry Sill, Site 3 (depths $\leq$ 40m), and the Intake, October 1996 – September 2002.

| | Site | Min. | Med. | Mean | Max. | N |
|---|---|---|---|---|---|---|
| Nitrogen, ammonia | Intake | -2.0 | 5.0 | 5.9 | 21.8 | 159 |
| ($\mu$g-N/L) | 3 | -3.1 | 4.8 | 5.2 | 30.7 | 264 |
| | s1 | -2.0 | 3.6 | 2.9 | 6.5 | 56 |
| | s2 | -1.8 | 3.0 | 3.0 | 14.8 | 88 |
| | s3 | -1.7 | 3.0 | 2.7 | 7.5 | 56 |
| Nitrogen, nitrate | Intake | 120.6 | 267.8 | 277.2 | 437.0 | 159 |
| ($\mu$g-N/L) | 3 | 150.1 | 363.1 | 338.1 | 537.0 | 264 |
| | s1 | 162.2 | 387.0 | 339.6 | 462.6 | 63 |
| | s2 | 155.3 | 407.0 | 349.3 | 463.4 | 96 |
| | s3 | 159.9 | 414.2 | 357.2 | 493.2 | 64 |
| Nitrogen, total | Intake | 184.4 | 407.1 | 408.3 | 843.0 | 152 |
| ($\mu$g-N/L) | 3 | 161.4 | 456.0 | 447.6 | 749.5 | 247 |
| | s1 | 297.2 | 490.2 | 492.1 | 925.0 | 64 |
| | s2 | 155.0 | 483.9 | 477.0 | 936.0 | 96 |
| | s3 | 253.0 | 489.0 | 482.0 | 907.0 | 64 |
| Phosphorus, soluble | Intake | -3.7 | 0.9 | 0.7 | 4.7 | 159 |
| ($\mu$g-P/L) | 3 | -3.5 | 1.0 | 1.0 | 12.2 | 264 |
| | s1 | -2.1 | 1.0 | 1.2 | 9.0 | 63 |
| | s2 | -2.5 | 1.2 | 1.5 | 10.6 | 96 |
| | s3 | -3.3 | 0.6 | 0.5 | 7.0 | 64 |
| Phosphorus, total | Intake | -4.0 | 4.0 | 4.1 | 27.9 | 159 |
| ($\mu$g-P/L) | 3 | 0.0 | 3.0 | 3.7 | 18.0 | 259 |
| | s1 | 1.6 | 3.0 | 3.3 | 15.4 | 64 |
| | s2 | 1.5 | 3.6 | 4.6 | 12.1 | 96 |
| | s3 | 1.2 | 3.0 | 3.0 | 8.5 | 64 |

Table 4: Water quality comparison between Strawberry Sill, Site 3 (depths $\leq$ 40m), and the Intake, October 1996 – September 2002, continued. Data have not been censored to remove values below the analytical detection limit, as indicated by negative minimum values for ammonia and phosphorus.

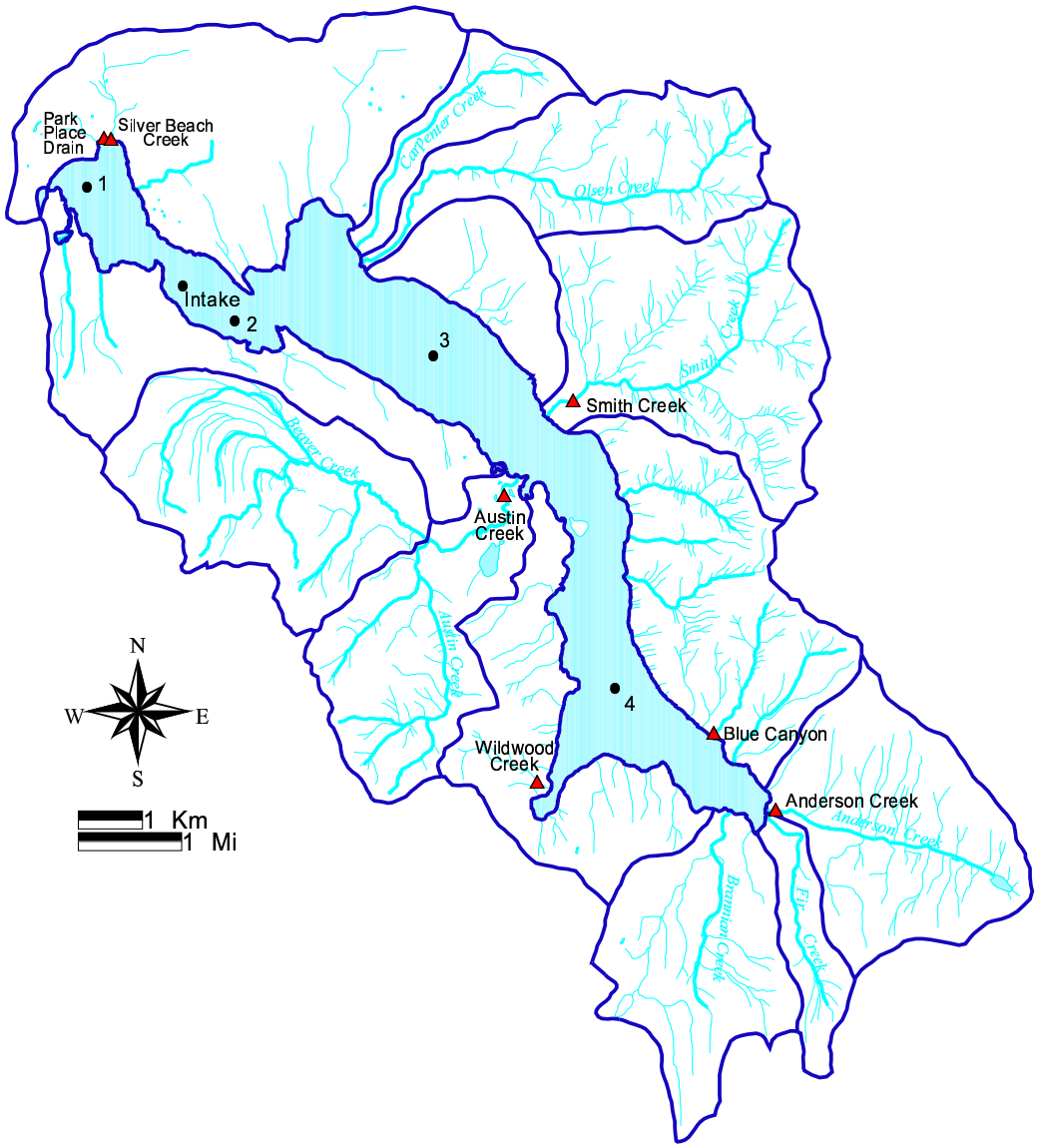


Figure 1: Lake Whatcom sampling sites.

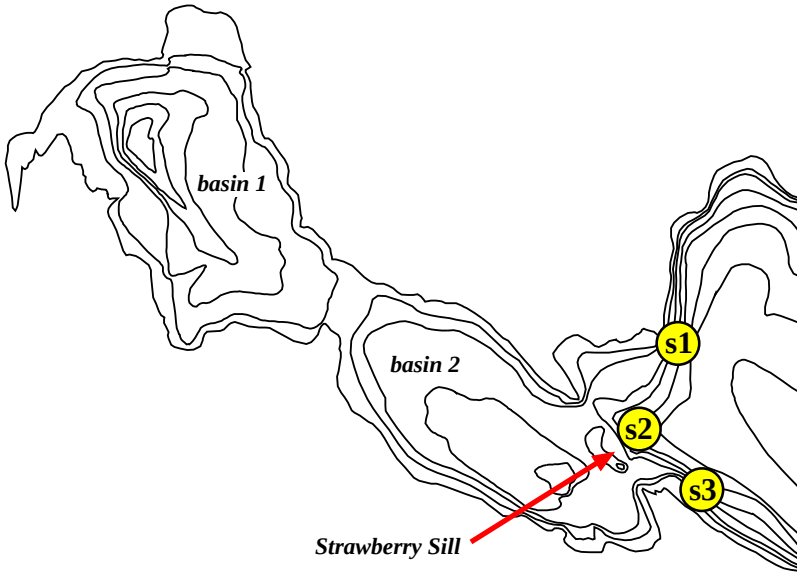


Figure 2: Strawberry Sill sampling sites.

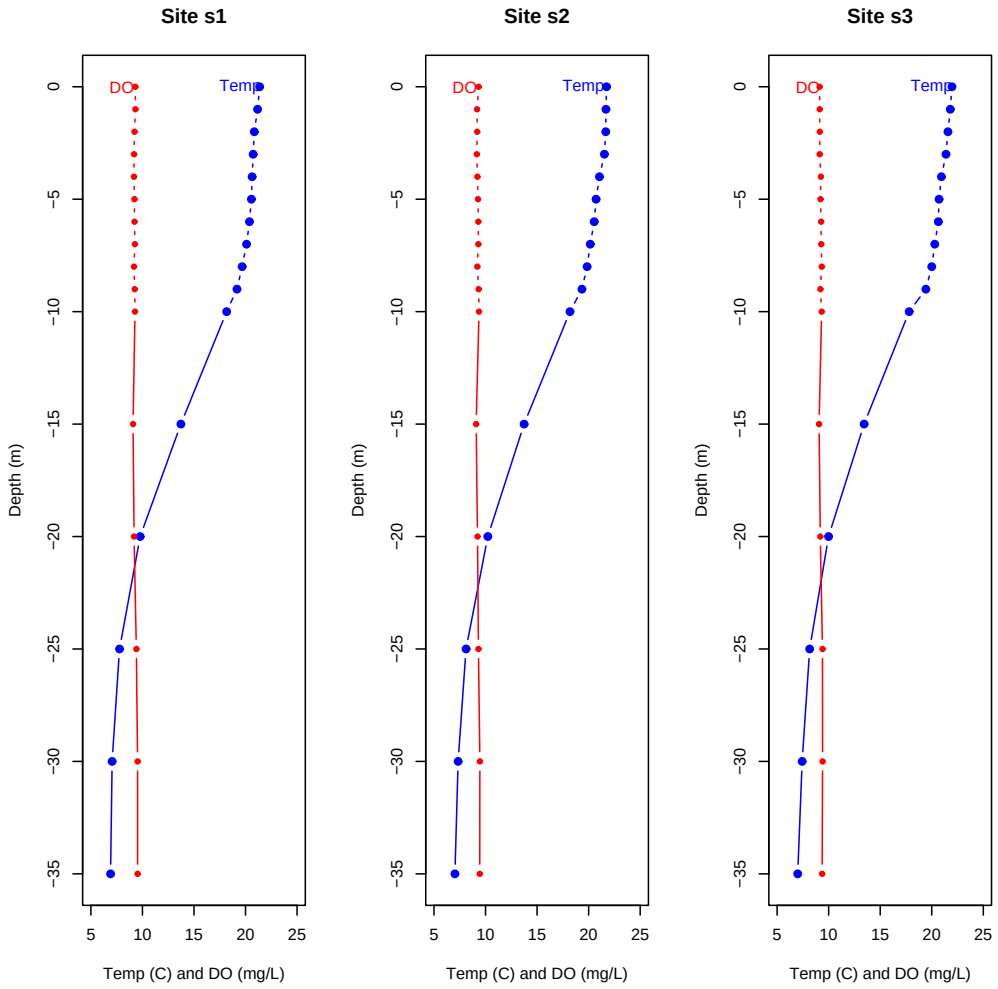


Figure 3: Strawberry Sill temperature and oxygen profiles on August 8, 2000.

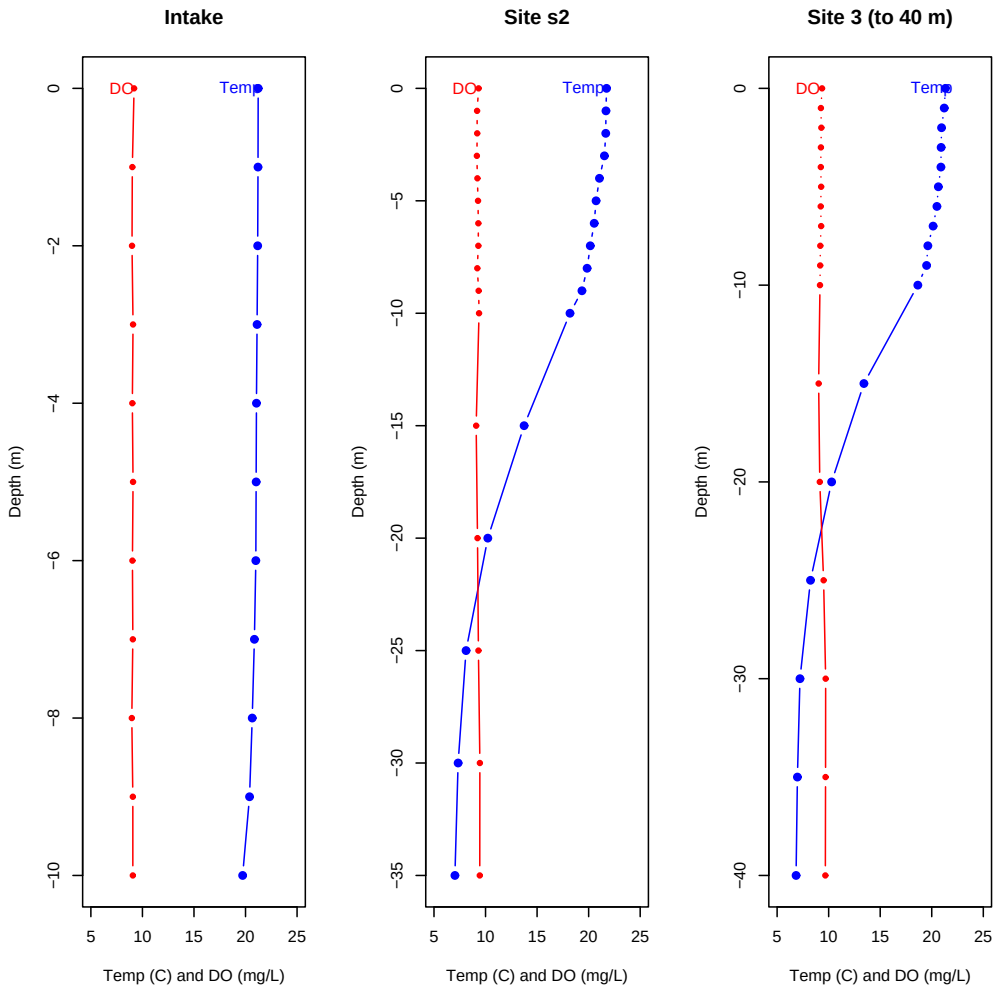


Figure 4: Comparison of August 8, 2000 temperature and oxygen profile from Strawberry Sill Site s2 to profiles from Intake and Site 3. The Intake was sampled on August 10, 2000 and Site 3 was sampled on August 8, 2000.

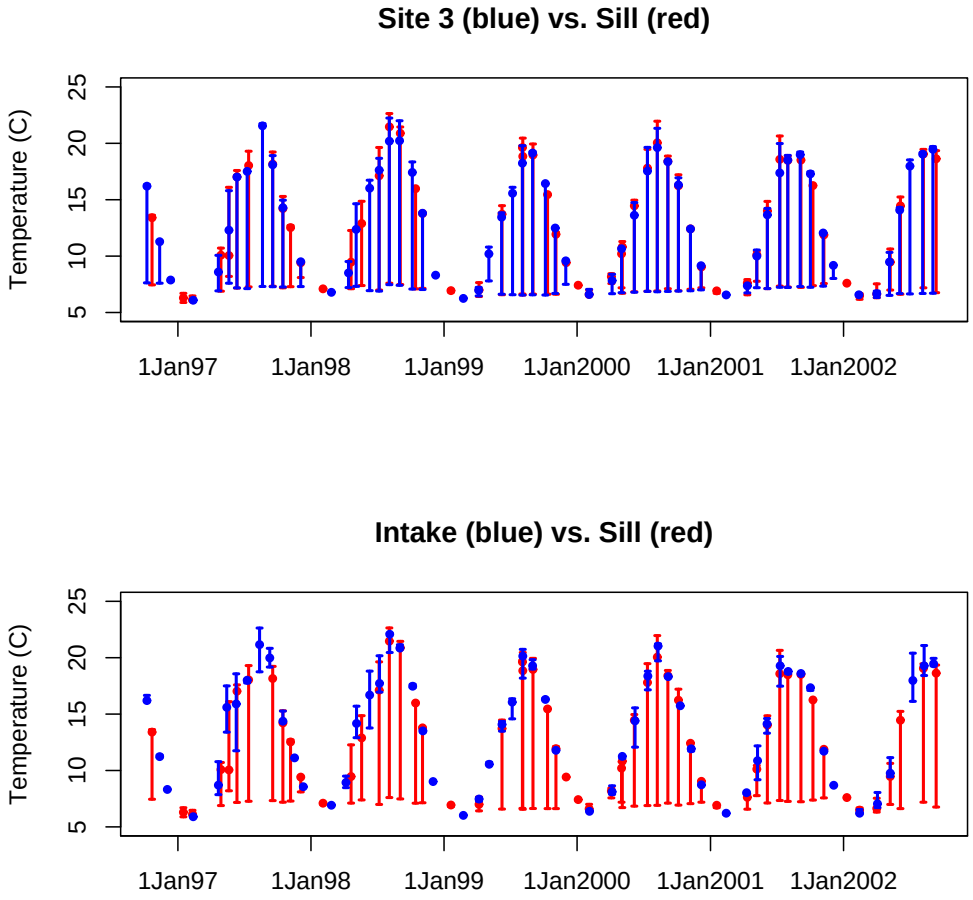


Figure 5: Water temperature levels at Strawberry Sill (all sites), Site 3, and the Intake, October 1996 – September 2002. Vertical lines show minimum, median, and maximum values for each sampling date. Tick width on bars show 7-day intervals.

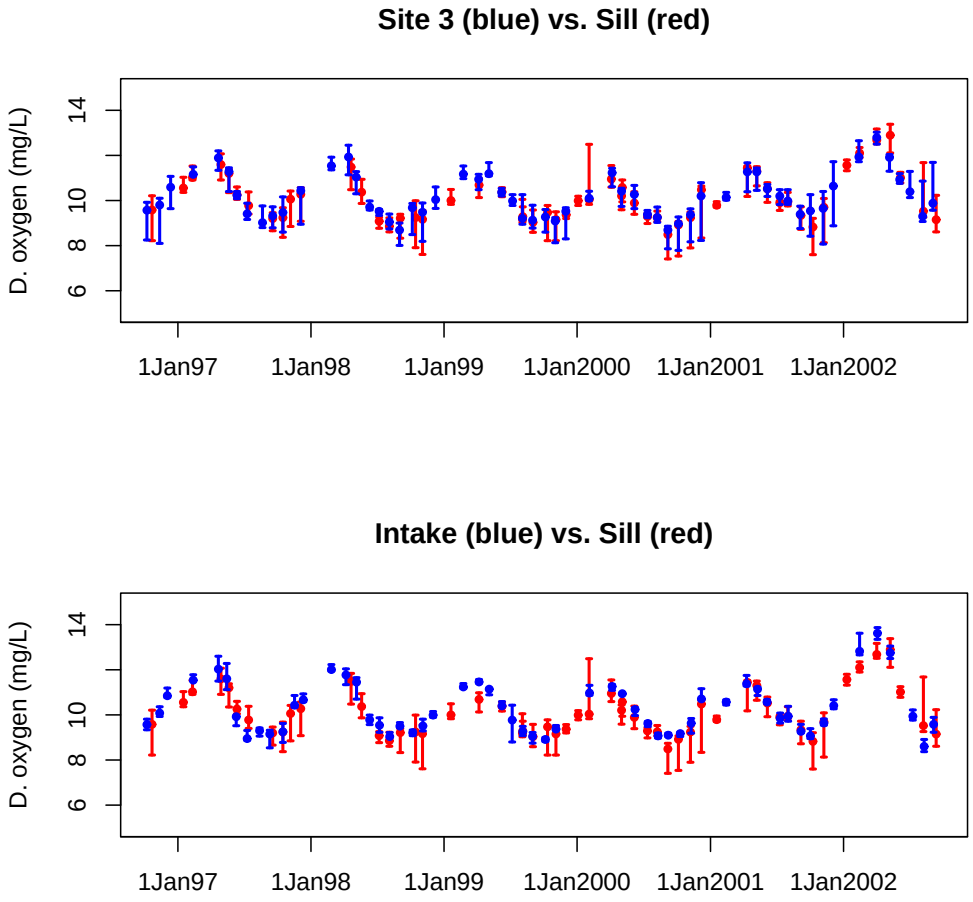


Figure 6: Dissolved oxygen concentrations at Strawberry Sill (all sites), Site 3, and the Intake, October 1996 – September 2002. Vertical lines show minimum, median, and maximum values for each sampling date. Tick width on bars show 7-day intervals.

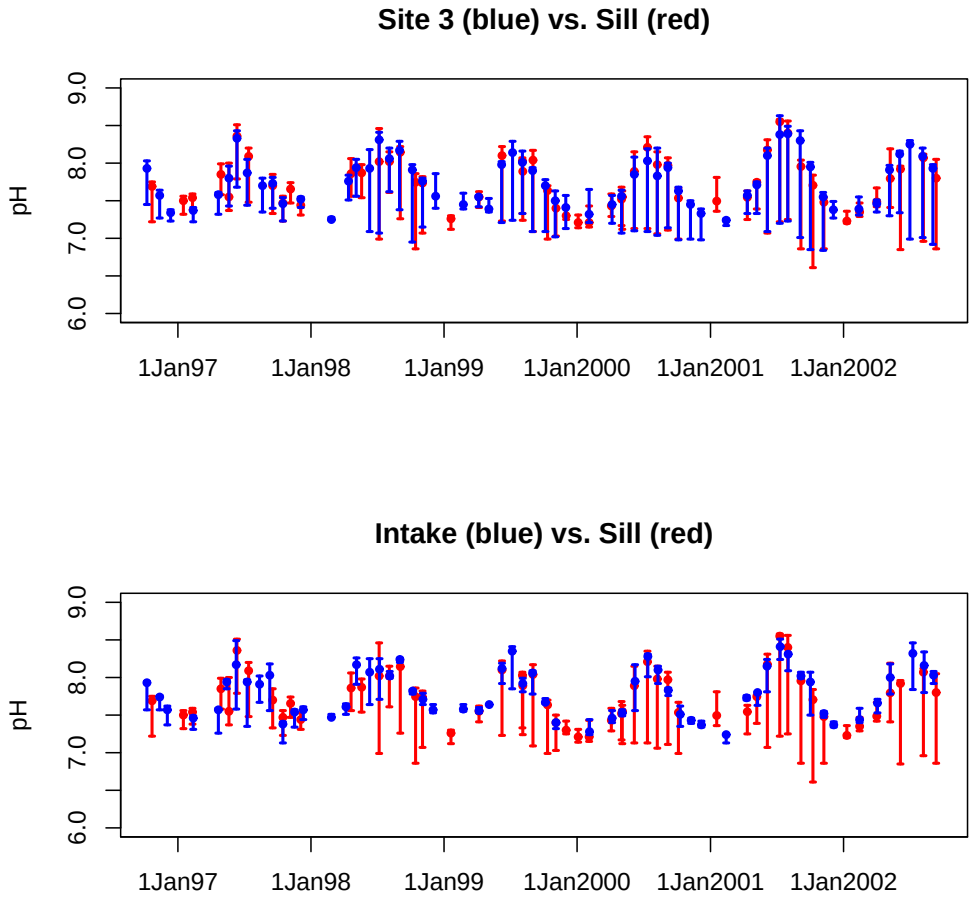


Figure 7: Ranges for pH at Strawberry Sill (all sites), Site 3, and the Intake, October 1996 – September 2002. Vertical lines show minimum, median, and maximum values for each sampling date. Tick width on bars show 7-day intervals.

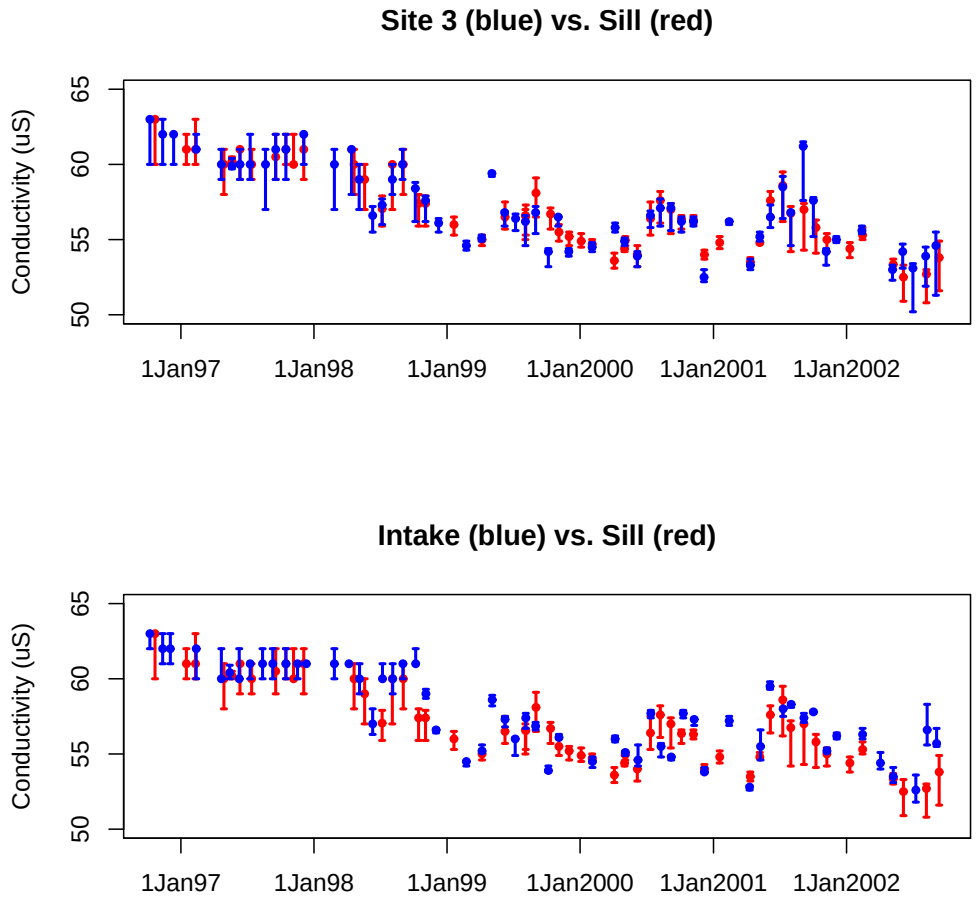


Figure 8: Conductivity levels at Strawberry Sill (all sites), Site 3, and the Intake, October 1996 – September 2002. Vertical lines show minimum, median, and maximum values for each sampling date. Tick width on bars show 7-day intervals. The decreasing values represent increased sensitivity of field equipment over time, not decreasing lake conductivity levels.

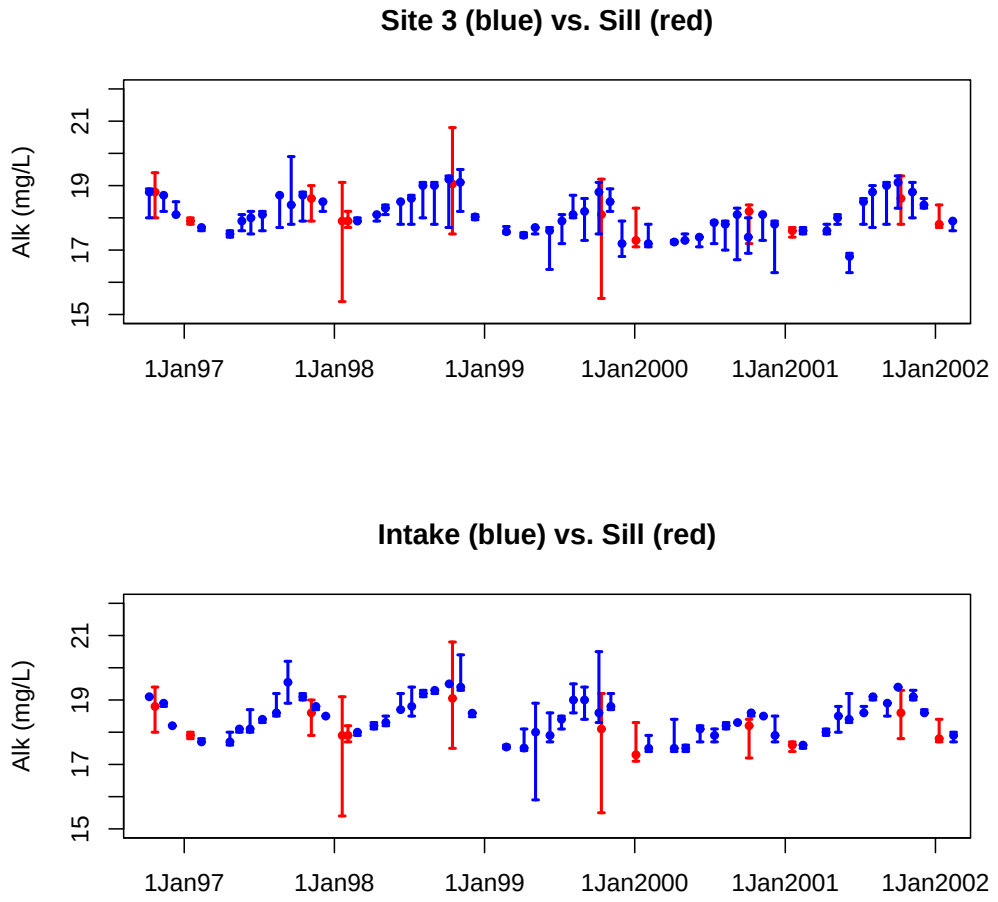


Figure 9: Alkalinity concentrations at Strawberry Sill (all sites), Site 3, and the Intake, October 1996 – September 2002. Vertical lines show minimum, median, and maximum values for each sampling date. Tick width on bars show 7-day intervals.

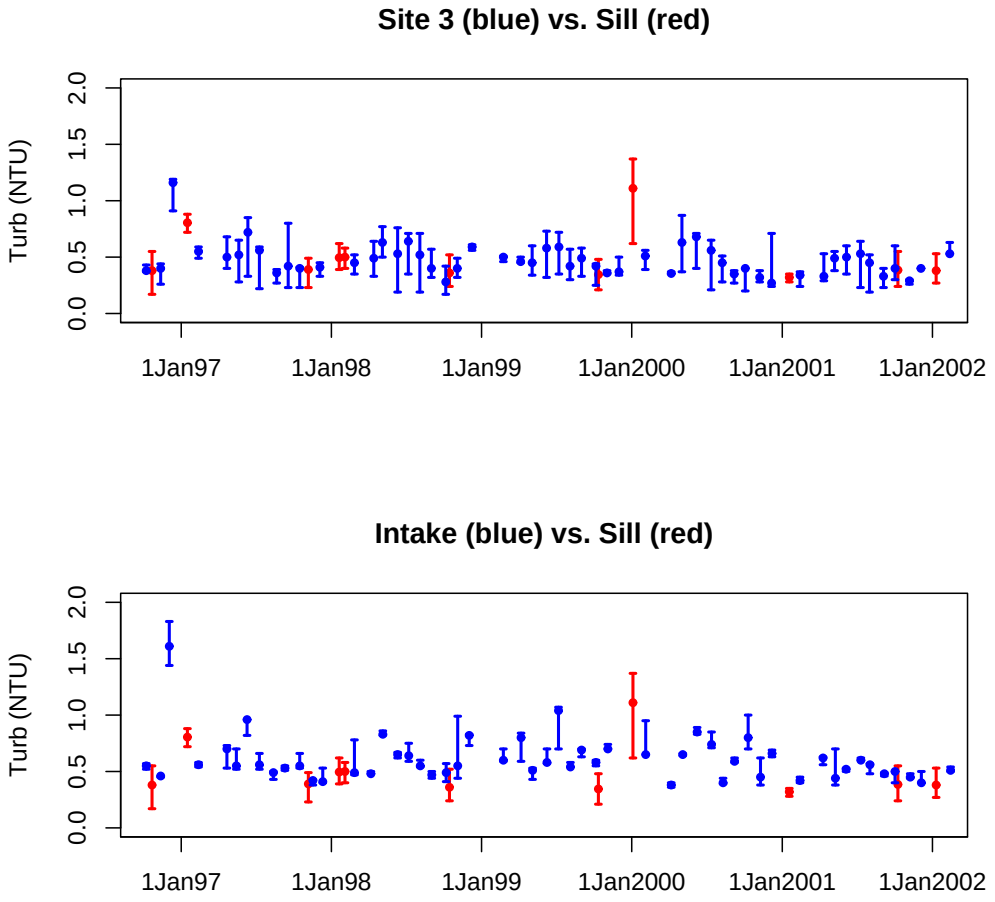


Figure 10: Turbidity levels at Strawberry Sill (all sites), Site 3, and the Intake, October 1996 – September 2002. Vertical lines show minimum, median, and maximum values for each sampling date. Tick width on bars show 7-day intervals.

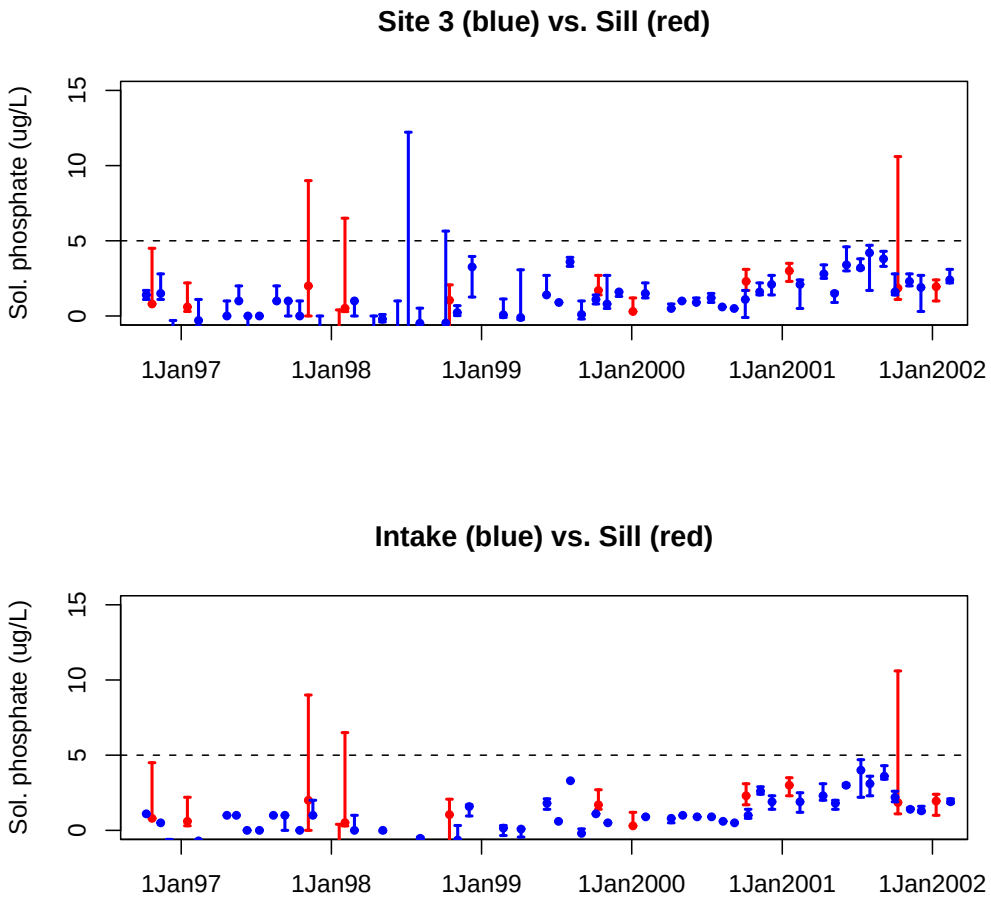


Figure 11: Soluble phosphate concentrations at Strawberry Sill (all sites), Site 3, and the Intake, October 1996 – September 2002. Vertical lines show minimum, median, and maximum values for each sampling date. Tick width on bars show 7-day intervals. Detection limit is indicated by a dotted line. Data have *not* been censored to remove below detection values.

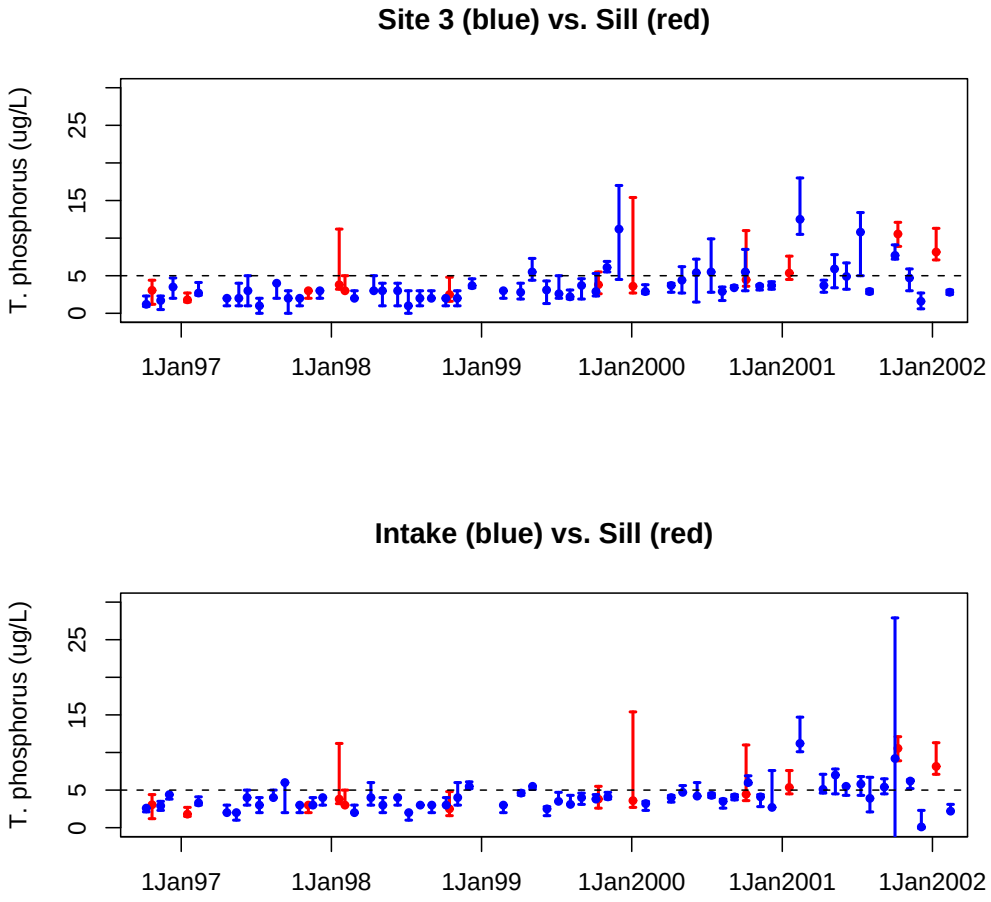


Figure 12: Total phosphorus concentrations at Strawberry Sill (all sites), Site 3, and the Intake, October 1996 – September 2002. Vertical lines show minimum, median, and maximum values for each sampling date. Tick width on bars show 7-day intervals. Detection limit is indicated by a dotted line.

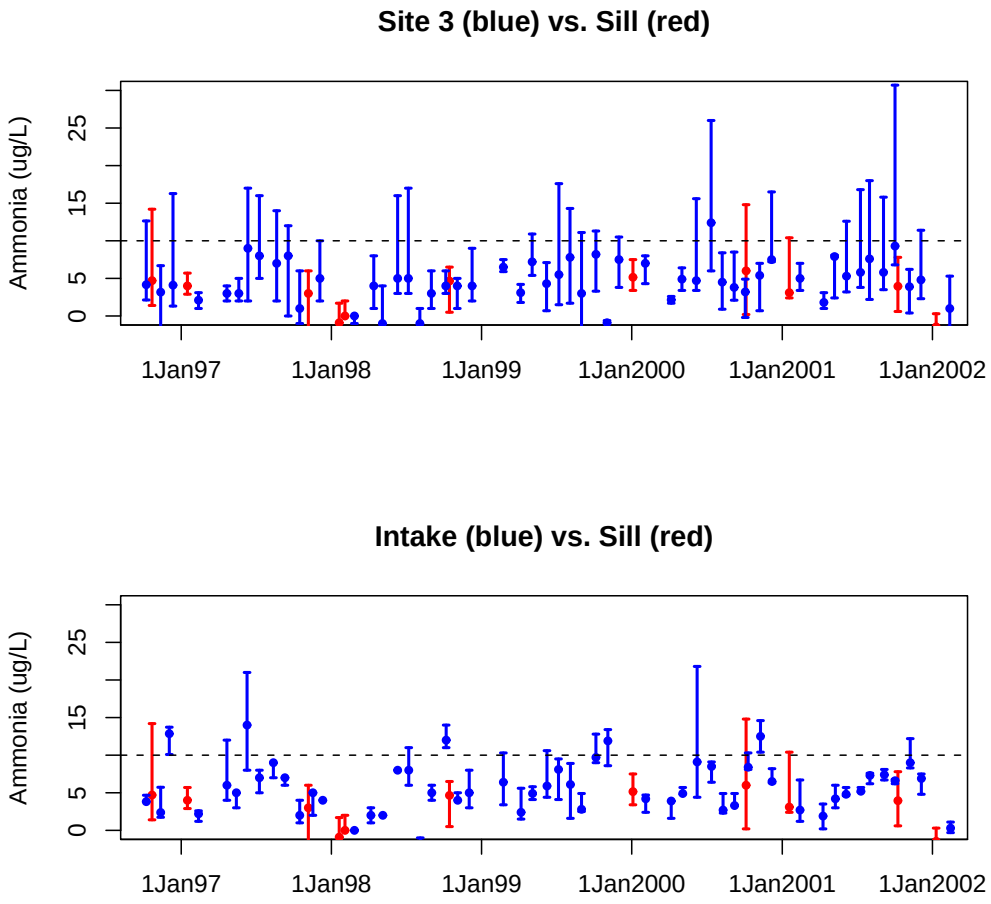


Figure 13: Ammonia concentrations at Strawberry Sill (all sites), Site 3, and the Intake, October 1996 – September 2002. Vertical lines show minimum, median, and maximum values for each sampling date. Tick width on bars show 7-day intervals. Detection limit is indicated by a dotted line. Data have *not* been censored to remove below detection values.

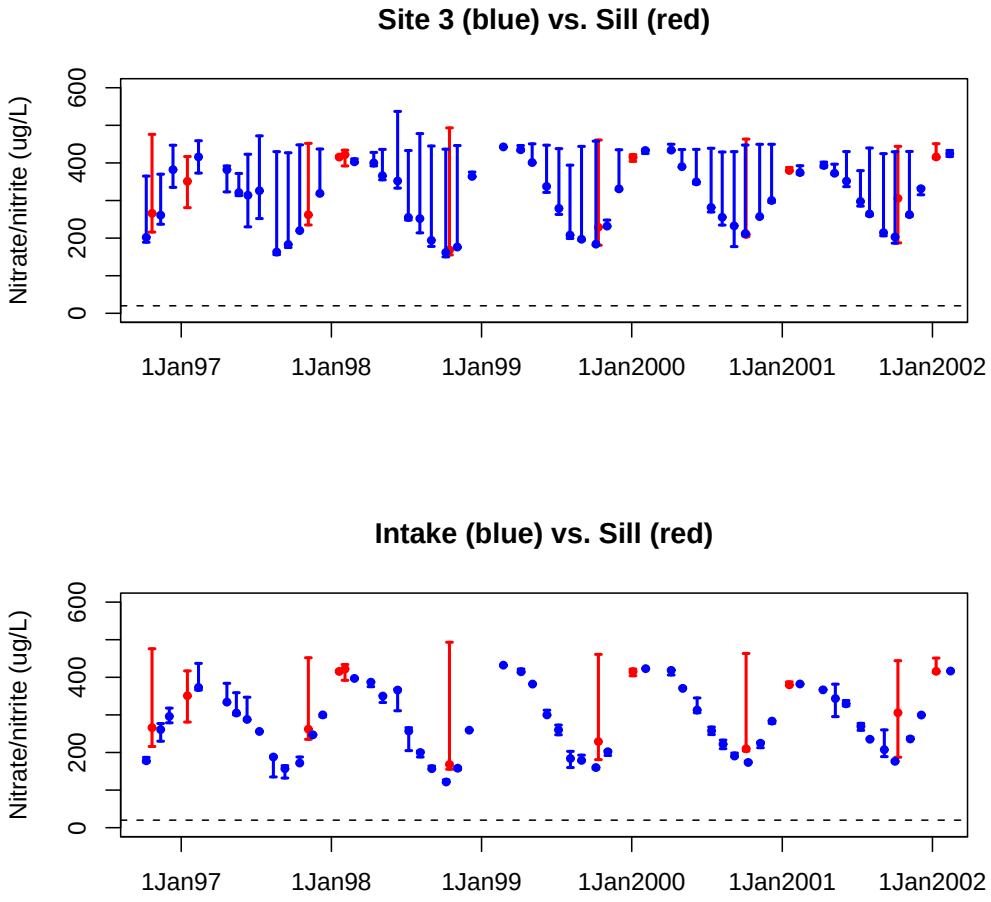


Figure 14: Nitrate/nitrite concentrations at Strawberry Sill (all sites), Site 3, and the Intake, October 1996 – September 2002. Vertical lines show minimum, median, and maximum values for each sampling date. Tick width on bars show 7-day intervals. Detection limit is indicated by a dotted line.

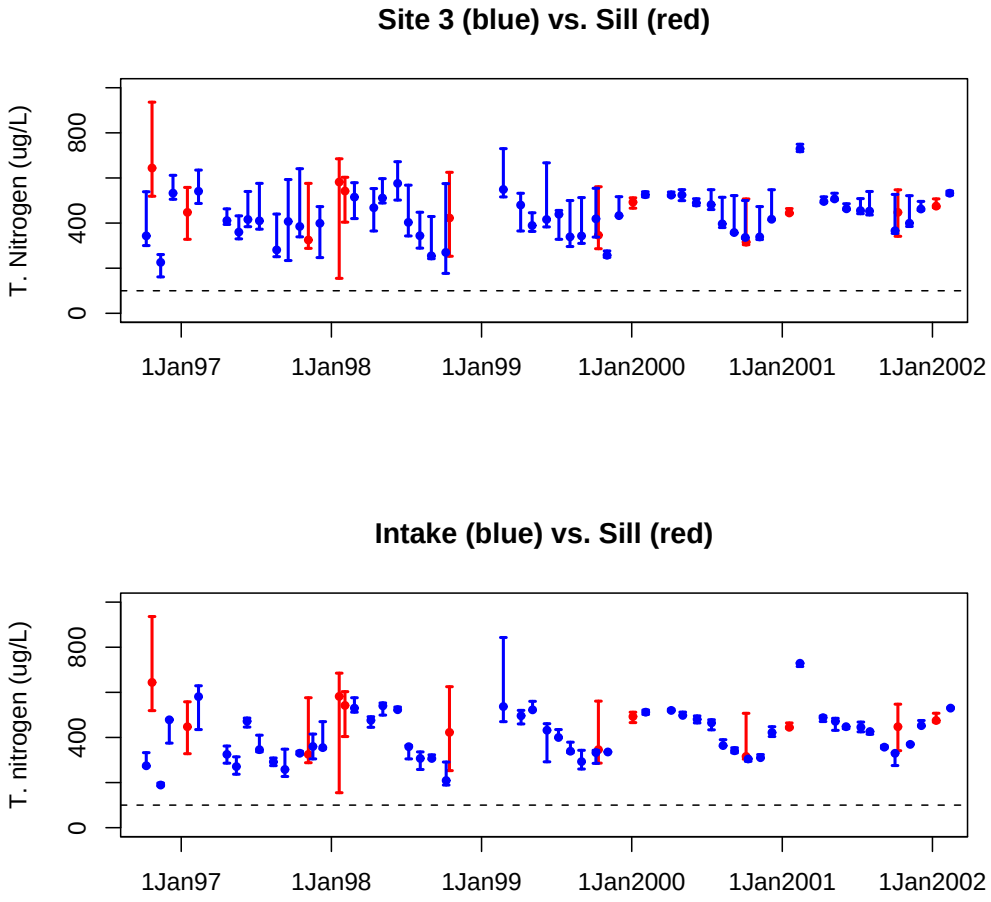


Figure 15: Total nitrogen concentrations at Strawberry Sill (all sites), Site 3, and the Intake, October 1996 – September 2002. Vertical lines show minimum, median, and maximum values for each sampling date. Tick width on bars show 7-day intervals. Detection limit is indicated by a dotted line.

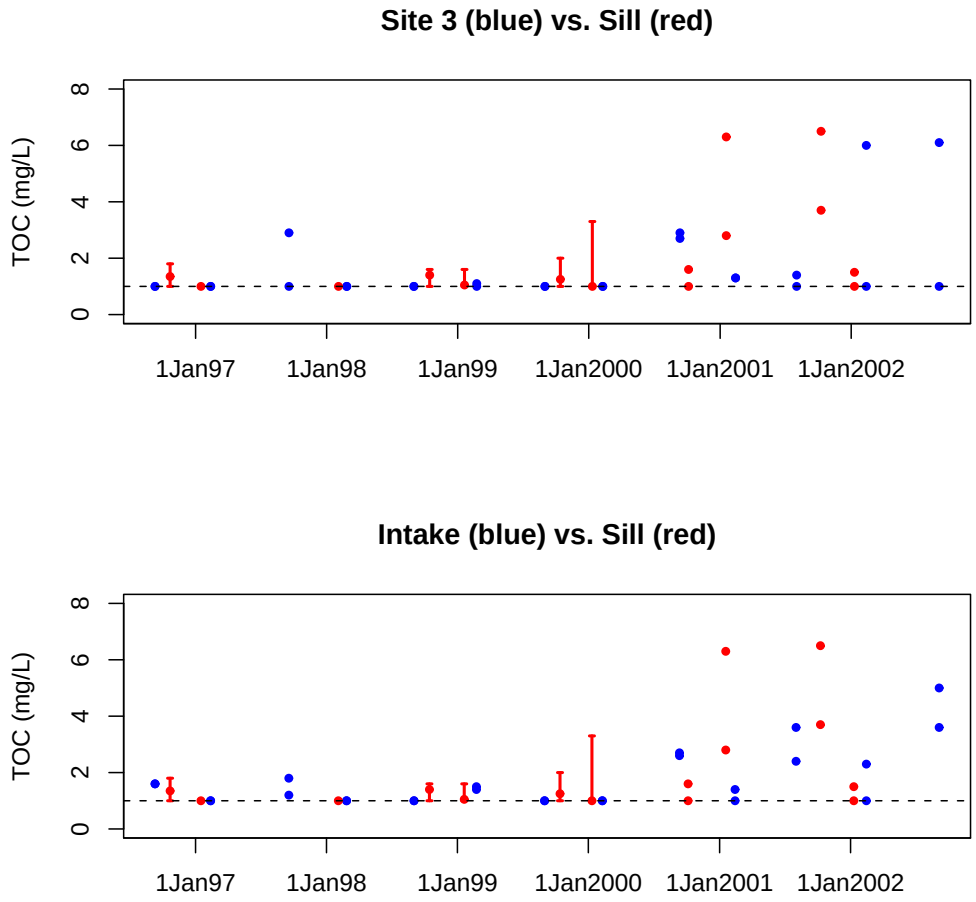


Figure 16: Total organic carbon concentrations at Strawberry Sill (all sites), Site 3, and the Intake, October 1996 – September 2002. Vertical lines show minimum, median, and maximum values for each sampling date. Tick width on bars show 7-day intervals. Detection limit is indicated by a dotted line. Dates represented by 3 or fewer samples were plotted as separate points rather than lines. Data *have* been censored by AmTest and are truncated at the analytical detection limit.

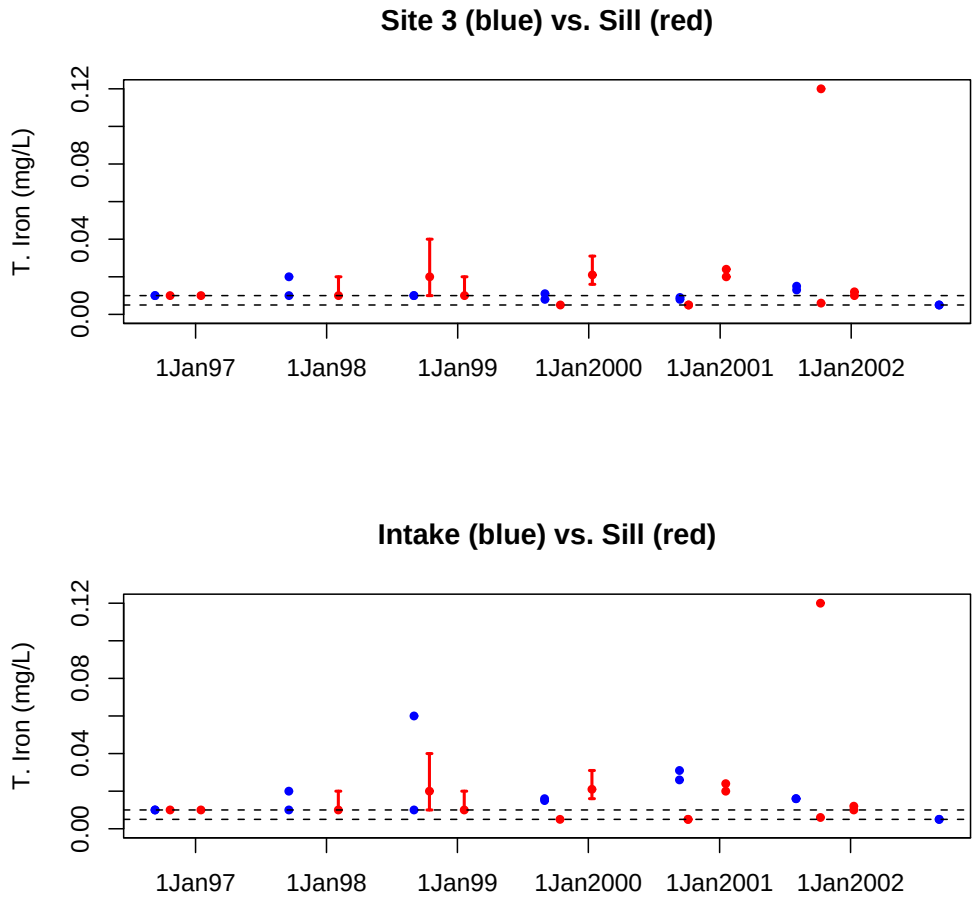


Figure 17: Total iron concentrations at Strawberry Sill (all sites), Site 3, and the Intake, October 1996 – September 2002. Vertical lines show minimum, median, and maximum values for each sampling date. Tick width on bars show 7-day intervals. Detection limits are indicated by dotted lines (AmTest detection limits changed during the sampling period). Dates represented by 3 or fewer samples were plotted as separate points rather than lines. Data *have* been censored by AmTest and are truncated at the analytical detection limit.

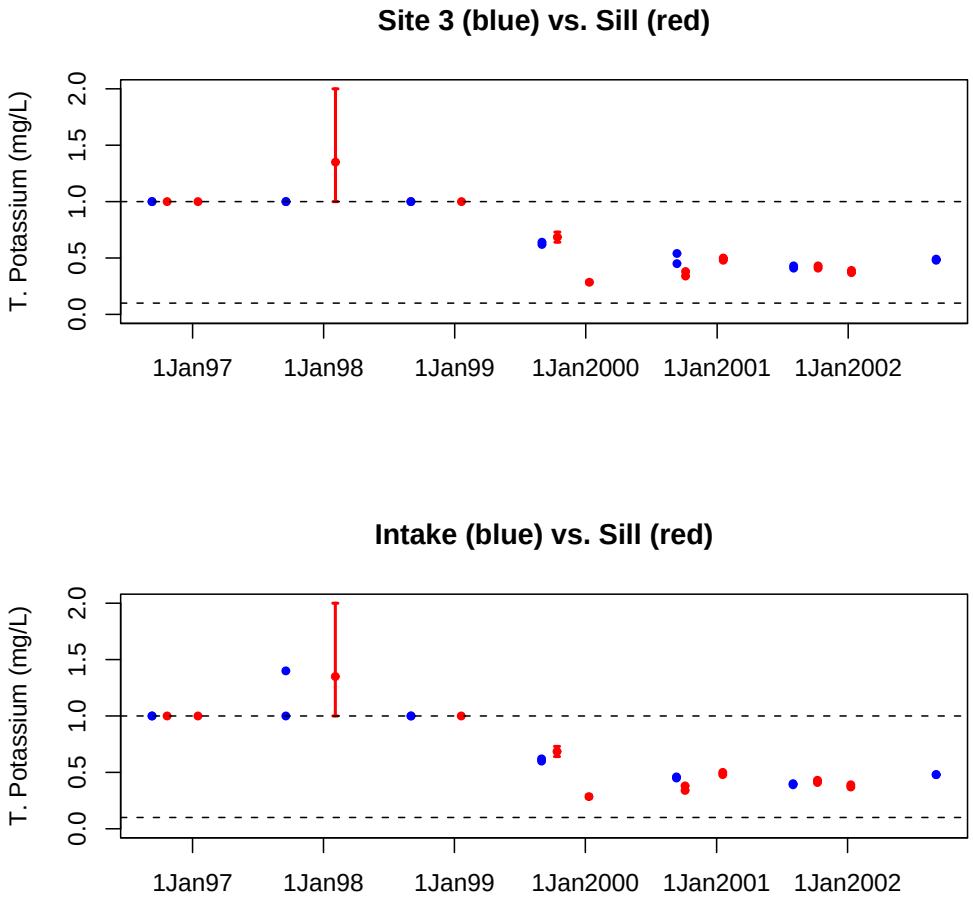


Figure 18: Total potassium concentrations at Strawberry Sill (all sites), Site 3, and the Intake, October 1996 – September 2002. Vertical lines show minimum, median, and maximum values for each sampling date. Tick width on bars show 7-day intervals. Detection limits are indicated by dotted lines (AmTest detection limits changed during the sampling period). Dates represented by 3 or fewer samples were plotted as separate points rather than lines. Data *have* been censored by AmTest and are truncated at the analytical detection limit.

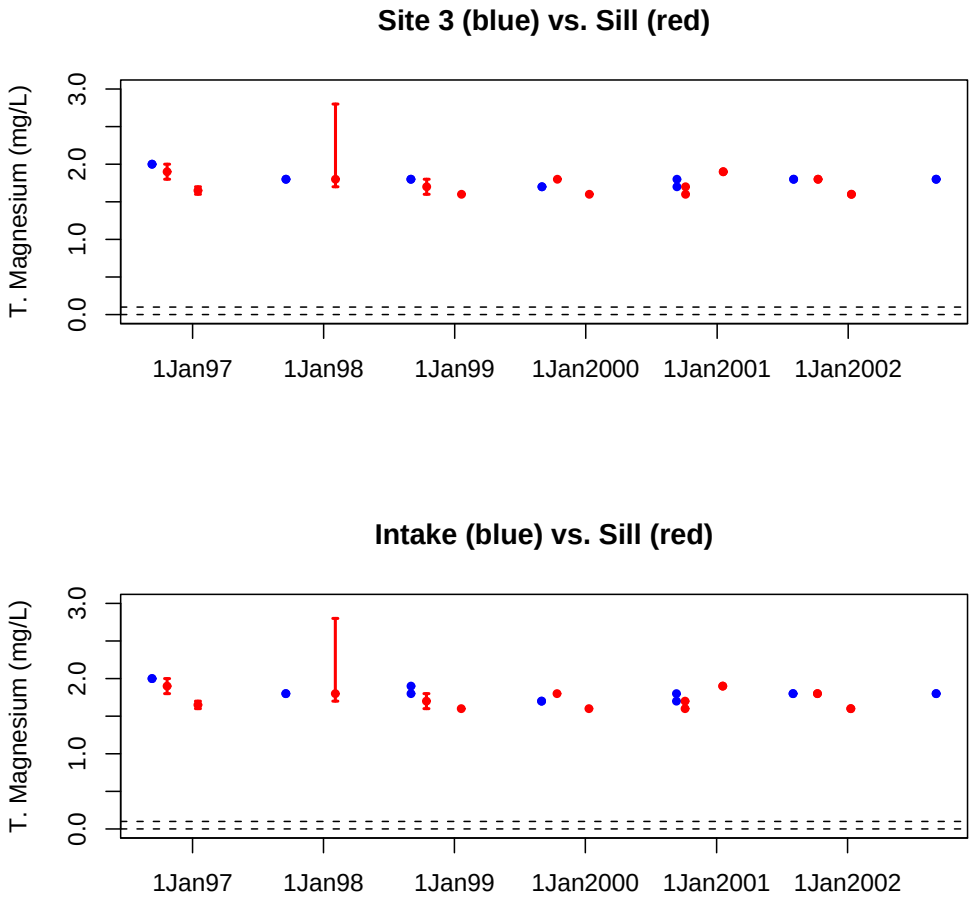


Figure 19: Total magnesium concentrations at Strawberry Sill (all sites), Site 3, and the Intake, October 1996 – September 2002. Vertical lines show minimum, median, and maximum values for each sampling date. Tick width on bars show 7-day intervals. Detection limit is indicated by a dotted line. Dates represented by 3 or fewer samples were plotted as separate points rather than lines. Data *have* been censored by AmTest and are truncated at the analytical detection limit.

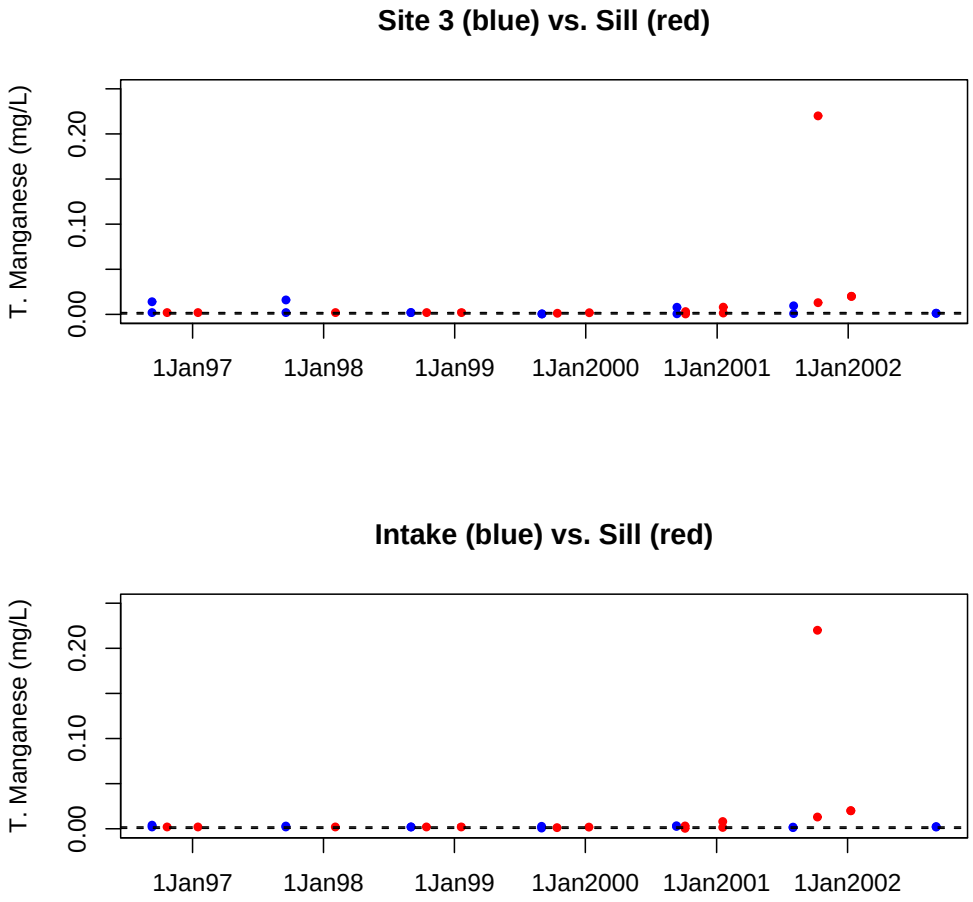


Figure 20: Total manganese concentrations at Strawberry Sill (all sites), Site 3, and the Intake, October 1996 – September 2002. Vertical lines show minimum, median, and maximum values for each sampling date. Tick width on bars show 7-day intervals. Detection limits are indicated by dotted lines (AmTest detection limits changed during the sampling period). Dates represented by 3 or fewer samples were plotted as separate points rather than lines. Data *have* been censored by AmTest and are truncated at the analytical detection limit.

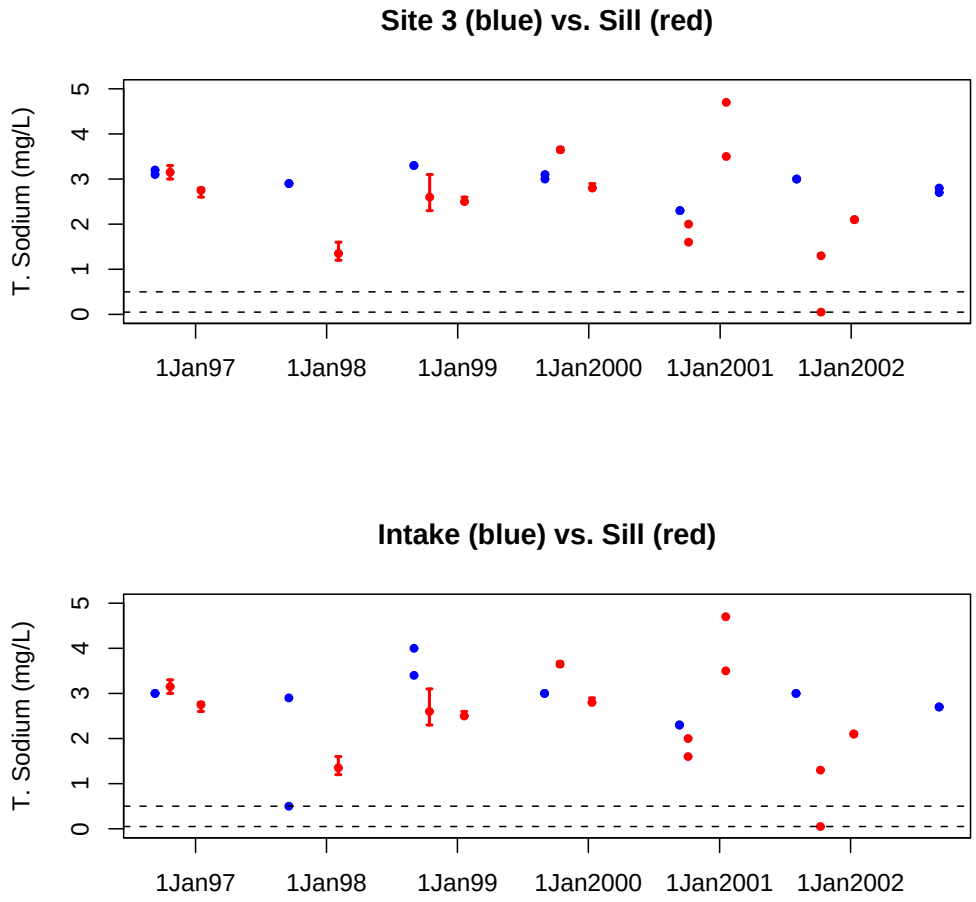


Figure 21: Total sodium concentrations at Strawberry Sill (all sites), Site 3, and the Intake, October 1996 – September 2002. Vertical lines show minimum, median, and maximum values for each sampling date. Tick width on bars show 7-day intervals. Detection limits are indicated by dotted lines (AmTest detection limits changed during the sampling period). Dates represented by 3 or fewer samples were plotted as separate points rather than lines. Data *have* been censored by AmTest and are truncated at the analytical detection limit.

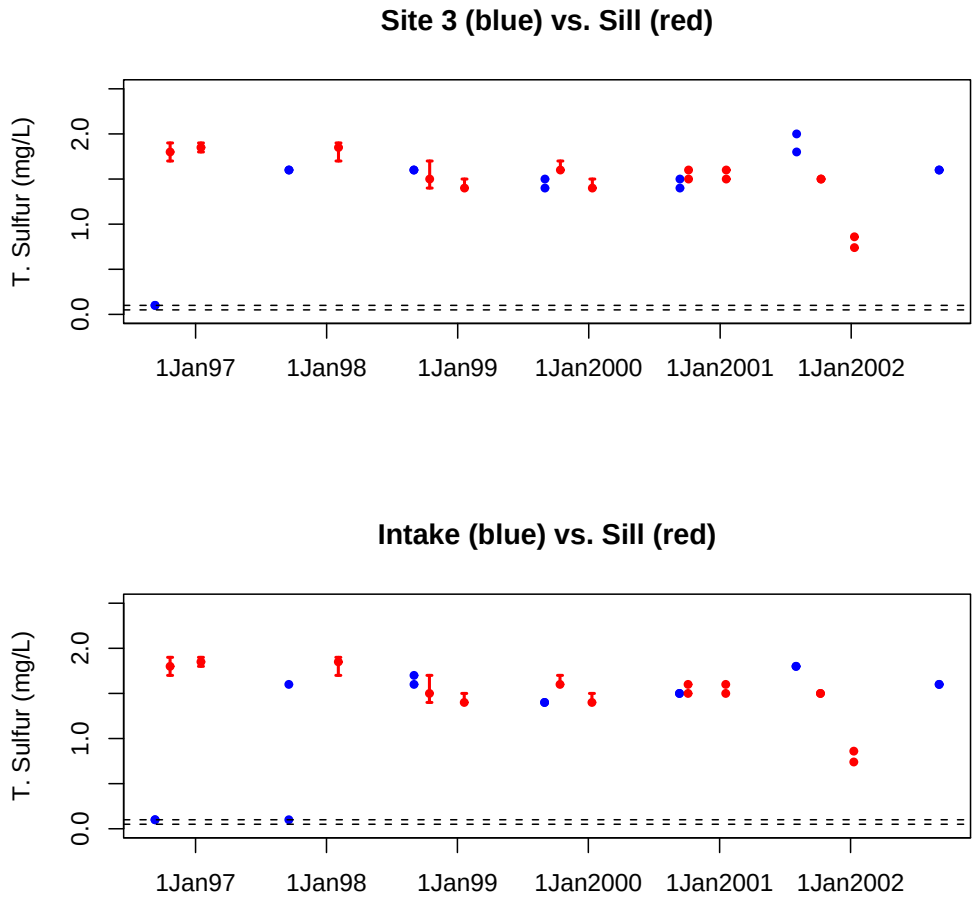


Figure 22: Total sulfur concentrations at Strawberry Sill (all sites), Site 3, and the Intake, October 1996 – September 2002. Vertical lines show minimum, median, and maximum values for each sampling date. Tick width on bars show 7-day intervals. Detection limits are indicated by dotted lines (AmTest detection limits changed during the sampling period). Dates represented by 3 or fewer samples were plotted as separate points rather than lines. Data *have* been censored by AmTest and are truncated at the analytical detection limit.

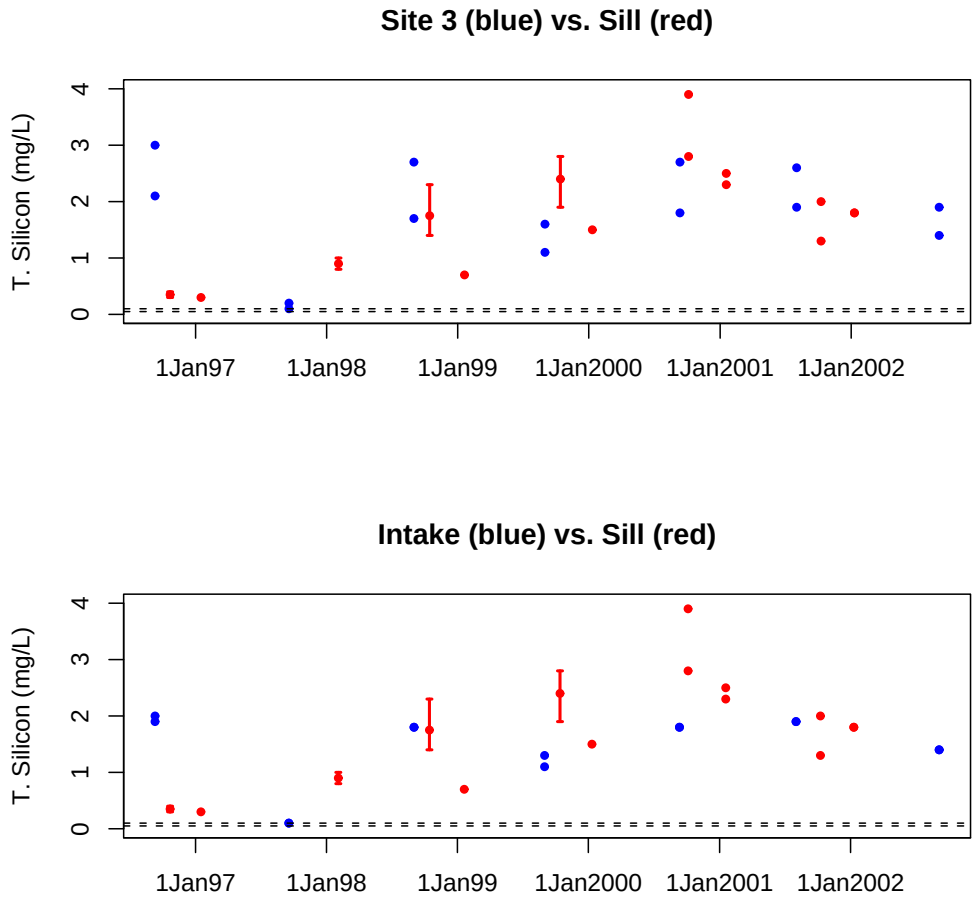


Figure 23: Total silicon concentrations at Strawberry Sill (all sites), Site 3, and the Intake, October 1996 – September 2002. Vertical lines show minimum, median, and maximum values for each sampling date. Tick width on bars show 7-day intervals. Detection limits are indicated by dotted lines (AmTest detection limits changed during the sampling period). Dates represented by 3 or fewer samples were plotted as separate points rather than lines. Data *have* been censored by AmTest and are truncated at the analytical detection limit.

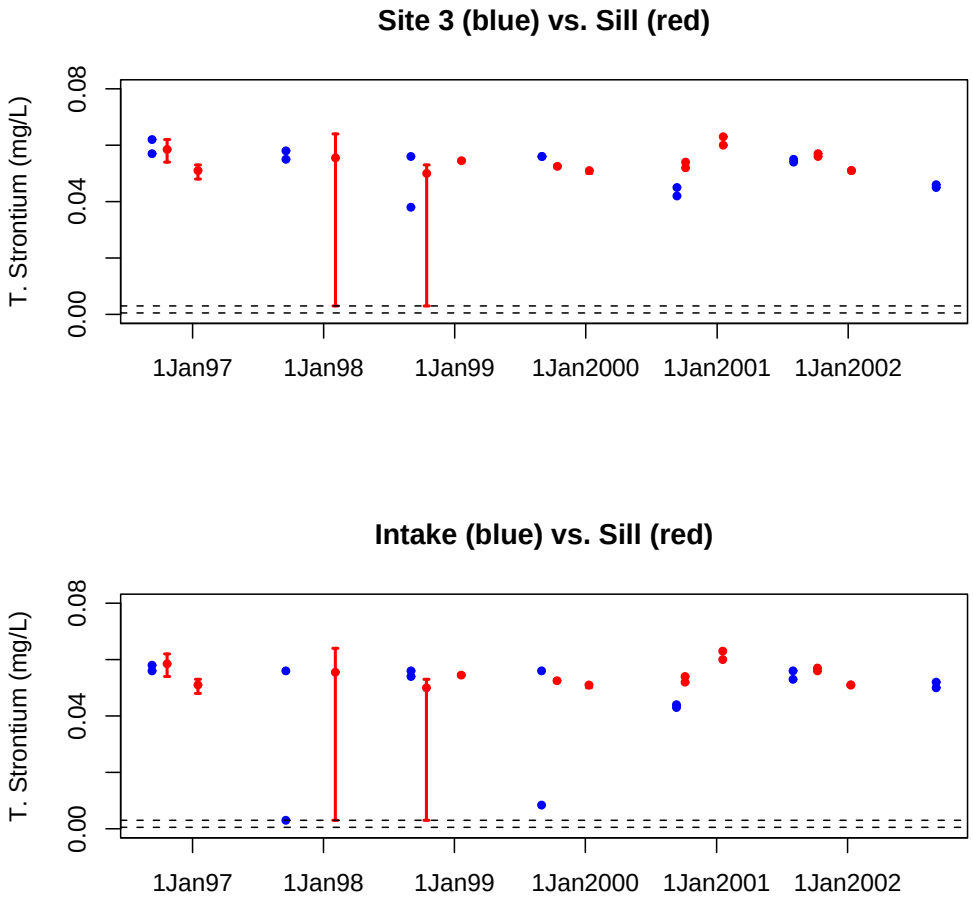


Figure 24: Total strontium concentrations at Strawberry Sill (all sites), Site 3, and the Intake, October 1996 – September 2002. Vertical lines show minimum, median, and maximum values for each sampling date. Tick width on bars show 7-day intervals. Detection limits are indicated by dotted lines (AmTest detection limits changed during the sampling period.) Dates represented by 3 or fewer samples were plotted as separate points rather than lines. Data *have* been censored by AmTest and are truncated at the analytical detection limit.

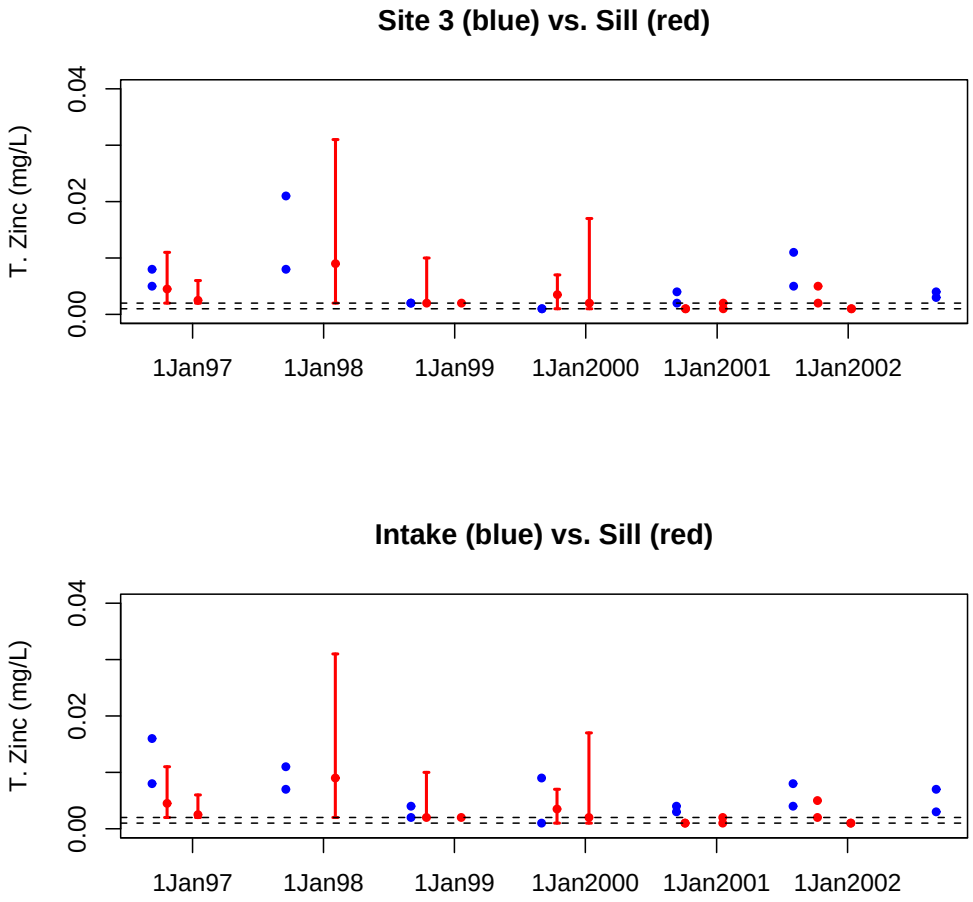


Figure 25: Total zinc concentrations at Strawberry Sill (all sites), Site 3, and the Intake, October 1996 – September 2002. Vertical lines show minimum, median, and maximum values for each sampling date. Tick width on bars show 7-day intervals. Detection limits are indicated by dotted lines (AmTest detection limits changed during the sampling period.) Dates represented by 3 or fewer samples were plotted as separate points rather than lines. Data *have* been censored by AmTest and are truncated at the analytical detection limit.