State of California
The Resources Agency

M e m o r a n d u m

To : Files **Date** : December 6, 2000

From : **Department of Fish and Game -- Post Office Box 47, Yountville, California 94599**

Subject: Marin-Sonoma Counties Agricultural Runoff Influence Investigation – 1999-2000 Summary

This program, supported in part by funding from the San Francisco Bay Regional Water Quality Control Board, was undertaken as a service to the Marin-Sonoma Animal Waste Committee, and local operators of confined animal feeding operations (CAFO), e.g. stables and dairies. The Department's program is limited to monitoring water quality at 20 stations in San Antonio, Stemple and Americano Creek watersheds of Sonoma County, and 20 stations in the Tomales Bay watershed of Marin County.

The 1999-2000 winter was relatively wet; yet most dairy operators were able to contain their contaminated runoff from reaching local creeks. The major exception to this was an incident this spring in upper Stemple Creek where runoff from one or more dairy operations above the study area was found to be the principal causal agent for unacceptable levels of dissolved oxygen, ammonia, and conductivity which moved downstream through the study area over a prolonged period of time. None-the-less, the data set continues to demonstrate the steady improvement in water quality within these watersheds since the early '90s as a result of increased attention to animal waste management by area producers.

Methods

A water sample was collected from each of 40 stations identified on Figures1a-e with the aid of an ACE 3-gallon, LRB sampler (little red bucket), and 50 feet of rope. Samples were collected from each station at least biweekly, with the Tomales watershed being sampled on alternating weeks with the Stemple, Americano, and San Antonio Creek watersheds. Some stations were sampled on a more frequent basis as a result of sample collection routing preferences.

All samples were initially collected with the LRB sampler, and then subsampled by immersing a chemically clean, glass, quart jar slowly into the sample as if it were the receiving water. Each subsample was then characterized in the field by measurement of pH, temperature, dissolved oxygen, and electrical conductivity, using a Cole/Parmer Model 5941-00 electronic pH probe, and a YSI Model 85 Dissolved Oxygen-Conductivity-Temperature Meter, respectively.

The quart samples were topped-off, sealed, labeled, placed in a sample carrier, kept cool and transported to the DFG Water Quality Laboratory in Yountville for analysis of turbidity and total ammonia, (usually the next morning), using a Hach Model 2100A Turbidimeter calibrated with Gelex® Secondary Turbidity Standards, and an Orion Model 290A pH/ISE meter with an Orion model 95-12 ammonia electrode. Concentrations of un-ionized ammonia (NH_3-tox) were calculated according to methods outlined in Morgan and Turner, 1977. Samples were also collected periodically for bacterial analysis in coordination the San Francisco Bay Regional Water Quality Control Board's contract laboratory (Sequoia Analytical Laboratories, 1455 McDowell Blvd. North, Suite D, Petaluma, CA 94954) as well as by Tomales Bay Oyster Growers and submitted to the County of Sonoma Public Health Laboratory in Santa Rosa for bacterial analysis. Although not an element of this program, laboratory results of bacterial analysis for samples collected at our station locations are included herein.

Results

The following tables represent descriptive statistics for the 1999-2000 water year as a whole, as well as by watershed. The entire data set arranged by station and date with descriptive statistics is included as Appendix A; summary data by watershed is included as Appendix B; and a summary by water years over the period of investigation are contained in Appendix C.

Table I
All 99-2000 (98-9) **Data**

	Dissolved Oxygen mg/l	Total Ammonia mg/l	Un-ionized Ammonia mg/l	Conductivity ?mhos/cm
Average *	**9.29** (10.09)	**0.420** (1.004)	**0.0068** (0.014)	**577** (412)
Range	**6.2-10.3** (2.0-15.9)	**0-25.2** (0-17.4)	**0-1.071** (0- 0.377)	**8-2342** (75-1690)
Criteria**	5.0-7.0	-	0.025	750
Exceedances	**53** (14)	-	**39** (77)	**125** (73)
Percent Exceedance	**6.36** (2)	-	**4.68** (12)	**15** (12)

* 833 measurements
** SF Bay RWQCB Basin Plan

Discussion

The majority of stations sampled revealed acceptable concentrations of all parameters, e.g. concentration of dissolved oxygen near saturation, low total ammonia and conductivity during most sampling events. Even at those locations where exceedances were locally great, the station averages appeared to indicate that conditions were marginally acceptable, --most of the time. However, averages of any water quality parameter can be misleading as fish and aquatic life are quite sensitive to change, and are more likely to be adversely affected by extremes than by averages. For example, if a lethal threshold of any parameter is reached, even for a few minutes, i.e. toxic levels of ammonia, or insufficient concentrations of dissolved oxygen, sensitive species of fish or invertebrates upon which they rely for food, will be killed. If conditions are then made more acceptable, either by abatement of discharge, reduction of contaminated stormwater runoff, or dilution, the habitat may again be able to sustain life, but few, if any organisms remain. Clearly, if our local streams are to have abundant fish and aquatic life, we must work hard to prevent receiving waters from experiencing these deleterious water quality excursions.

With the early onset of rains in the fall, streams began flowing; and we were again able to begin monitoring by the middle of November. The marginal habitat conditions resulting from oxygen depressions and lethal concentrations of ammonia observed during the first flush last season was much less pronounced this year. While probably not a true flush, it does represent the effect of mobilized decomposable organics and nutrients either deposited during the dry season within the stream channels, or washed into channels with the first periods of runoff. Under these low flow conditions pollutants are neither diluted significantly, nor carried out of the system; and bacterial decomposition and conversion of urea and ammonia to nitrate is very active. These conditions can inhibit the later establishment of the food web necessary for the survival of fish and invertebrates which will colonize the habitat when flows increase.

Trends

From Table I, and Figures 1- we can see a dramatic improvement in nearly all parameters. The mean total ammonia concentrations, for example, for all data by year represented in Figure 1 shows an increase of about 30% in 97/98 from the previous winter, but then an equivalent decline in 98/99, followed by an amazing 60% decline in 99/00. The range of total ammonia represented in Figure 2 does not compliment the image of continual improvement, but rather the variability of the worst case scenarios.

Figure 1
All Data-Mean Total NH3

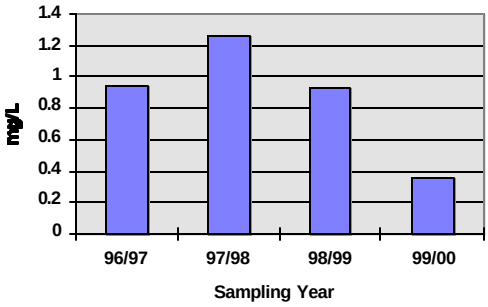


Figure 2
All Data-Mean Total NH3
With Range

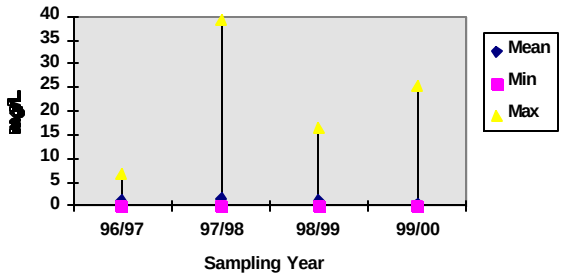


Figure 3
All Data-Mean Toxic NH3

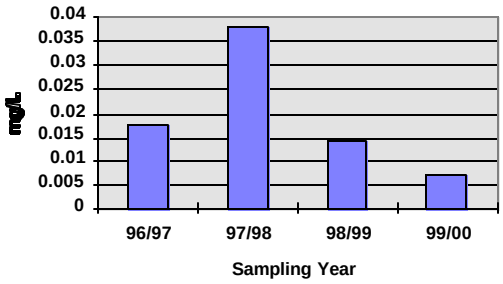


Figure 4
All Data-Mean Toxic NH3
With Range

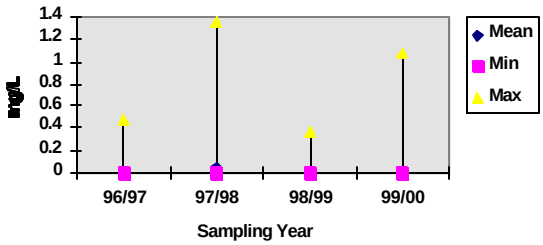


Figure 5
All Data-Maximum Total NH3

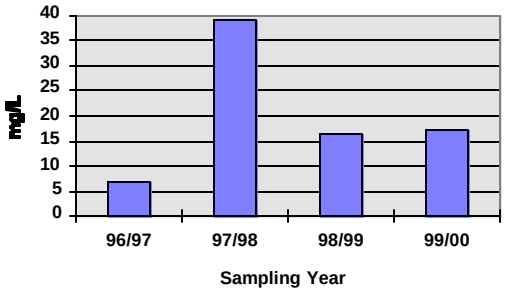


Figure 6
All Data-Maxumum Toxic NH3

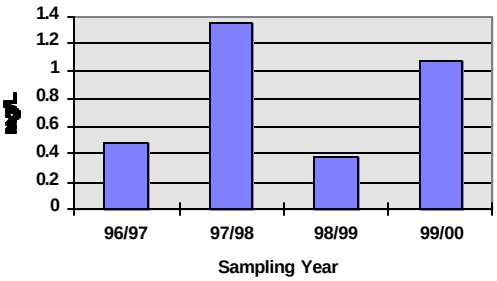


Figure 7
All Data-Mean D.O.

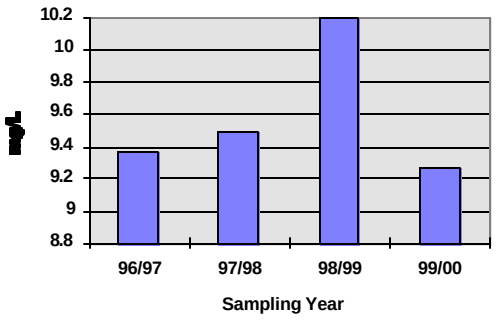


Figure 8
All Data-Mean D.O.
With Range

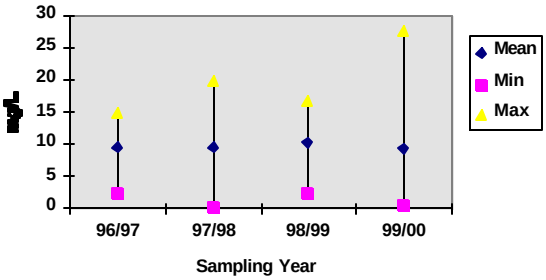


Figure 9
All Data-Minimum D.O.

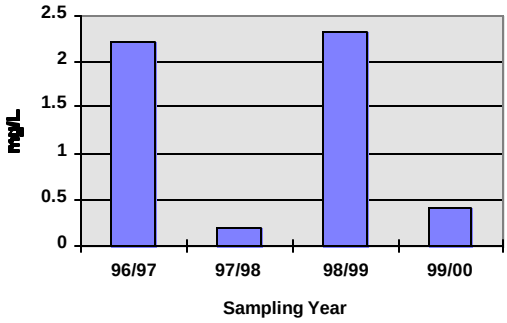


Figure 10
All Data-Mean Turbidity

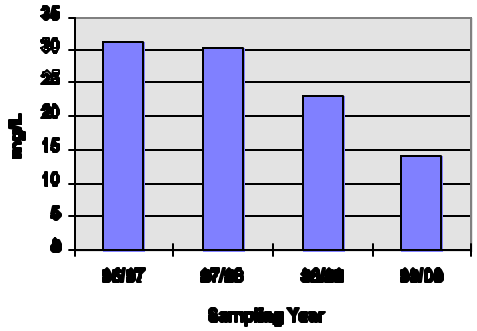


Figure 11
All Data-Mean Conductivity

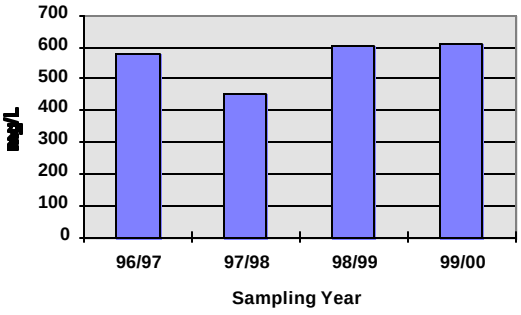
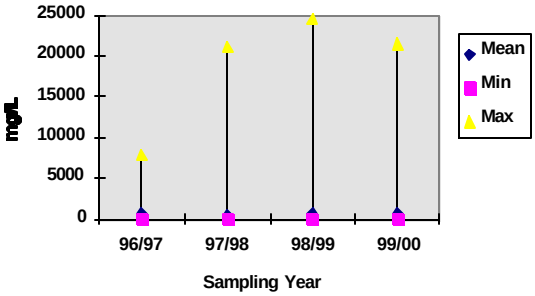


Figure 12
All Data-Mean Conductivity
With Range



San Antonio Creek (>Petaluma River)

Water quality in the San Antonio Watershed, a small basin tributary to the Petaluma river, for which we have the longest continuous record, has shown steady, and at times dramatic improvement over the years. Most recently the tributary sampled as Station 3, a site which has experienced severe fluctuations in both dissolved oxygen and toxic concentrations of ammonia during the past several years, now reveals an entirely different condition; comparable to most reference, or animal-free watersheds. Unfortunately, the change is not attributable to changes in animal waste management, but rather changes in land use brought about by cessation of dairy operations at a facility located immediately upstream.

Table II
San Antonio Creek Watershed
99-00 (98-99)

	Dissolved Oxygen mg/l	Total Ammonia mg/l	Un-ionized Ammonia mg/l	Conductivity µhos/cm
Average *	**9.28** (10)	**0.4212** (1.173)	**0.00494** (0.0115)	**568** (463)
Range	**1.78 - 22.39** (2.0-13.9)	**0 - 7.15** (0.0-17.4)	**0 -0.086** (0.0-0.152)	**66 - 2092** (20-1690)
Criteria**	5.0-7.0	-	0.025	(750)
Exceedance	**7** (2)	-	**5** (15)	**23**(18)
Percent Exceedance	**4.88** (1.47)	-	**5** (11)	**35.2** (13.2)

*** 205** (136) **measurements**
**** SF Bay RWQCB Basin Plan**

Figure 13
San Antonio Ck.-Mean Total NH3

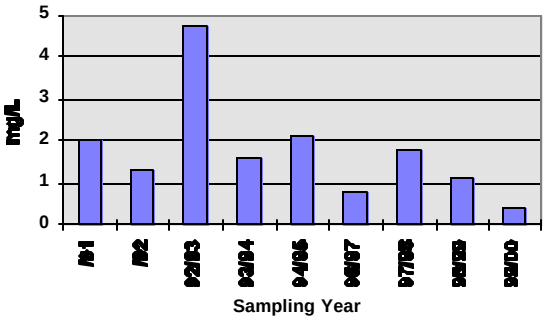


Figure 14
San Antonio Ck.-Mean Total NH3
With Range

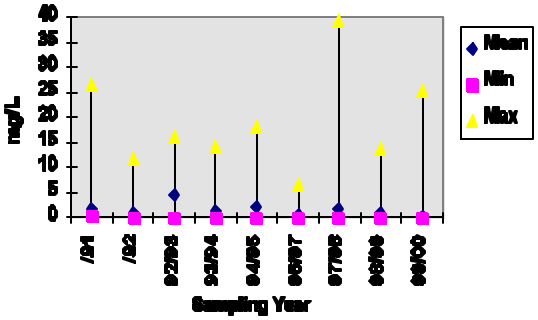


Figure 15
San Antonio Ck.-Mean Toxic NH3

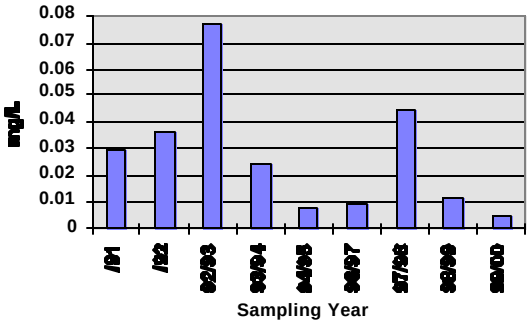


Figure 16
San Antonio Ck.-Mean Toxic NH3
With Range

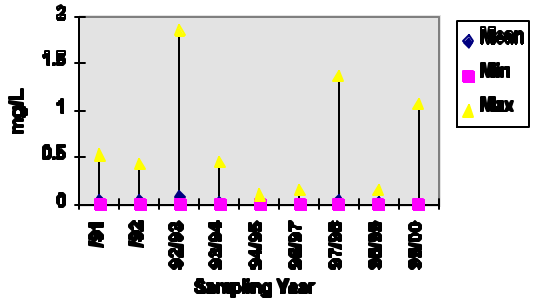
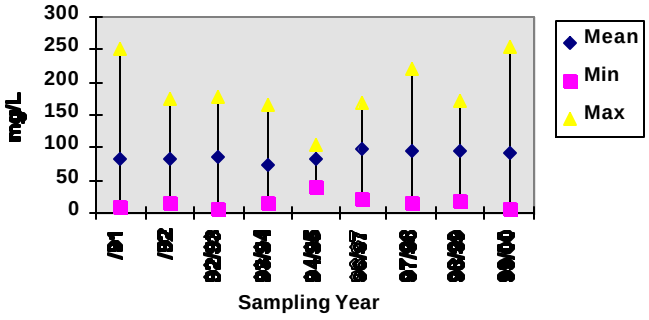


Figure 17
San Antonio Ck.-Mean Percent Sat.
With Range



Ellis Creek Watershed (>Petaluma River)

Mean concentrations of dissolved oxygen have dipped slightly, while those for total and un-ionized ammonia have improved dramatically. The continued excursions of conductivity, especially during the higher flow periods, reflects the increasing load of salts from animal wastes in the watershed.

Table III
Ellis Creek Watershed
99-00 (98-9) Data

	Dissolved Oxygen mg/l	Total Ammonia mg/l	Un-ionized Ammonia mg/l	Conductivity µmhos/cm
Average *	**9.38** (11.3)	**0.1693**	**0.003921**	**998**(790)
		(0.534)	(0.0226)	
Range	**2.98 - 11.58**	**0.0 -0.94**	**0.0 - 0.0262**	**489 - 1980**
	(8.0-15.9)	(0.07-2.45)	(0.001-0.058)	(330-1070)
Criteria**	5.0-7.0	-	0.025	(750)
Exceedance	**3** (13)	-	**1** (4.3)	**24**(9)
Percent Exceedance	**10.34** (0)	^	**3.5** (53)	**79.3** (50)

* 29(18) **measurements**
**** SF Bay RWQCB Basin Plan**

Figure 18
Ellis Ck.-Mean Total NH3

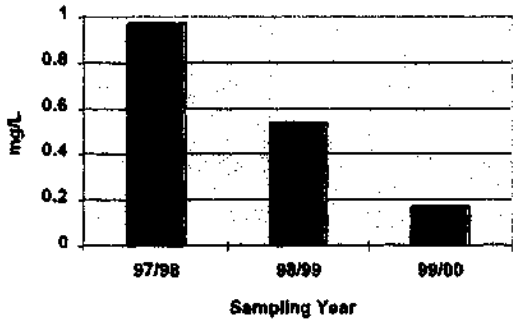


Figure 19
Ellis Ck.-Mean Total NH3
With Range

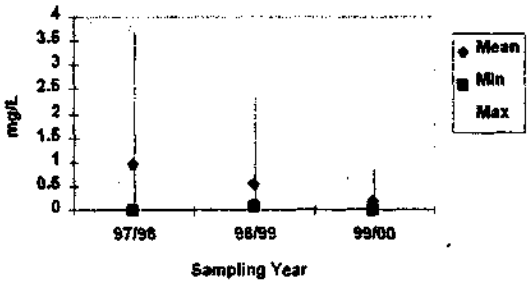


Figure 20
Ellis Ck.-Mean Toxic NH3

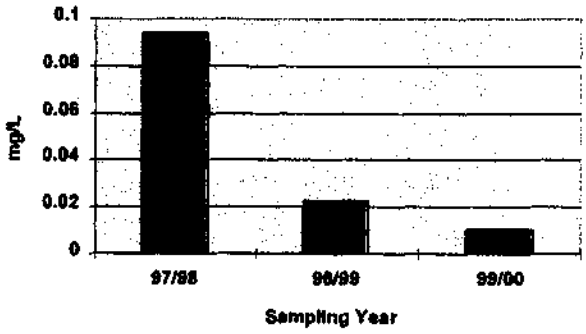


Figure 21
Ellis Ck.-Mean Toxic NH3
With Range

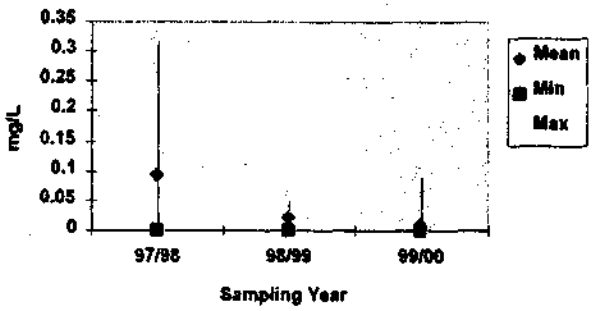


Figure 22
Ellis Ck.-Mean Percent Sat.

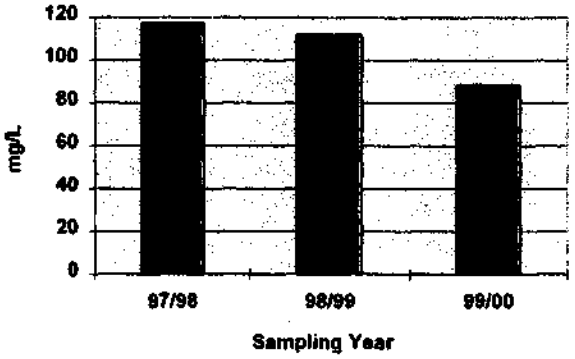
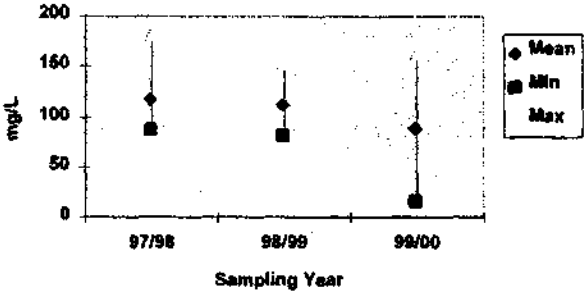


Figure 23
Ellis Ck.-Mean Percent Sat.
With Range



Stemple Creek Watershed (>Estero Americano> Pacific Ocean)

Data from Table IV (below) show a significant reduction in the averare dissolved oxygen and percent saturation with only a slight improvement in the average total and un-ionized ammonia. The range of all parameters was greater this year than last, representing the influence of a single, but long-term excursion in water quality which resulted from a release of animal wastes upstream of the study area. The extremely low dissolved oxygen concentrations (<1ppm), the extremely high concentrations of total and un-ionized ammonia (17.4, and 1.07ppm respectively) together with increased conductivity would be lethal to any and all aquatic life, sensitive or not, during it's prolonged existence in the creek. This release of animal wastes was sufficient to negate the water quality improvements realized in the previous year; and emphasizes the point that continued water quality improvement is a cumulative function of everyone working together.

Table IV
Stemple Creek Watershed
99-00 (98-9) **Data**

	Dissolved Oxygen mg/l	Total Ammonia mg/l	Un-ionized Ammonia mg/l	Conductivity ?mhos/cm
Average *	**8.9** (10.1)	**0.876** (1.055)	**0.0180** (0.0194)	**546** (437)
Range	**0.75 - 27.71** (2.7-15.9)	**0.0 - 17.4** (0.07-8.95)	**0.0 - 1.071** (0.0-0.229)	**6 - 1789** (75-1200)
Criteria**	5.0-7.0	-	0.025	(750)
Exceedance	**23**(7)	-	**19**(35)	**27**(11)
Percent Exceedance	**11**(3.6)	-	**9.3**(17.85)	**13**(5.6)

***203**(196) **measurements**
**** SF Bay RWQCB Basin Plan**

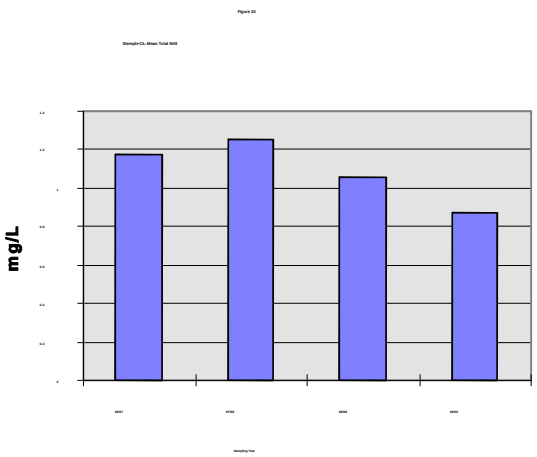
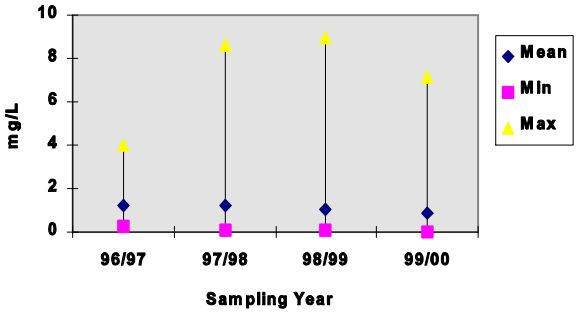


Figure 25
Stemple Ck.-Mean Total NH3
With Range



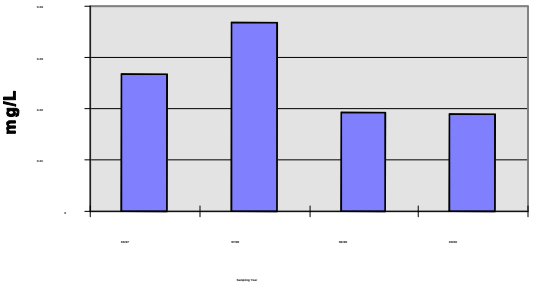
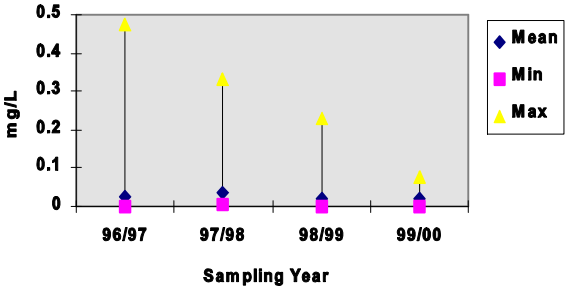
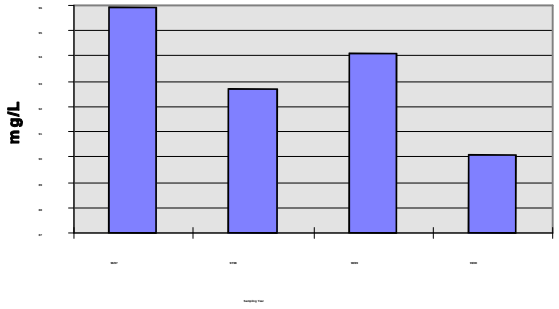
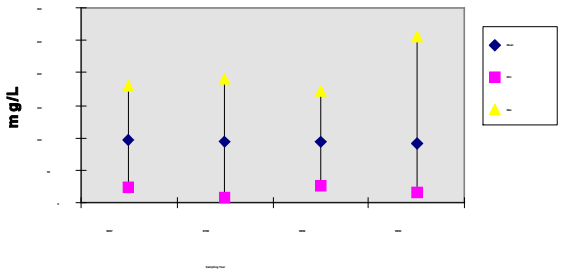


Figure 27
Stemple Ck.-Mean Toxic NH3
With Range







Bloomfield Fork of Americano Creek (>Americano Creek> Estero San Antonio)

Water quality in this sub basin has improved dramatically over the past 10 years; however the trend was quickly, and significantly reversed this year due to release of animal wastes at Station 16. The average total ammonia increased by 280% over last season's average, while the maximum increased by nearly an order of magnitude. The number, and percentage of exceedances as well as the maximum conductivity increased dramatically. This, again, demonstrates the effect of one producer's management on receiving water quality of the entire sub-basin.

Bloomfield Fork
99-00 (98-9) **Data**

	Dissolved Oxygen mg/l	Total Ammonia mg/l	Un-ionized Ammonia mg/l	Conductivity ?mhos/cm
Average *	**7.68** (9.76)	**1.938** (0.684)	**0.010** (0.007)	**447** (334)
Range	**1.62-12.6** (6.0-12.8)	**0-25.2** (0.1-2.73)	**0-0.201** (0.001-0.043)	**190-1127** (75-650)
Criteria**	5.0-7.0	-	0.025	(750)
Exceedance	**5**(0)	-	**3**(0)	**1**(0)
Percent Exceedance	**13**(0)	-	**7.9**(0)	**2.6**(0)

***38** (31) **measurements**
****** **SF Bay RWQCB Basin Plan**

Figure 30
Bloomfield Trib.-Mean Total NH3

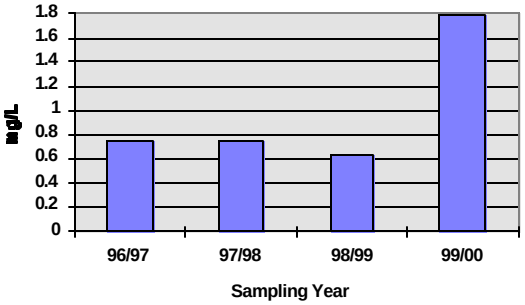


Figure 31
Bloomfield Trib.-Mean Total NH3
With Range

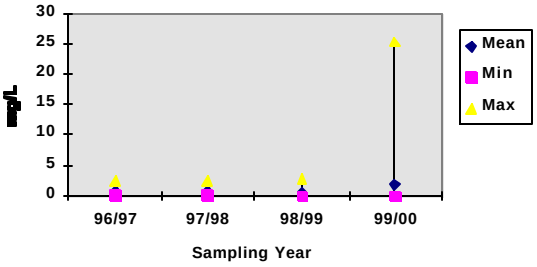


Figure 32
Bloomfield Trib.-Mean Toxic NH3

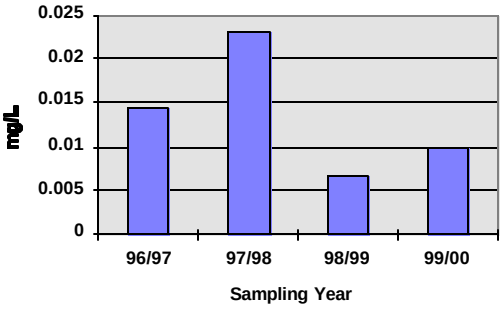
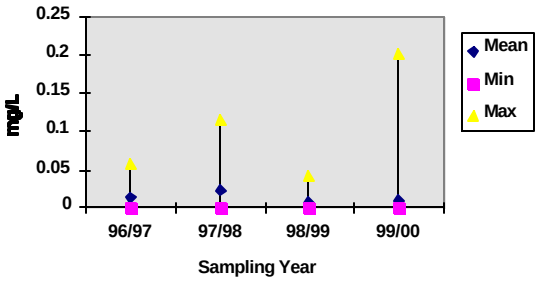


Figure 33
Bloomfield Trib.-Mean Toxic NH3
With Range



Tomales Bay Watershed (>Pacific Ocean)

Twenty (20) stations were sampled again this year along the south and eastern shoreline of Tomales Bay at bridges or culverts under Hwy 1 wherever flow could be sampled. No attempt was made to specifically sample streams draining known dairy lands. Many of the tributary streams flow from areas which do not contain any confined animal operations, and as such provide a good reference.

With three notable exceptions, water quality parameters for samples collected within this watershed were very good. D.O. was consistently at or near saturation, total ammonia was low, with a notable exception, the toxic form of ammonia was low, and conductivity showed some slight improvement.

Tomales Bay Watershed
99-00 (98-9) **Data**

	Dissolved Oxygen mg/l	Total Ammonia mg/l	Un-ionized Ammonia mg/l	Conductivity ?mhos/cm
Average *	**9.87** (10.1)	**0.61** (0.678)	**0.001** (0.0071)	**624** (781)
Range	**0.4-14.2** (6.4-9.0)	**0-3.45** (0-14.0)	**0.0-0.19** (0.0-0.19)	**8-21,500** (85-24,500)
Criteria**	5.0-7.0	-	0.025	(750)
Exceedance	**5** (1)	-	**3** (14)	**28** (9)
Percent Exceedance	**1.5**(<1)	-	**<1** (6.4)	**8.5** (4.1)

***329 measurements**
**** SF Bay RWQCB Basin Plan**

Files
MSCARII 99-00
December 6, 2000

Figure 34
Tomales Tribs.-Mean Total NH3

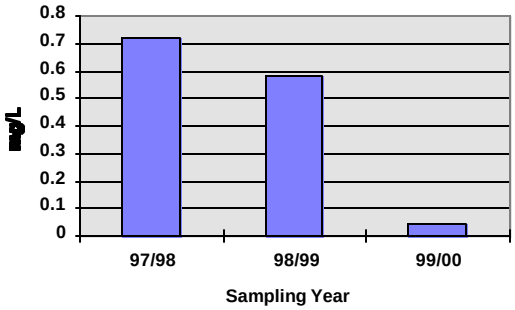


Figure 35
Tomales Tribs.-Mean Total NH3
With Range

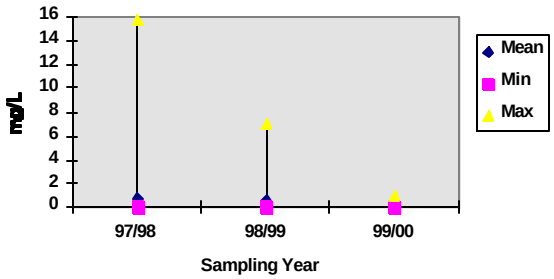


Figure 35
Tomales Tribs.-Mean Toxic NH3

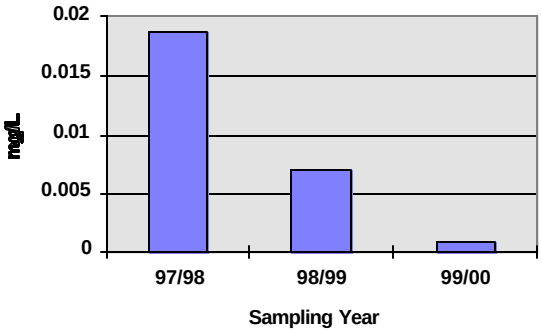


Figure 36
Tomales Tribs.-Mean Toxic NH3
With Range

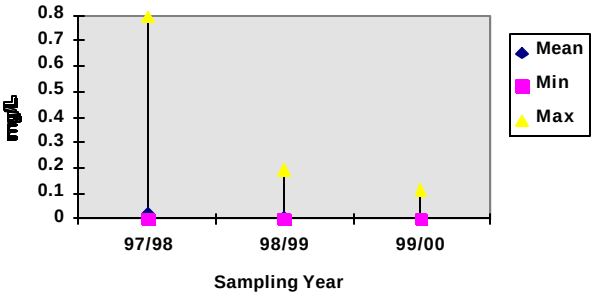


Figure 38
Tomales Tribs.-Mean Percent Sat.

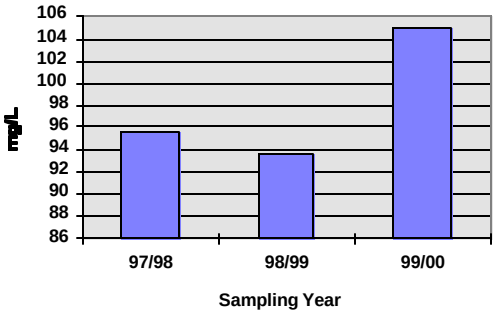
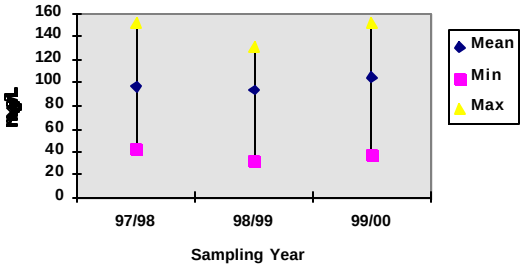


Figure 39
Tomales Tribs.-Mean Percent Sat.
With Range



Conclusions

The nearly normal winter did not create any serious water quality problems in most streams within the study area. Water quality problems encountered were principally the result of runoff of animal wastes from loafing areas, walkways, or disposal areas, or the resultant eutrophication and disruptive effects upon oxygen dynamics. Operators who experienced problems were contacted by Committee members or Western United Dairymen and responded appropriately to provide the necessary interim corrective action. Most problems encountered were not related to the unusual rainfall pattern, but rather to poor planning or management on the part of a few operators. Increased participation by operators on the Animal Waste Committee, together with completion of the UC Cooperative Extension Ranch Planning Workshops could bring about the necessary improvements in water quality.

If there are any questions on the sample methods, station locations, data or its evaluation, please give me a call at (707) 944-5523.

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Region 3