SAN FRANCISQUITO CREEK WATERSHED LTMAP DATA REVIEW AND ANALYSIS

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and
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INTRODUCTION

This report provides the results of a review and analysis of creek water quality monitoring data from four locations within the San Francisquito Creek watershed. The monitoring data were produced according to procedures contained in the *Long-Term Monitoring and Assessment Plan for the San Francisquito Creek Watershed* ("LTMAP"; Brosseau and Ruby, 2002). This review and analysis provides an important link between monitoring and management of the watershed, also as prescribed in the LTMAP.

The following tasks were undertaken in the review and analysis of the San Francisquito Creek watershed LTMAP monitoring data:

- Compile and format/organize LTMAP water quality monitoring data into a single, consistent data file
- Assess methods of sample collection and analysis for conformance with the LTMAP and associated monitoring plan and with relevant industry practices
- Assess alternate analytical methods for constituents with a preponderance of "ND" results
- Assess quality of data collected to date and perform related QA/QC review to the extent appropriate to identify/enable essential improvements
- Combine LTMAP water quality data from all sites and assess temporal and spatial trends (2001-2006)
- Perform comparisons of LTMAP data with historical Creek data (where available) for 303(d)-listed pollutants (copper, diazinon, mercury, PCBs and sediment, based on Bay and/or Creek listings) and 2-4 selected other constituents
- Check compliance of 303(d)-listed pollutants with water quality objectives based on LTMAP data; derive compliance frequencies
- Assess mercury/methyl mercury data levels/ratios where available; relate to potential for methylation in watershed (as readily feasible)
- Assess correspondence of water quality data with creek flow for 303(d)-listed pollutants and 2-4 selected other constituents
- Evaluate presentation of results in previous annual consultant reports; recommend improvements
- Provide written report of findings and recommendations
- Attend meeting of LTMAP Work Group to present and discuss results

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OVERVIEW OF MONITORING, DATA SET TO DATE

Monitoring was conducted at four creek sites within the San Francisquito ("SF") Creek watershed. These sites comprise four of the six long-term monitoring station locations specified in the LTMAP (see LTMAP Figure 3):

- SF Creek at Newell: the downstream site in the watershed, just above the tidal influence (LTMAP Site #1). Monitoring included 23-29 events per constituent (27 typically), from Feb. 2001 – May 2006.
- SF Creek at Piers Lane: just above the confluence with Los Trancos Creek (LTMAP Site #2). Monitoring included 13-22 events (20 typically), from Feb. 2002 – Dec. 2005.
- Los Trancos Creek at Piers Lane: just above the confluence with SF Creek (LTMAP Site #3). Monitoring included 13-22 events (19-20 typically), from Feb. 2002 – Dec. 2005.
- Bear Creek just above the confluence with SF Creek (LTMAP Site #5). Monitoring included 3-12 events (11 typically), from Dec. 2003 – Dec. 2005.

Monitoring at the Newell Road site was performed by the City of Palo; monitoring at the three upstream sites was performed by Balance Hydrologics under contract to Stanford University. A significant difference between SF Creek at Newell and the other sites is that the flow at Newell is seasonal, while the other three sites flow year-round. For the Newell site, about five samples were collected annually, during the rainy season or spring, when flow is present. For the three upstream sites, nominally five samples were collected per year, with attempts to include the following conditions: a first flush or early season storm, two winter storms, a spring storm, and late summer baseline flow.

Sampling and analysis was performed for a wide range of constituents, including conventional pollutants, nutrients, metals, and organic compounds, in conformance with the list of analytes specified in the LTMAP. For complete sample collection and analysis protocols, see the *Sampling and Analysis Plan: San Francisquito Creek Watershed Surface Water Quality Monitoring* ("SAP"), Appendix D in the LTMAP.

Composite samples were collected when feasible and when permitted by protocols; otherwise grab samples were collected. Grab sample dates followed the composite sample dates within a day or two but are meant to correspond. By local convention, the sample date for the composite samples is the setup date. The grab samples were typically collected at the time the composite sample was picked up, usually one or two days after composite sample initiation.

The LTMAP 2001-06 data were compiled and organized into an Excel dataset, and formatted as necessary for analysis.

The analysis includes characterization of the 2001-06 LTMAP data set, assessments of trends within the data, and comparisons to historical data from the 1990s.

SAMPLING AND ANALYSIS METHODS

Monitoring methods were generally found to conform to methods specified in the LTMAP SAP and with standard industry practice. In cases where equipment failure or other conditions prevented implementation of planned activities, field crews appear to have made reasoned decisions as to how to proceed (for example, collecting grab samples when equipment failure prevented composite sample collection).

Identified sampling/analysis issues that deserve attention include:

- Composite sample timing: when possible, composite samplers should be set to auto-start based on rainfall, stream flow/gage height, or a combination of those factors for storm-based events to increase capture runoff influence on creek flows
- Grab sample timing: grab samples should be collected near the estimated mid-point of the stream hydrograph for storm-based events, rather than at the end of the event (at completion of composite sampling), as end-of-event grabs may be less representative of the overall event

Some recommendations are made for improvements in procedures and monitoring facilities to provide for improved conformance with SAP protocols and increased success in completion of monitoring events (see Recommendations section).

CONSTITUENTS FREQUENTLY NOT-DETECTED

For those constituents that were typically reported as non-detect ("ND"), an assessment was made as to whether lower laboratory reporting limits could be practically achieved, and whether such a change would likely result in more frequent reporting of detectable concentrations at levels that would be meaningful with respect to the lowest prevailing water quality objective ("WQO") for the constituent. The typical reporting limits found in the LTMAP data set were initially compared in such cases to the reporting limits specified in the LTMAP SAP. The following summarizes the findings and recommendations from this assessment:

- Ammonia: <50% detected, RL = 0.2 mg/L
  Recommendation: attempt to achieve 0.1 mg/L (per LTMAP) or lower; should be feasible at commercial labs and at municipal/POTW labs
- Lead: <50% detected, RL = 0.4 μg/L
  Recommendation: OK as is - WQO is ≥1.44 μg/L; LTMAP spec. =1 μg/L
- Silver: very few detects, RL = 0.2 μg/L
  Recommendation: OK as is - WQO is ≥1.44 μg/L; LTMAP spec. =0.2 μg/L
- Pesticides (OPs, OCs, Pyrethroids): no detects
  - Diazinon: RL = 0.05-0.6 μg/L, Chlorpyrifos: RL = 0.05-0.5 μg/L
    Recommendation: try to achieve lower RLs (0.01 μg/L or lower).
  - OC Pesticides (SF Creek at Newell only)
    Recommendation: try to achieve lower RLs or drop from list.
- PAHs: no detects

Recommendation: try to achieve lower RLs at SF Creek at Newell site.

QUALITY ASSURANCE/QUALITY CONTROL

Based on a limited review, quality assurance and quality control have generally been acceptable throughout the LTMAP monitoring that has taken place to date.

Identified QA/QC issues that deserve attention include:

- Mercury sampling: clean hands techniques should be adhered to so as to minimize potential contamination (see SAP)
- Installed field probes: cleaning frequency and field calibration should be adjusted as needed to maintain probes in reliable working order
- QA/QC schedule: prior to each monitoring year a schedule of QA/QC samples should be established to ensure that all required QA/QC tests are performed (see SAP, Table 3)
- Autosampler-creek tubing cleaning: tubing should be removed and cleaned annually (during dry weather) per protocols specified in the SAP

Some recommendations are made for improvements to monitoring procedures that are expected to improve data quality and enhance the documentable QA/QC measures undertaken for LTMAP monitoring (see Recommendations section).

STATISTICAL SUMMARY OF LTMAP DATA

Statistical summaries of the 2001-06 LTMAP data are shown in Table 1 by site and constituent, including descriptive statistics for all constituents with at least 20% detected data. For data sets that include non-detect (“ND”) data, a regression-based method was used to compute the mean and other computationally-derived statistics.

TEMPORAL TRENDS

For several constituents with nearly-100% detected data, plots of concentration vs. date were produced in an effort to identify any apparent trends over time for the LTMAP data during the 2001-06 period (see Figures 1-4).

As these plots demonstrate, during 2001-2006 there were no trends apparent in the data scatter. This is not surprising due to the high variability in concentrations typically observed in natural systems, particularly when monitoring occurs during wet weather (storm-based) conditions, where variations in hydrological conditions lead to even greater variability in the water quality data.

HISTORICAL COMPARISONS

Limited comparisons of LTMAP 2001-06 data were made to available historical data sets. These comparisons are summarized in Table 2.

From these comparisons it appears that diazinon concentrations have decreased from average levels of 0.040-0.073 µg/L in the 1990s at all four creek sites to non-detectable levels in recent years. This trend is somewhat inconclusive, however, as the lab reporting limits during 2001-06 were 0.05-0.6 µg/L (ELISA methods were used for analysis of some samples during the 1990s to achieve lower detection limits). All LTMAP diazinon samples were non-detect at all four sites.

Results of comparisons of LTMAP data with historical data for copper, lead and mercury are inconclusive.

SPATIAL (SITE-TO-SITE) DIFFERENCES

As can be observed from the statistical summaries shown in Table 1, there are no striking differences among the four creek monitoring sites for most constituents. In Table 1 the high values for mean and median for each constituent are highlighted, and there is a fairly even and apparently random distribution of high values among the four sites. Site-to-site differences were subjected to statistical testing using ANOVA for selected constituents, with $p=0.05$ as the threshold for statistical significance.

Based on the ANOVA results, there were no significant site differences for Al, Cu, Hg, or TSS. Bear Creek had the highest mean and median concentrations for Hg and TSS, but the site-to-site differences were not statistically significant for either constituent. Of the constituents tested, only hardness exhibited statistically-significant site differences.

Mean and median copper values were highest at SF Creek at Newell. The difference in means between SF Creek at Newell and Los Trancos Creek was nearly statistically significant ($p=0.08$). However, because SF Creek runs dry annually at Newell, additional testing was performed using wet weather data only, in an effort to determine whether seasonal differences in sampling regimens - with dry season samples being collected at the upstream sites but not at Newell - could have influenced the pattern of results.

The dissolved copper measurements made during the dry season (June-September) at the three upstream sites were all in the lower range of the overall copper data set, varying from 1.2 - 2.7 µg/L. Very few measurements made outside of that period were within that range. The minimum observed concentrations occurred during those months for all 3 upstream sites. While most of the higher concentrations in the overall copper data set occurred at Newell, only two points (both 27 µg/L) stand out above the pack. There were no June-September samples at Newell. These factors would tend to contribute to differences in average copper concentrations between Newell and the upstream sites.

When the June-September data points were removed from the data set, the mean differences between Newell and the other sites decreased substantially, and the probabilities that the differences are not statistically significant increased in site-to-site comparisons (as shown by higher "p" values in the ANOVA test). Both effects are demonstrated by comparison of the ANOVA results for all copper data vs. wet season data only, as shown below:

ANOVA: Tukey's All Pairs Comparison
– All Dissolved Copper Data

Comparison	Mean Difference	P
SF Cr Newell vs Los Trancos Cr	3.36	0.08
SF Cr Newell vs SF Cr Piers	2.79	0.19
SF Cr Newell vs Bear Cr	2.58	0.42

ANOVA: Tukey's All Pairs Comparison
– Wet Season Dissolved Copper Data Only

Comparison	Mean Difference	P
SF Cr Newell vs Los Trancos Cr	2.66	0.31
SF Cr Newell vs SF Cr Piers	1.93	0.59
SF Cr Newell vs Bear Cr	1.65	0.81

SF Creek at Newell remains higher on average than the three upstream sites, even when dry season data are removed from the comparisons. So part of the reason that Newell runs higher in copper on average is explained by the seasonal sampling differences, but only part. It seems likely that inputs of copper from urban runoff in the lower watershed also contribute to the higher copper levels observed at Newell, although the data do not "prove" this.

The two Piers Lane sites (SF Creek and Los Trancos Creek) are both substantially higher in hardness than either the SF Creek at Newell and Bear Creek sites, and these site differences are statistically significant according to the results of the ANOVA test (see results, below). This helps to explain why neither of the Piers Lane sites exhibited concentrations above the hardness-based metals objectives (see Comparisons to Water Quality Objectives, below). The highest mean and median hardness occurred at Los Trancos, while SF Creek at Piers Lane had the second-highest mean and median. The difference between Los Trancos and SF Creek at Piers Lane was not statistically significant.

ANOVA: Tukey's All Pairs Comparison - Hardness
(Statistically-significant site differences highlighted)

Comparison	Mean Difference	P
Los Trancos Cr vs Bear Cr	187.	0.0006
Los Trancos Cr vs SF Cr Newell	168.	< .0001
Los Trancos Cr vs SF Cr Piers	57.9	0.433
SF Cr Piers vs Bear Cr	129.	0.0283
SF Cr Piers vs SF Cr Newell	111	0.0138
SF Cr Newell vs Bear Cr	18.6	0.9723

COMPARISONS WITH WATER QUALITY OBJECTIVES

For all constituents with sufficient detected data, comparisons were made from the LTMAP data to relevant water quality objectives ("WQOs"). The Marshack "Compilation of Water Quality Goals", compiled by the Central Valley Regional Water Quality Control Board, was used as a reference source for applicable regulatory limits. See: http://www.swrcb.ca.gov/rwqcb5/available_documents/wq_goals/

LTMAP constituents that exhibited one or more concentrations above a water quality objective are Al, Cu, Pb, Hg, and TSS. The water quality objectives are shown on the "over time" plots for Al, Hg and TSS (Figures 1-3). In general, there is no clear trend over time regarding relative frequency of occurrence of measured concentrations above the WQOs, nor is there any consistent pattern in the sites that exhibit values above the WQOs.

The WQOs used for Al (0.087 and 0.75 mg/L for chronic and acute criteria, respectively) are the USEPA Recommended Water Quality Criteria for Freshwater Aquatic Life. They are represented as total recoverable. The criteria citations in Marshack are accompanied by this note:

> *(62) For pH between 6.5 and 9.0. Use of Water-Effects Ratios might be appropriate because: (1) aluminum is less toxic at higher pH and hardness but relationship not well quantified; (2) aluminum associated with clay particles may be less toxic than that associated with aluminum hydroxide particles; (3) many high quality waters in U.S. exceed 87 μg/L as total or dissolved.*

[The above is an abbreviated version of the footnote from EPA's criteria compilation, which can be found at: http://www.epa.gov/waterscience/criteria/wqcriteria.html
Note that aluminum is a "non-priority pollutant" and is not included within the California Toxics Rule (CTR). The EPA compilation indicates that the original reference for the Al criteria document is: *Aluminum (EPA 440/5-86-008).*]

Copper and lead are special cases because the water quality criteria are hardness-dependent, with the objectives calculated from a formula that references the water-body-specific hardness at the time of sample collection. For copper and lead, the measured concentrations are plotted against the hardness-based objectives as calculated for each sample (Figures 5, 6).

Of the six copper data points that were above their respective hardness-based objectives, five occurred at SF Creek at Newell, and one occurred at Bear Creek. No exceedances occurred at either SF Creek at Piers Lane or Los Trancos Creek (at Piers Lane), partially because hardness tends to be substantially higher at those sites, so the calculated water quality objectives are higher. Only one measured lead concentration was found to be over its associated hardness-based objective; that sample also was collected from SF Creek at Newell.

MERCURY RATIOS

An important consideration in assessment of watershed mercury levels is the relative proportion of total mercury that is in the form of methyl mercury, as the methylated version is much more highly bioavailable and toxic. Both dissolved mercury and methyl mercury were plotted against total mercury, based on available data from SF Creek at Newell (Figure 7), and regression lines were computed for each subset. While the relationship between dissolved and total mercury is weak ($r^2 = 0.37$), the relationship between methyl and total mercury is quite strong ($r^2 = .90$). However, the slope of the methyl/total regression line is very shallow, indicating that methyl mercury increases little with increasing total mercury.

When assessing the potential for mercury methylation, areas where water is retained and where there are wetlands are typically considered to be relatively more favorable for methyl mercury production. In this context, Searsville Lake would seem to be one location that presents relatively high potential for mercury methylation.

CORRESPONDENCES WITH FLOW

It is common for water quality studies to demonstrate positive correlations between flow and constituent concentrations in natural waterways. To investigate this possible relationship, plots were constructed of concentration vs. flow for several constituents, including aluminum, dissolved copper, dissolved lead, mercury, nitrate and TSS (Figures 8-13). These plots include data from SF Creek at Piers Lane, Los Trancos Creek, and Bear Creek. For constituents without hardness-dependent objectives (Al, Hg, TSS), water quality objectives are also plotted on these figures, to illustrate the potential connection between flow and the occurrence of concentrations above WQOs (no NO3 values were greater than applicable objectives).

For all of these plots, the x-axis (flow) was log-transformed to better distribute the data for viewing. For Al, Hg and TSS the y-axis (concentration) was also log-transformed for the same purpose.

The constituents most associated with particulate matter (Al, Hg and TSS) appear to have the best correlation with flow, based on these plots. Correspondingly, for these constituents there tend to be more concentrations greater than WQOs at higher flow rates. However, the correlation coefficients are fairly weak ($r = 0.27$ for Al/flow; $r = 0.13$ for Hg/flow; $r = 0.37$ for TSS/flow for the untransformed data), so there is little ability to predict occurrence of concentrations above WQOs from flow rate.

RECOMMENDATIONS

Based on the preceding analysis, the following recommendations are made by activity category for the LTMAP creek monitoring.

Sample Analysis:

- Improve (lower) RL for ammonia (0.1 mg/L or lower)
- Improve (lower) RLs for diazinon, chlorpyrifos (0.01 µg/L)
- SF Creek at Newell only: improve (lower) RLs for OC pesticides and PAHs

Constituents:

- Consider dropping silver
- Add methyl mercury to upstream sites, continue at Newell
- Add sediment chemistry sampling/analysis; include analysis for pyrethroids, TOC, mercury, methylmercury, sulfate
- Add water and sediment toxicity testing using standard protocols at least annually

Sample Collection:

- Composite samplers should be set to auto-start based on rainfall, stream flow/gage height, or combination for storm-based events
- Collect grab samples near the estimated mid-point of the stream hydrograph for storm-based events whenever feasible
- Measure and record creek flow during each monitoring event

QA/QC:

- Follow QA/QC schedule (see SAP, Table 3)
- Remove/clean autosampler-creek tubing annually
- Use clean hands techniques as described in SAP for mercury sample collection

Equipment/Operations:

- Increase cleaning frequency and field calibration of field probes (minimum monthly if possible)
- Install AC power to all stations
- Install land-based telephone lines to all stations

Reporting:

- Hardness-dependent objectives: limit to 2 signif. digits; cap at 400 mg/L hardness
- Produce matrix of key hydrological parameters (rainfall amount, rainfall intensity, cumulative precipitation to date, antecedent dry period) for monitored events; identify any gaps in monitored storm types

Data Management/Analysis:
- Coordinate annual compilation of data from all LTMAP sites
- Add flow data for SF Creek at Newell to dataset for analysis of concentrations vs. flow
- Investigate questions concerning metals fractions (dissolved vs. total recoverable) in City of Palo Alto database

Follow-up Investigation/Analysis:
- Conduct additional comparisons to historical data if additional historical data can be reliably identified
- Investigate potential for mercury methylation, particularly in and around Searsville Lake

Budget:
- Count on annual need for equipment maintenance/replacement in budget
- Budget for increased cleaning of installed field probes
- Budget for necessary QA/QC sampling/analysis
- Arrange/fund AC power installation
- Arrange/fund hard-wired telephone installation
- Budget for periodic data analysis to promote adaptive management

Table 1. Statistical Summary of San Francisquito Creek Watershed LTMAP Data, 2001-2006

METALS

ALUMINUM	SF Cr @Newell - Al (mg/L)	SF Cr @Piers - Al (mg/L)	Los Trancos Cr - Al (mg/L)	Bear Cr - Al (mg/L)
n	**25**	**18**	**18**	**11**
Percent detected	**100%**	**89%**	**78%**	**91%**
Mean	**3.5**	2.9	4.5	4.2
Standard Deviation	**3.8**	3.4	9.3	3.7
Coeff. of Variation	**1.1**	1.2	2.1	0.9
Median	**2.1**	**2.15**	0.51	**3**
Min. Detected Value	**0.024**	**0.03**	**0.03**	**0.02**
Max. Detected Value	**15**	**12**	**33**	**11**

COPPER	SF Cr @Newell - Cu (Dis.)	SF Cr @Piers - Cu (Dis.)	Los Trancos Cr - Cu (Dis.)	Bear Cr - Cu (Dis.)
n	**27**	**20**	**20**	**11**
Percent detected	**100%**	**100%**	**100%**	**100%**
Mean	**8.1**	**5.3**	**4.7**	**5.5**
Standard Deviation	**6.7**	**3.9**	**3.1**	**3.0**
Coeff. of Variation	**0.83**	**0.73**	**0.67**	**0.5**
Median	**6.5**	**4.7**	**3.8**	**4.9**
Min. Detected Value	**1.1**	**1.4**	**1.4**	**1.2**
Max. Detected Value	**27**	**17**	**11**	**10.6**

LEAD	SF Cr @Newell - Pb (Dis.)	SF Cr @Piers - Pb (Dis.)	Los Trancos Cr - Pb (Dis.)	Bear Cr - Pb (Dis.)
n	**27**	**20**	**20**	**11**
Percent detected	**56%**	**30%**	**30%**	**27%**
Mean	0.71	0.35	0.28	0.24
Standard Deviation	1.4	0.29	0.32	0.31
Coeff. of Variation	1.9	0.83	1.1	1.3
Median	0.39	0.28	0.17	0.14
Min. Detected Value	**0.4**	**0.4**	**0.4**	**0.4**
Max. Detected Value	**6**	**1.1**	**1.2**	**0.9**

Table 1, cont'd.

MERCURY	SF Cr @Newell - Hg (Tot.) (ng/L)	SF Cr @Piers - Hg (Tot.) (ng/L)	Los Trancos Cr - Hg (Tot.) (ng/L)	Bear Cr - Hg (Tot.) (ng/L)
n	**27**	**16**	**16**	**9**
Percent detected	**93%**	**100%**	**100%**	**100%**
Mean	61	**25**	**47**	**74**
Standard Deviation	112	**37**	**84**	**98**
Coeff. of Variation	1.8	**1.5**	**1.8**	**1.3**
Median	23	**11**	**16**	**38**
Min. Detected Value	**1.8**	**0.9**	**1**	**1.7**
Max. Detected Value	**490**	**130**	**270**	**280**

NICKEL	SF Cr @Newell - Ni (Dis.)	SF Cr @Piers - Ni (Dis.)	Los Trancos Cr - Ni (Dis.)	Bear Cr - Ni (Dis.)
n	**27**	**19**	**19**	**11**
Percent detected	**100%**	**100%**	**100%**	**100%**
Mean	**5.1**	**4.9**	**4.7**	**4.0**
Standard Deviation	**3.5**	**1.4**	**2.6**	**1.3**
Coeff. of Variation	**0.69**	**0.29**	**0.54**	**0.32**
Median	**4.5**	**4.6**	**3.9**	**3.9**
Min. Detected Value	**2.6**	**3**	**2.9**	**2.4**
Max. Detected Value	**19**	**9**	**12**	**7**

SELENIUM	SF Cr @Newell - Se (Tot.)	SF Cr @Piers - Se (Tot.)	Los Trancos Cr - Se (Tot.)	Bear Cr - Se (Tot.)
n	**29**	**18**	**19**	**11**
Percent detected	**97%**	**100%**	**100%**	**91%**
Mean	0.34	**0.39**	**0.47**	0.26
Standard Deviation	0.24	**0.29**	**0.60**	0.17
Coeff. of Variation	0.69	**0.75**	**1.3**	0.67
Median	**0.3**	**0.3**	**0.3**	**0.2**
Min. Detected Value	**0.1**	**0.2**	**0.1**	**0.1**
Max. Detected Value	**1**	**1.3**	**2.1**	**0.6**

ZINC	SF Cr @Newell - Zn (Dis.)	SF Cr @Piers - Zn (Dis.)	Los Trancos Cr - Zn (Dis.)	Bear Cr - Zn (Dis.)
n	**27**	**20**	**20**	**11**
Percent detected	**96%**	**95%**	**90%**	**100%**
Mean	25	20	18	**24**
Standard Deviation	14	10	14	**11**
Coeff. of Variation	0.57	0.52	0.77	**0.46**
Median	**28**	**21**	**16**	**24**
Min. Detected Value	**6**	**6**	**2.1**	**6**
Max. Detected Value	**51**	**38**	**50**	**41**

Table 1, cont'd.

NUTRIENTS

AMMONIA	SF Cr @Newell - NH4 (mg/L)	SF Cr @Piers - NH4 (mg/L)	Los Trancos Cr - NH4 (mg/L)	Bear Cr - NH4 (mg/L)
n	**25**	**22**	**22**	**11**
Percent detected	**36%**	**14%**	**27%**	**55%**
Mean	0.19		0.17	0.20
Standard Deviation	0.20		0.21	0.12
Coeff. of Variation	1.08		1.20	0.58
Median	0.13		0.10	**(ND)**
Min. Detected Value	**0.22**	**0.31**	**0.22**	**0.2**
Max. Detected Value	**0.89**	**1.2**	**0.79**	**0.44**

NITRATE	SF Cr @Newell - NO3 (mg/L)	SF Cr @Piers - NO3 (mg/L)	Los Trancos Cr - NO3 (mg/L)	Bear Cr - NO3 (mg/L)
n	**23**	**13**	**14**	**3**
Percent detected	**100%**	**100%**	**100%**	**100%**
Mean	**1.4**	**2.1**	**2.5**	**0.65**
Standard Deviation	**1.1**	**1.6**	**1.5**	**0.40**
Coeff. of Variation	**0.79**	**0.76**	**0.61**	**0.62**
Median	**0.8**	**1.4**	**2.2**	**0.74**
Min. Detected Value	**0.3**	**0.38**	**0.43**	**0.27**
Max. Detected Value	**3.6**	**5.5**	**5.7**	**0.95**

PHOSPHATE	SF Cr @Newell - PO4 (mg/L)	SF Cr @Piers - PO4 (mg/L)	Los Trancos Cr - PO4 (mg/L)	Bear Cr - PO4 (mg/L)
n	**27**	**20**	**19**	**11**
Percent detected	**100%**	**100%**	**100%**	**100%**
Mean	**1.2**	**0.93**	**1.5**	**1.3**
Standard Deviation	**0.94**	**0.94**	**1.9**	**0.71**
Coeff. of Variation	**0.80**	**1.0**	**1.3**	**0.54**
Median	**1.0**	**0.75**	**0.89**	**1.4**
Min. Detected Value	**0.123**	**0.18**	**0.15**	**0.245**
Max. Detected Value	**4.6**	**3.98**	**7.05**	**2.73**

Table 1, cont'd.

CONVENTIONALS

TSS

	SF Cr @Newell - TSS (mg/L)	SF Cr @Piers - TSS (mg/L)	Los Trancos Cr - TSS (mg/L)	Bear Cr - TSS (mg/L)
n	**27**	**17**	**17**	**12**
Percent detected	**100%**	**100%**	**100%**	**100%**
Mean	**121**	**134**	**161**	**203**
Standard Deviation	**132**	**191**	**450**	**176**
Coeff. of Variation	**1.1**	**1.4**	**2.8**	**0.87**
Median	**71**	**84**	**14**	**125**
Min. Detected Value	**0.7**	**2.2**	**1.5**	**1.8**
Max. Detected Value	**440**	**710**	**1530**	**450**

HARDNESS

	SF Cr @Newell - Hardness (mg/L)	SF Cr @Piers - Hardness (mg/L)	Los Trancos Cr - Hardness (mg/L)	Bear Cr - Hardness (mg/L)
n	**25**	**18**	**18**	**10**
Percent detected	**100%**	**100%**	**100%**	**100%**
Mean	**198**	**309**	**367**	**179**
Standard Deviation	**75**	**154**	**141**	**51**
Coeff. of Variation	**0.38**	**0.50**	**0.38**	**0.29**
Median	**175**	**290**	**327**	**170**
Min. Detected Value	**60**	**104**	**184**	**94**
Max. Detected Value	**316**	**643**	**590**	**246**

Notes for statistical summary tables:
Bolded values are exact calculations, directly from the data.
Non-bolded values are estimated using regression on ordered statistics (ROS).
Estimates of distribution parameters become less accurate as the percent detected data decreases, and may be unacceptable below a 40% detection threshold.

Table 2. Comparisons of LTMAP Data with Historical Data

	Cu (µg/L)	Hg (µg/L)	Pb (µg/L)
SF Creek at Newell 1992-95:	21	0.18	9
SF Creek at Newell 2001-06:	22	0.061	6.3

Source: Memo from Leo Sarmiento, City of Palo Alto, July 28, 1995 (metals are assumed to be reported as total recoverable)

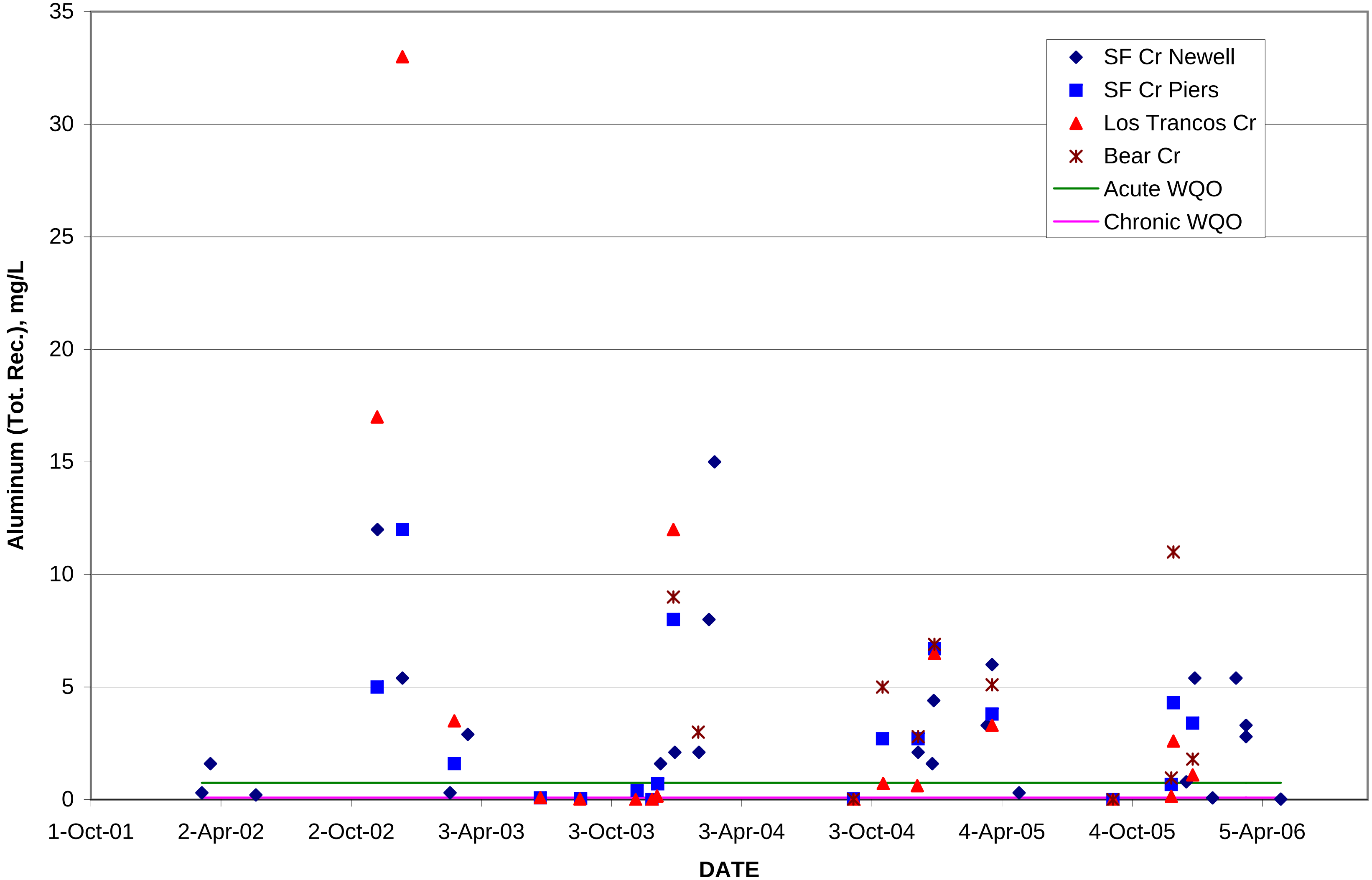
	Diazinon (µg/L)
SF Creek at Newell 1994-95:	0.048
SF Creek at Newell 2001-06:	ND (at RL = 0.05-0.6 µg/L)

Source: *Diazinon in Surface Waters in the San Francisco Bay Area: Occurrence and Potential Impact*, Katznelson and Mumley, June 30, 1997

	Diazinon (µg/L)	Hg (µg/L)
SF Creek at Piers 1997-98:	0.040	ND (at RL = 0.1 µg/L)
SF Creek at Piers 2002-05:	ND (at RL = 0.05-0.6 µg/L)	0.025
Los Trancos Creek 1997-98:	0.073	ND (at RL = 0.1 µg/L)
Los Trancos Creek 2002-05:	ND (at RL = 0.05-0.6 µg/L)	0.047
Bear Creek 1997-98:	0.046	0.15
Bear Creek 2003-05:	ND (at RL = 0.05-0.6 µg/L)	0.074

Source: *Sampling and Analysis of Water from the San Francisquito Creek Watershed: 1997-98*, Jim Johnson, March 24, 1999.

Figure 1. Aluminum Concentration Over Time



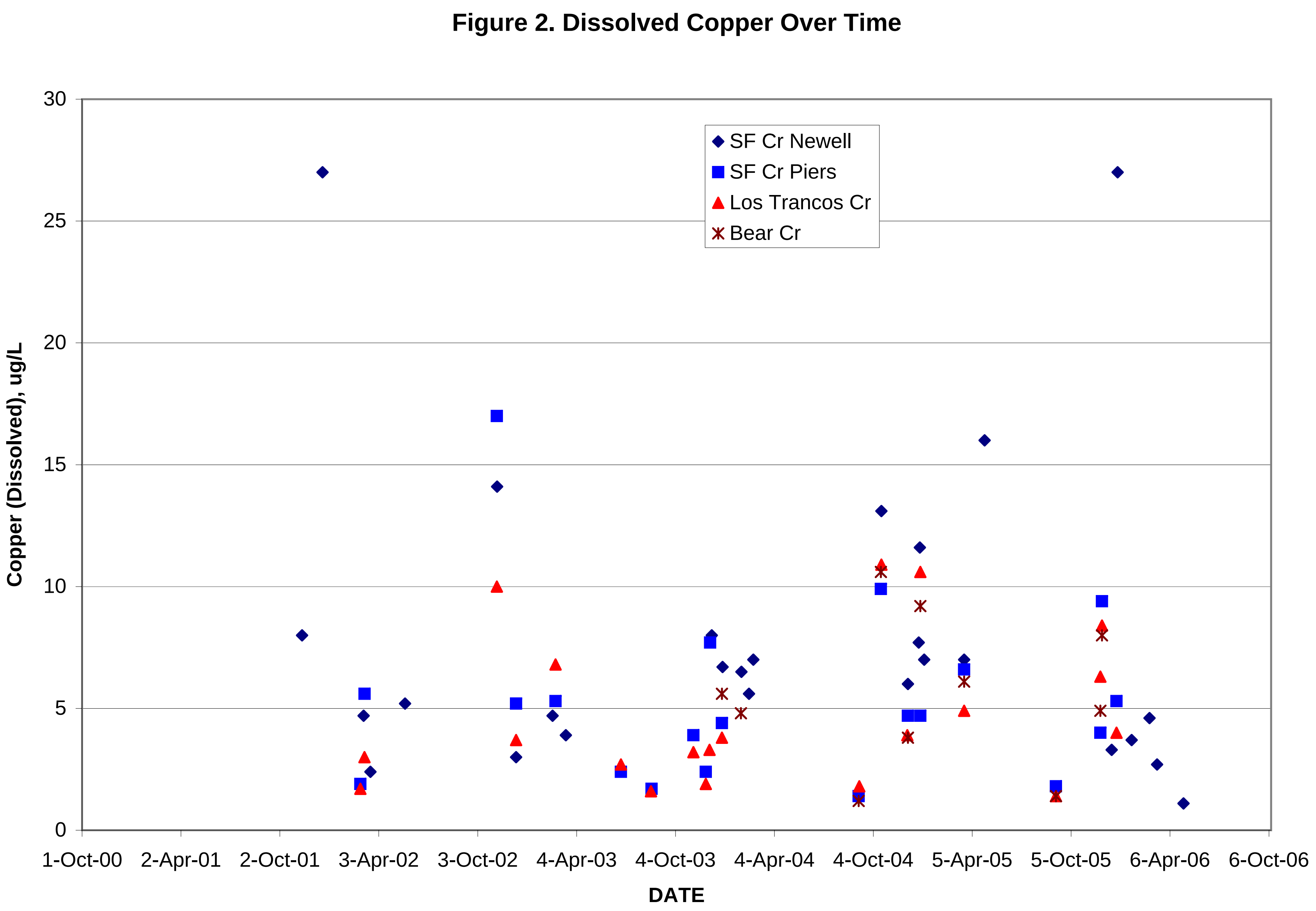


Figure 2. Dissolved Copper Over Time
Copper (Dissolved), ug/L
30
25
20
15
10
5
0
SF Cr Newell
SF Cr Piers
Los Trancos Cr
Bear Cr
1-Oct-00
2-Apr-01
2-Oct-01
3-Apr-02
3-Oct-02
4-Apr-03
4-Oct-03
4-Apr-04
4-Oct-04
5-Apr-05
5-Oct-05
6-Apr-06
6-Oct-06
DATE

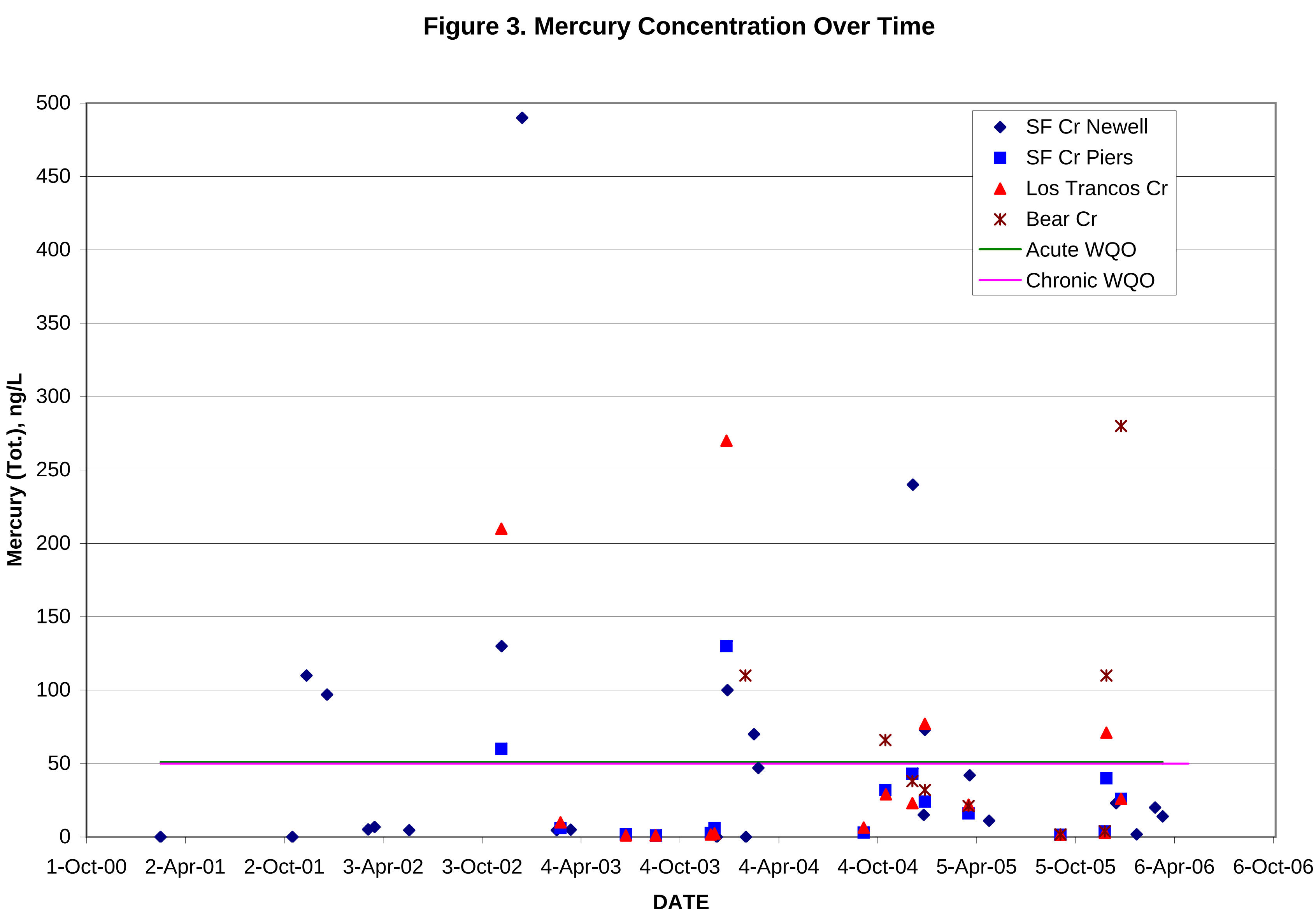


Figure 3. Mercury Concentration Over Time
Mercury (Tot.), ng/L
500
450
400
350
300
250
200
150
100
50
0
1-Oct-00
2-Apr-01
2-Oct-01
3-Apr-02
3-Oct-02
4-Apr-03
4-Oct-03
4-Apr-04
4-Oct-04
5-Apr-05
5-Oct-05
6-Apr-06
6-Oct-06
DATE
SF Cr Newell
SF Cr Piers
Los Trancos Cr
Bear Cr
Acute WQO
Chronic WQO

Figure 4. TSS Concentration Over Time

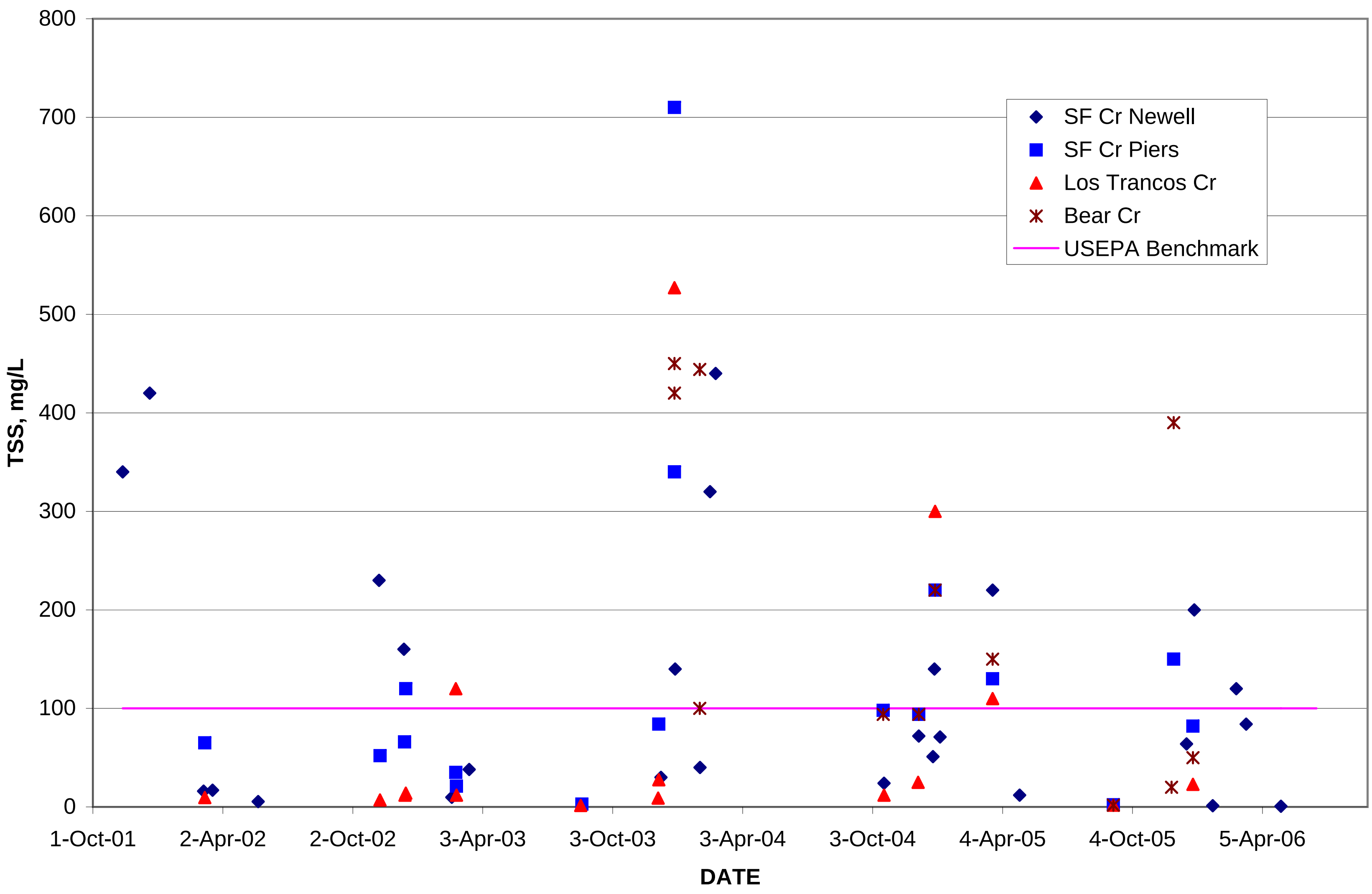


Figure 5. Dissolved Copper Concentrations versus Water Quality Objectives

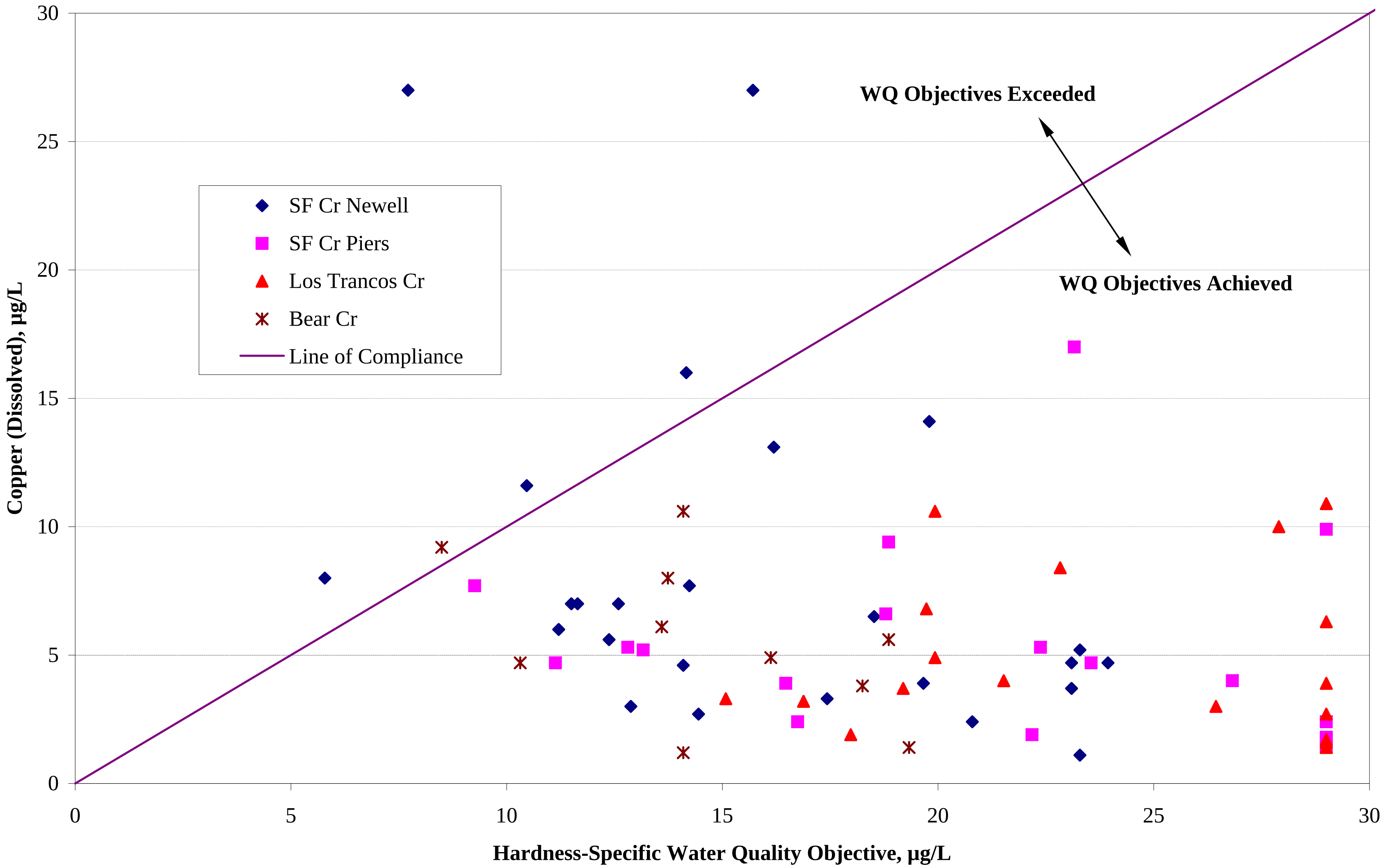


Figure 6. Dissolved Lead Concentrations versus Water Quality Objectives

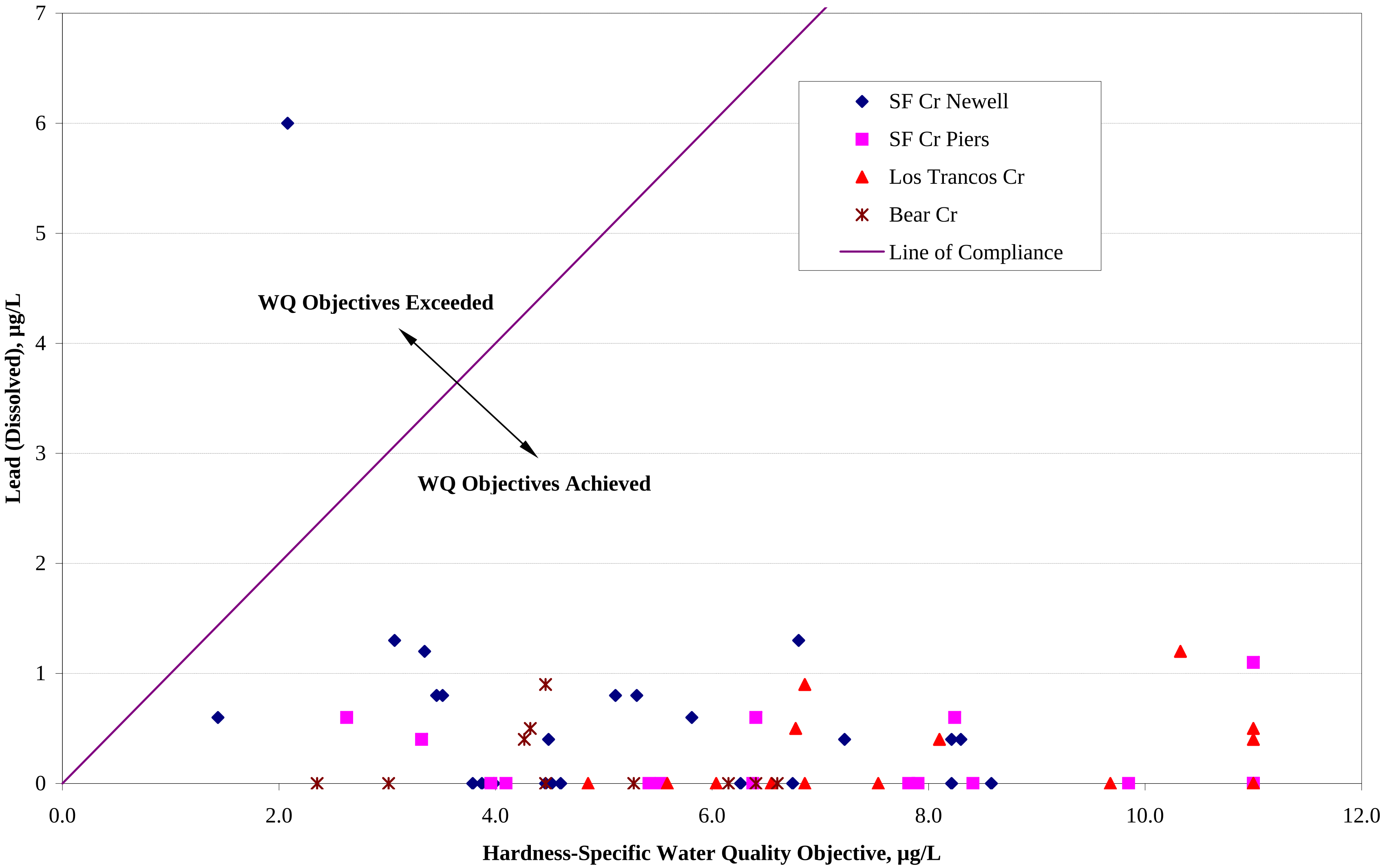


Figure 7. Correspondence of Dissolved and Methylmercury to Total Mercury in San Francisquito Creek, 2004-06

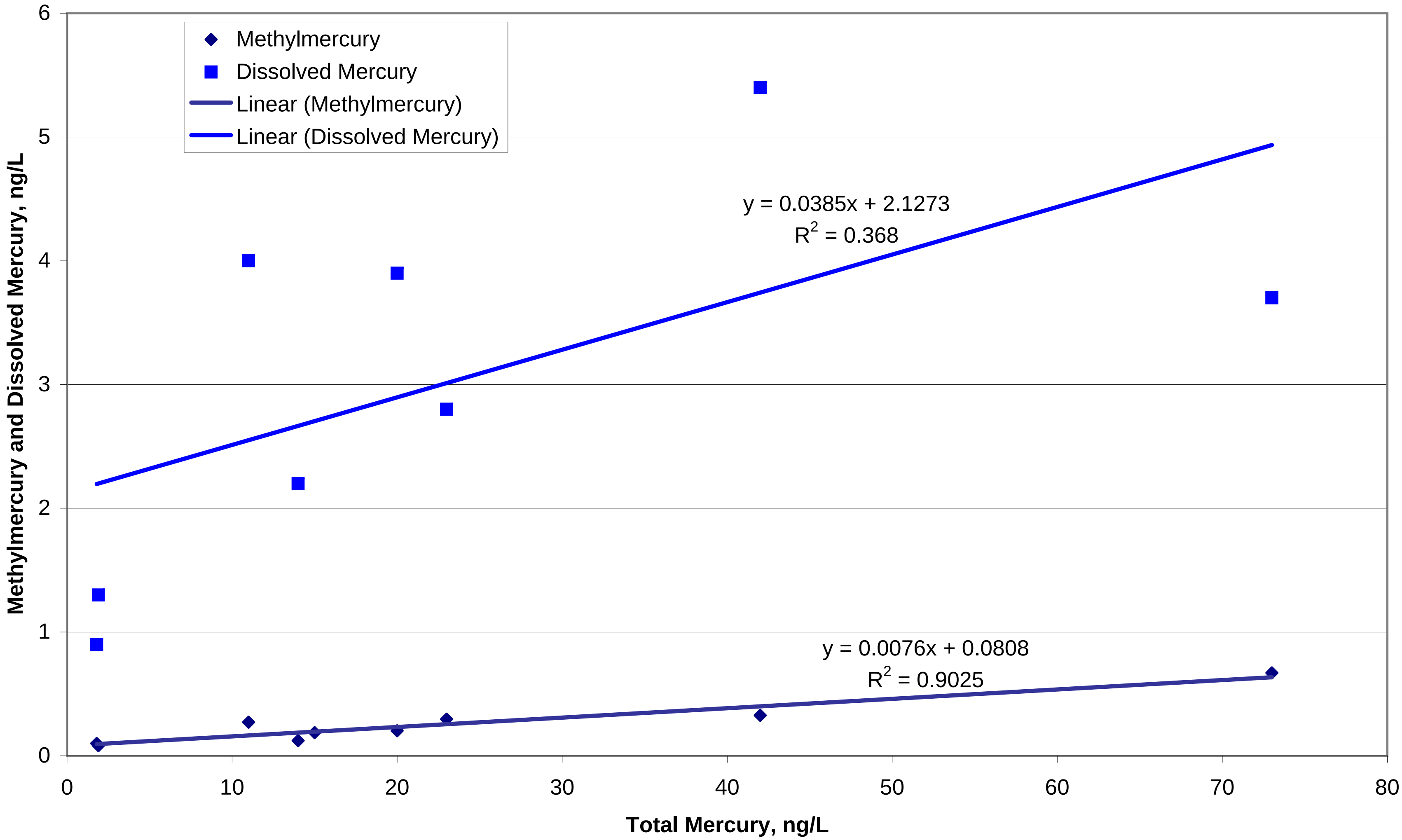


Figure 8. Aluminum Concentration vs. Average Event Flow

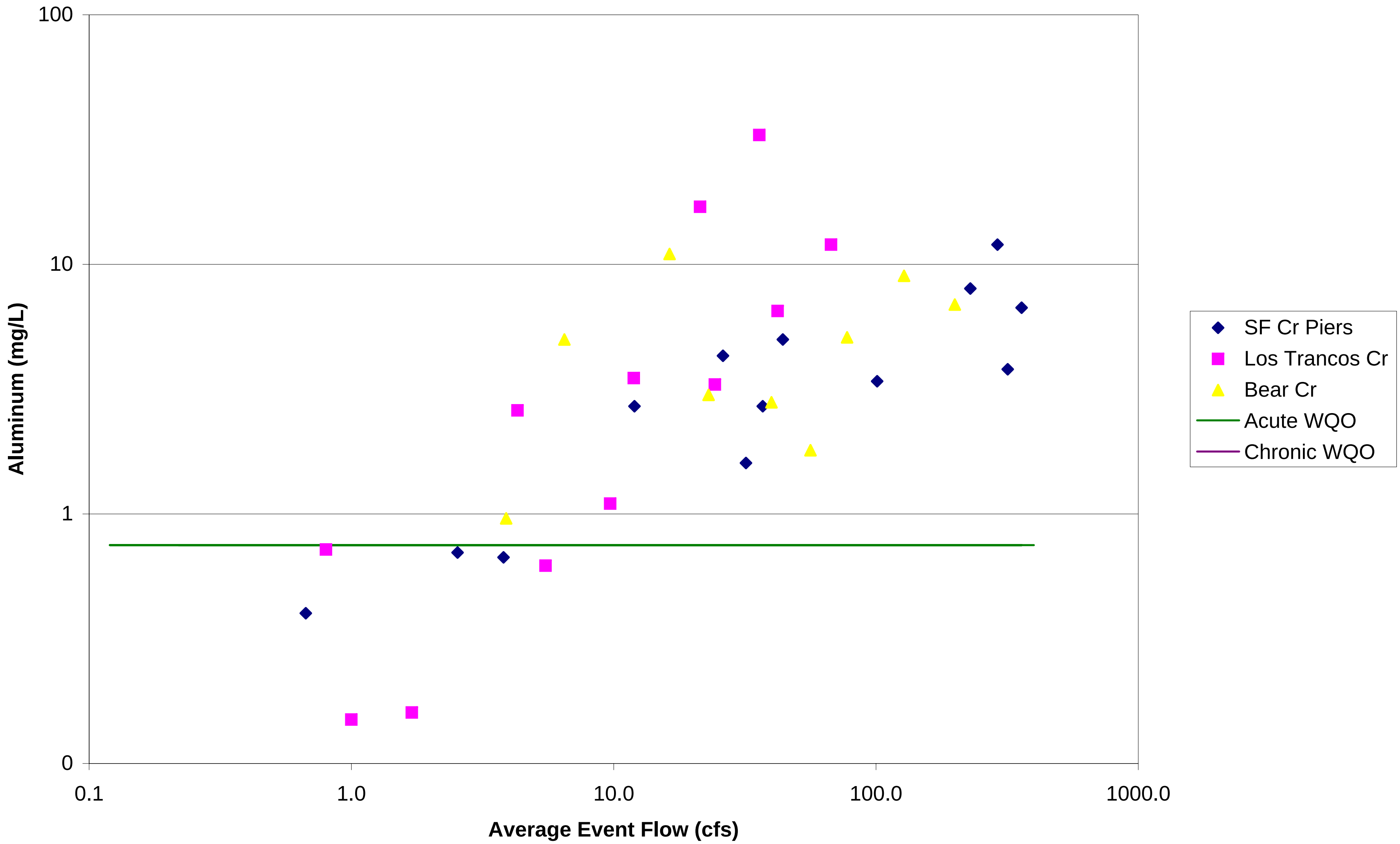


Figure 9. Dissolved Copper Concentration vs. Average Event Flow

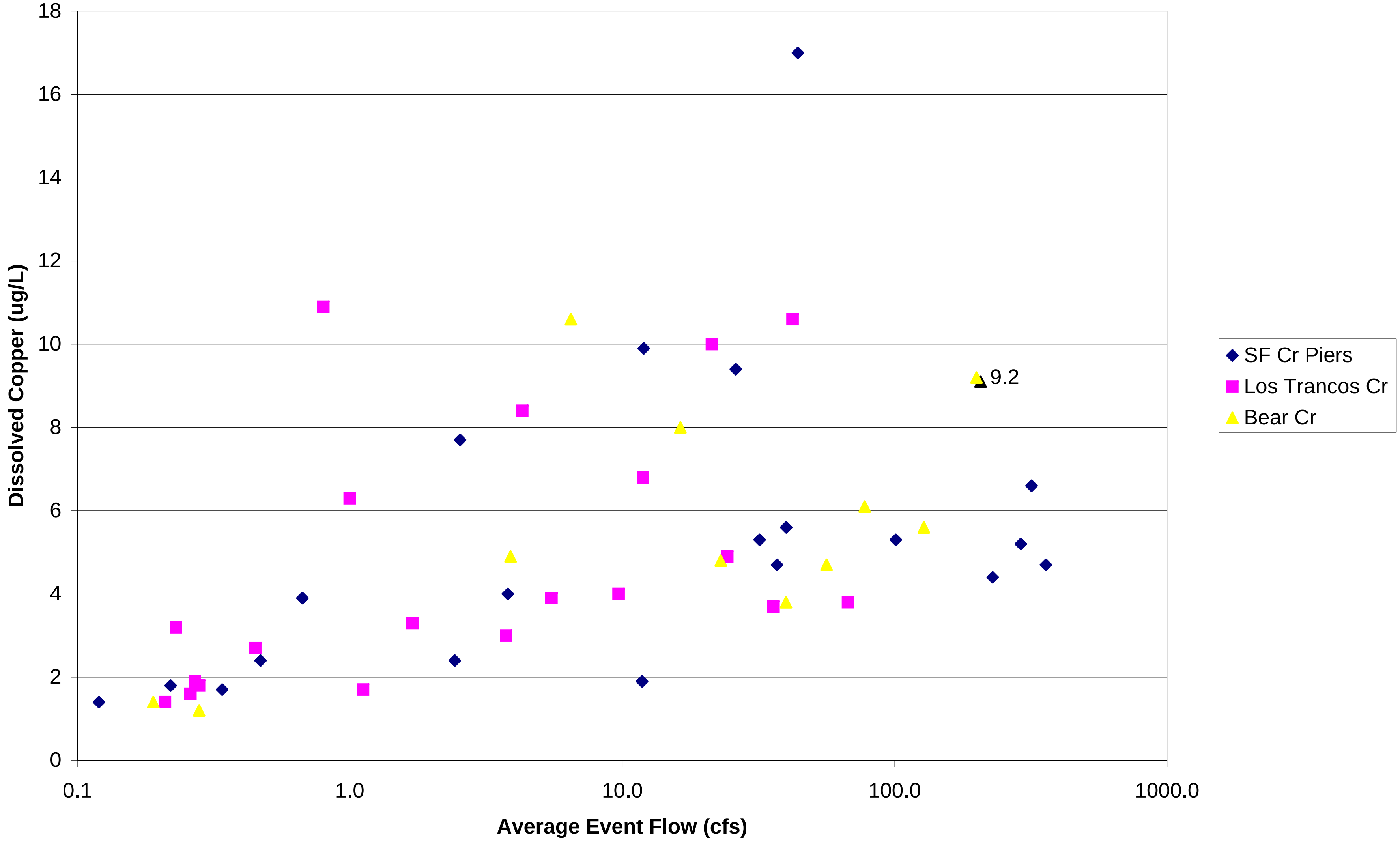


Figure 10. Dissolved Lead Concentration vs. Average Event Flow

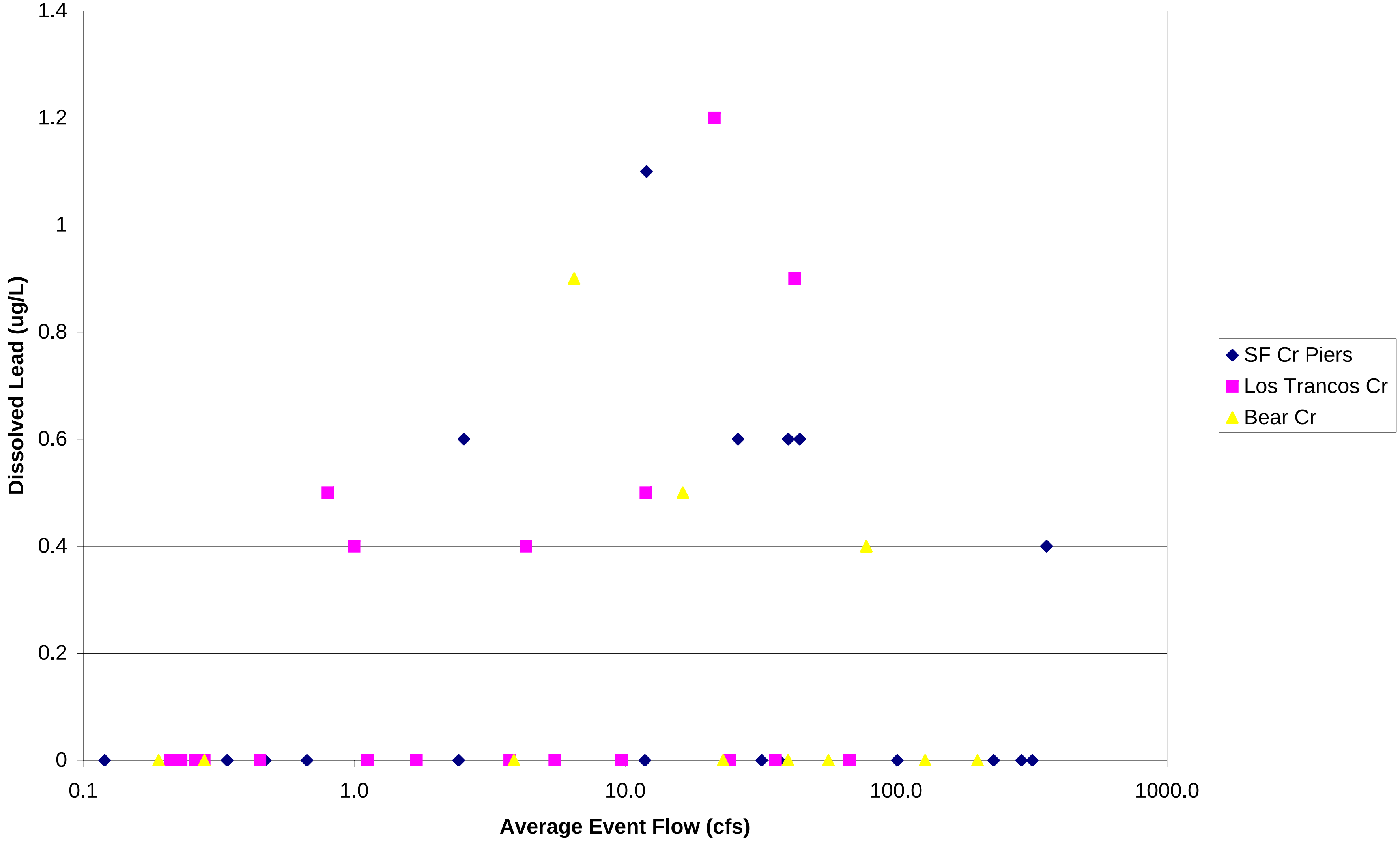


Figure 11. Mercury Concentration vs. Average Event Flow

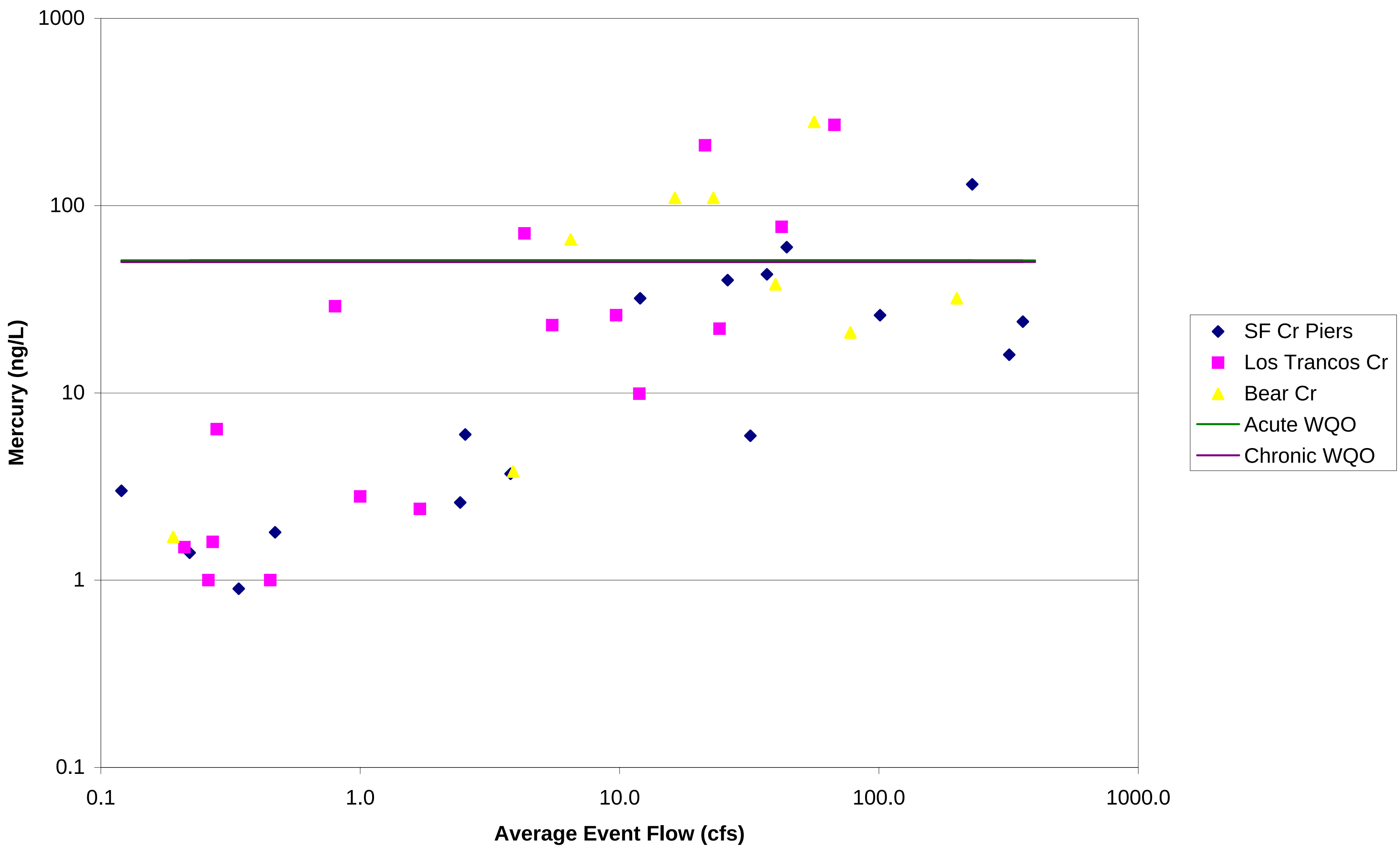


Figure 12. Nitrate Concentration vs. Average Event Flow

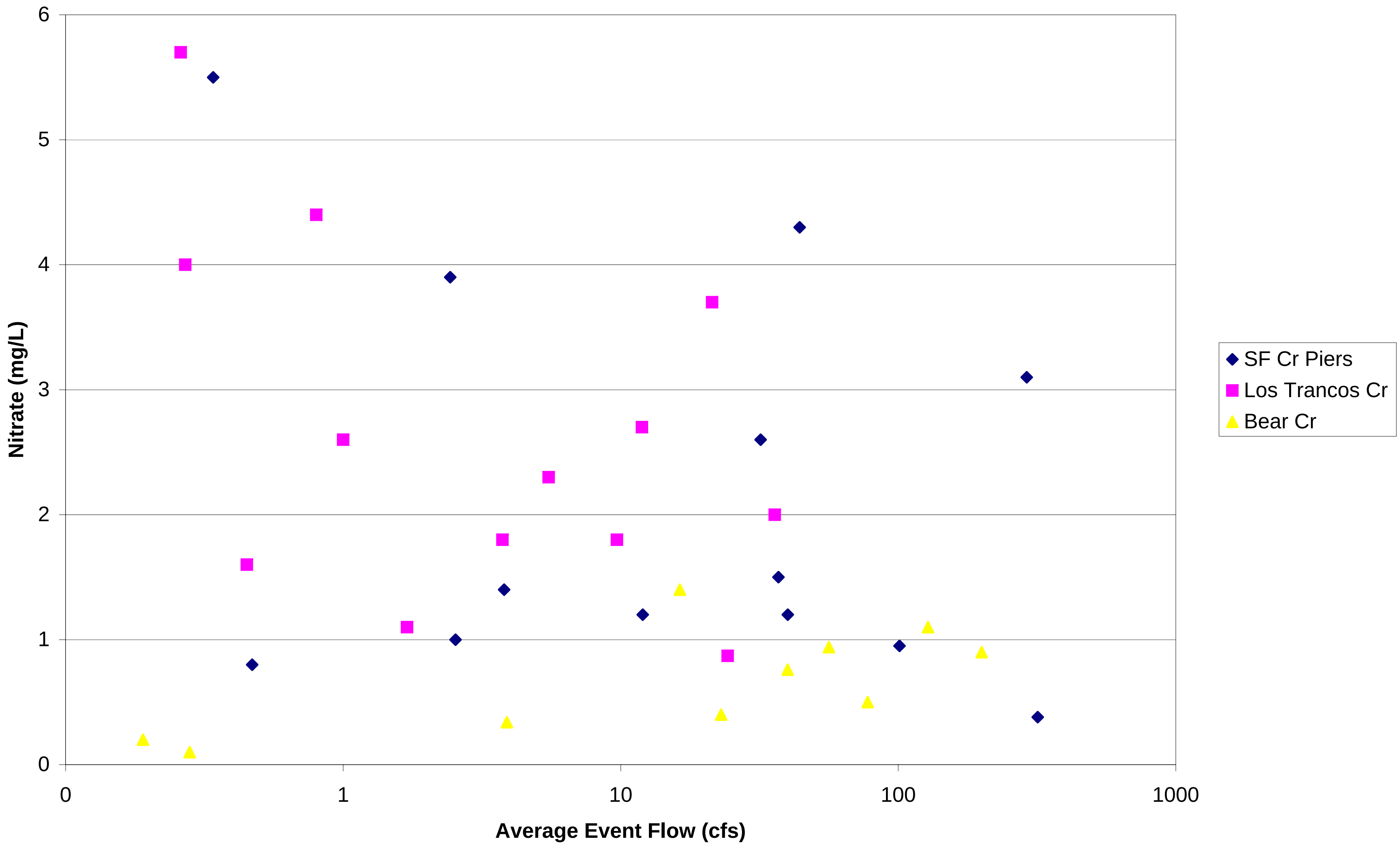


Figure 13. TSS Concentration vs. Average Event Flow