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Friends of the Russian River preserve, restore and enhance the natural systems of the Russian River, its tributaries, riparian corridors and uplands through citizen action, public education, scientific research and expert advocacy

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RWQCB
REGION 1
MAY 15 2001

RE: CWA 303(d) Water Quality Information

Impairment:
Phosphate & Dissolved Oxygen
Water Body:
Laguna de Santa Rosa
Data:
Dr. Daniel E. Wickham and Robert W. Rawson, Jan 2000, **Phosphate Loading and Eutrophication in the Laguna de Santa Rosa**
(Enclosed)

Narrative:
The North Coast Basin Plan states Dissolved Oxygen (DO) median should be 10mg/L or above. Saturation for freshwater is about 8mg/L. Readings during the day that exceed the saturation are evidence of excessive nutrient loading. All measurements are taken during the day with some measurements reaching 20mg/L. This means that photosynthetic organisms have fixed a good deal of carbon to have produced that amount of O2. At night, when light disappears, algae respire and excess oxygen beyond saturation escapes into the atmosphere. This means O2 isn't available for the algae at night and DO drops to zero. For these reasons, DO limits should include excess limits as well as minimum readings. We hope to address excess DO in the upcoming Triennial Review of the North Coast Basin Plan. DO is critical in the Laguna because the low DO in the sediment layer is what releases bound phosphate (loaded during winter) making it available for summer algae blooms.

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January 28, 2000

Report to
Russian River Watershed Protection Committee
and
City of Santa Rosa

on

Phosphate Loading and Eutrophication in the Laguna de Santa Rosa

by

Dr. Daniel E. Wickham
and
Robert W. Rawson

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Phosphate Loading and Eutrophication in the Laguna de Santa Rosa

by
Dr. Daniel Wickham and Robert Rawson
IOS Corporation
January 28, 2000

Introduction

IOS Corporation was contracted by the Russian River Watershed Protection Committee in conjunction with the City of Santa Rosa to conduct a study of existing data on the release of phosphor compounds into the Laguna de Santa Rosa. The intent of this study was to determine whether phosphate pollution from Santa Rosa Subregional System reclaimed water was a significant factor in nutrient loads to the Laguna and Russian River.

Phosphate

Liminologists widely regard phosphate as the predominant limiting nutrient for plant production in freshwater ecosystems. While other nutrients combine with phosphate to fulfill the metabolic needs of plants, such as nitrogen, sulfur, iron, and various other mineral and organic compounds, phosphate is typically the compound that is in lowest availability in free form. Where all available phosphate has been consumed in the course of the production cycle, plant growth stops. This can occur even though all other nutrients, including nitrogen, remain abundant.

Phosphate is not the only compound that can function as a "limiting nutrient". Any of the other nutrients can equally be limiting if they are the least available component in solution. Typically nitrogen is the other compound of primary concern in studies of nutrient loading and, because nitrogen has other effects beyond its role as a nutrient, including nitrate toxicity to humans and ammonia toxicity to aquatic wildlife, nitrogen has typically received equal attention. Phosphate in usually encountered concentrations does not have toxicity effects beyond its nutrient role so is not considered a direct public health threat.

Eutrophication

Eutrophication is the process whereby nutrient loading into aquatic ecosystems stimulates the level of plant production in the water. Phosphorus is a key nutrient in this process. The reason eutrophication is a concern is that water bodies have balanced ecosystems that require various conditions in order to maintain a diverse plant and animal community. Virtually all food to support these ecosystems originates through photosynthesis by plants. Briefly, plant chlorophyll catalyzes the chemical combination of carbon, derived from carbon dioxide in the atmosphere, and water to create carbohydrates in the form of sugars, the basic metabolic building block. This process is driven by the energy of sunlight and requires the other nutrients such as nitrogen to form proteins and amino acids and phosphorus to form DNA, RNA, NADP, ATP and the other essential compounds necessary for complex life.

Photosynthesis generates one primary waste byproduct, oxygen. Virtually all of the oxygen in the modern atmosphere is produced through photosynthesis. Oxygen dynamics are complex in aquatic environments because water has a limited ability to hold oxygen in solution. Freshwater of typical ambient temperature can only hold in solution about 7-9 mg of oxygen per liter. Clear water that is free of plant life will be saturated with oxygen since it will diffuse in from the atmosphere and reach equilibrium. Plants add to the oxygen in water through its release as a byproduct of photosynthesis. However, in the dark, when photosynthesis is not occurring, plants metabolize and use oxygen in the same fashion that animals do.

During the course of a 24 hour cycle an individual plant will produce slightly more oxygen than it consumes as it increases in biomass. Over the course of a plants entire life cycle the total amount of oxygen released by the plant as it grows will eventually be consumed in its decay and no net oxygen production will occur. The exception to this is that some plant material escapes oxidation by sinking to the bottom of lakes or oceans where it forms petroleum or is stored as wood in forests for decades or centuries. The reason there is a residual of oxygen in the atmosphere today is because billions of tons of unoxidized plant material are bound in the form of long-lived wood product in forests and in the form of petroleum beneath the earth's surface.

<u>Cycling of Oxygen</u>
Eutrophication is a concern because, while aquatic plants can produce copious quantities of oxygen during photosynthesis, most of this oxygen escapes into the atmosphere due to water's inability to contain more than 7-9 mg/L over long periods. In heavy algae blooms one frequently finds readings as high as 20 mg/L oxygen concentration in water, but that is a transient phenomenon. Any excess over 7-9 mg/L will quickly escape. The more plants you have producing oxygen in the water during the day, the more plants you have consuming oxygen during the night. Since the bulk of the oxygen produced by dense phytoplankton populations during the day escapes, remaining oxygen in the water at night is often insufficient to meet plant respiratory needs. Aquatic plants end up competing for the oxygen with fish and invertebrate populations which are far more sensitive to oxygen deficits.

These processes are dynamic and must be balanced. Specific environments achieve these balances at different levels. There are many natural water bodies with high levels of plant productivity that contain animals communities capable of surviving in a low oxygen environment. Aquatic communities of value in Northern California, however, are typical of those in low nutrient water bodies. The species of fish most closely identified with the Russian River watershed, and of highest concern in our efforts to conserve our natural resources, are the salmonids, along with their associated fauna. These species evolved in waters with very low nutrient levels (oligotrophic as opposed to eutrophic). They can only survive where water is clear, relatively cool, and high in oxygen.

Laguna de Santa Rosa:
The Laguna de Santa Rosa is the southern drainage for the Santa Rosa plain into the Russian River. Much debate exists over the exact nature of the Laguna prior to settlement by people of European descent. The very fact that this system was home to salmonid populations and still contains upland salmonid habitat indisputably indicates that a large portion of it was oligotrophic in nature with low levels of plant nutrients.

The Laguna de Santa Rosa of today is highly eutrophic. Levels of plant nutrients are extremely high compared to other local water bodies. Turbidity during winter due to sediment loading is high while turbidity due to persistent algae blooms is high during the rest of the year. Oxygen levels in many portions of the Laguna are low during dark periods or in the deeper sections but range to as high as 20 mg/L in the sunshine, indicating excessive phytoplankton growth. Salmonids are virtually non-existent in the southern reaches of the Laguna and the current fish population is typical of eutrophic environments, carp and sucker being two examples. Deep channels no longer exist in much of the Laguna indicating that sedimentation in the watercourse has been substantial.

Dense algae blooms are common in much of the Laguna all summer indicating that nutrient levels persist at a high level. Multiple sources of these nutrients include urban development with increased runoff of sediment and petroleum hydrocarbons; nitrogen compounds from automobile and industrial air pollution; increased flow and erosion from channelization for flood control; cattle ranching with surface runoff of manure and sediment from pasture lands; urban lawn fertilization; farm fertilization for sod or vegetable production along the Laguna; septic tank and leach field loading from rural residences; and releases to the Laguna from the Santa Rosa Subregional Wastewater Treatment system which collects and treats waste from most of the human population in the Santa Rosa plain.

Past Management of Nutrient Loading
While the contributors to eutrophication of the Laguna are easily identified their quantitative roles are difficult to assess. Many isolated studies of nutrients in the Laguna and Russian River have been undertaken over the years. Unfortunately few have comprehensively addressed the total nutrient budget of the Laguna or included all the pertinent data necessary to understand nutrient cycling. This document, therefore, rests on a data collection that contains substantial voids.

Most attention to nutrients in the Laguna has been on nitrogen loading. The Subregional System has worked closely with the North Coast Regional Water Quality Control Board (NCRWQCB) to reduce the volume of nitrogen released to the Laguna through their wastewater discharges. They have also made substantial investment in infrastructure to minimize nitrogen loading from watershed dairies using reclaimed water for pasture irrigation. The Regional Water Quality Control Board is developing standards for Total Maximum Daily Loads (TMDL) of nitrogen in the Laguna that ultimately will encompass all identifiable sources of this nutrient in order to control its absolute volume.

Nitrogen, however, can never be completely controlled since it is available from numerous other sources, including natural ones. Nitrogen oxides are readily available from polluted air typical of an urbanized area such as the Santa Rosa Plain. Many species of photosynthetic bacteria and blue-green algae are nitrogen fixers capable of drawing nitrogen in molecular form from the atmosphere and incorporating it into plant tissue as they photosynthesize. The attempt to limit nitrogen in the Laguna, while a worthy goal for many reasons, is potentially fruitless if it is the sole nutrient being addressed.

Phosphate operates very differently in this dynamic because it is not available from the atmosphere in gaseous form. Typically it occurs in three forms; 1) dissolved as phosphate in water, 2) incorporated in biological compounds such as ATP or DNA which are primarily in particulate cellular form, or 3) adsorbed and chemically bound in soil or precipitated as mineral particles that settle to the sediments.

Dissolved phosphate, or orthophosphate, is the form in which it is most readily available as a nutrient for algae growth. When accompanied by various mineral particles phosphate can readily be adsorbed and removed from the water column. Wastewater that is discharged through subsurface infiltration in soils is readily cleansed of phosphate because it is easily adsorbed by the minerals in soil. This is not the case with nitrate and makes nitrate concentration an important consideration in assessing groundwater contamination by wastewater.

Surface releases of phosphate, especially orthophosphate, are readily available to planktonic and fixed plants in freshwater bodies. Similarly phosphates that precipitate into sediments are often recycled as wind mixes them back into suspension or when pH or redox conditions release them from their bound form back into solution. These processes make phosphorus in sediments re-available to stimulate phytoplankton growth.

The unique characteristics of phosphate that make it critical in controlling water pollution are fully addressed in EPA-R3-72-001 Ecological Research Series paper "Role of Phosphorus in Eutrophication". This paper unequivocally states "...of all nutrient elements known to be growth-controlling in lakes, only phosphorus is also controllable by man." (their underline). Their discussion is presented in the context of lake pollution but is equally applicable to the Laguna because for much of the year the Laguna exists as a series of pools that are equivalent to lakes in their dynamics. Their conclusions are presented in whole in italics to underscore the urgency with which they view this issue:

" Conclusions

1. It is affirmed that limiting phosphorus availability in lakes is the single, most important and necessary step to be taken now in eutrophication control.

2. The most effective way to do this is to reduce phosphorus inputs.

3. Because all inputs are additive, and therefore potentially significant, all should be considered for control.

4. Municipal sewage is the major point source. All such discharges to lakes and other susceptible waters should be treated to reduce phosphorus content to realistic target levels.

5. Phosphorus contributions to sewage should be reduced in every feasible way.

6. Nutrient budgets should be established for all major lakes to facilitate curtailing nutrient inputs from all significant diffuse and point sources.

7. Technology, where not at hand, must be developed to effectively curtail phosphorus inputs from all significant point and diffuse sources.

8. Where slow flushing impedes improvement from curtailed phosphorus inputs, accessory steps to inactivate, harvest, or otherwise retrieve nutrients from lakes must be considered."

We will return to these recommendations later in the discussion of phosphate dynamics in the Laguna de Santa Rosa and the need for the Regional Board and the Subregional System to seriously consider such dynamics.

Phosphate Concentration in Santa Rosa Treated Effluent

Phosphate concentrations in the effluent from the Santa Rosa Llano Road Treatment Plant have historically been relatively high. Santa Rosa expresses phosphate as mg/L of the element phosphor (or P). The average reading of phosphate concentration (measured as P) presented in the Subregional EIR prepared in 1996 equals 4.2 mg/L (Appendix 1). It should be noted that typical concentrations of phosphate (as P) in most natural water bodies are less than ranges from 0.005 - 0.1 mg/L (Wetzel, 1983).

To understand just how much phosphate this represents, at the above concentration the Santa Rosa treatment plant releases in 20 MGD of treated effluent approximately 700 lb. of elemental phosphor to the Laguna each day. This is the equivalent of 3,500 lb. of one of the most common commercial phosphate fertilizers, Calcium Phosphate $Ca_3(PO_4)_2$, every day. In the past the Santa Rosa Subregional system released 1,300 lb. P daily (California Water Resources Board, 1968) or the equivalent of over 2,300,000 pounds of this same commercial fertilizer per annum into the Laguna.

To put this in context Buhr, et al., WEF Operators Forumn (1999) discussed phosphate control by the Las Vegas, Nevada WWTP, which discharges 88 MGD of treated effluent. Las Vegas has been able to achieve average phosphorus releases of 0.16 mg/L, largely through operational modifications to a plant that is similar to the Santa

Rosa Llano Road Plant. Very little capital spending was necessary to achieve this goal. The Santa Rosa Plant would need to reduce phosphor loading from 700 to 27 lb./day in order to match the performance of the Las Vegas WWTP.

The Calif. Water Resources Board (1968) Report on the Russian River identified phosphate pollution as the primary cause of excessive phytoplankton blooms in the Russian River. As earlier mentioned phosphor releases by City of Santa Rosa into the Laguna at that time equaled approximately 1,300 lb./day. This quantity, when entering the river from Mark West Creek, resulted in a doubling of phosphate concentration in the River. The 700 lb load cited above indicates that Santa Rosa has been able to reduce phosphorus by about 30% since then. Nevertheless, at that level the load of phosphorus from Santa Rosa is still considerable, particularly when compared to that achieved in other parts of the country.

Closer analysis of the EIR data, however, show that throughout the 1990's Santa Rosa has steadily moved to reduce the phosphate concentration in its effluent. The four years covered by the EIR indicate the following average annual concentrations:

Year	Phosphor conc. (Mg/l)
1991	5.26
1992	5.13
1993	3.81
1994	2.54

Subsequent data over the period from 1995 through the early part of 1999 show that phosphate concentrations in Santa Rosa effluent reached their lowest levels in spring of 1999 (Appendix 2). This decrease did not persist, however. Data for December 1999 indicate that Phosphate concentration has returned to higher levels with a concentration of over 2 mg/L. The reduction in concentration in spring of 1999 occurred when flow volumes were high due to spring rains. The December 1999 increase in phosphate may have been due to reduced water flows during this dry period. This suggests that phosphate concentration in City effluent may be more a function of dilution than actual changes in daily load on a lb. basis. The system appears to have a great deal of room for improvement in reducing phosphorus load to the Laguna and one recommendation would be that phosphorus be monitored closely in the plant to work toward greater phosphate removal at the plant.

The most significant reduction in nutrient loading to the lower Russian River occurred in the early 1970's when the City of Santa Rosa discontinued direct summer stream discharge. Since then wastewater has been applied to the land through one of the states largest wastewater irrigation systems. Summer is the season in which phosphate pollution has the most significant effect since that is the season when river flows decline and phytoplankton blooms most heavily. Summer releases of phosphate into the Laguna, and concomitantly into the Russian River, have been dramatically reduced because instead of surface discharge direct to the Laguna, wastewater only reaches the Laguna through subsurface recharge. Data obtained from groundwater studies within the City's irrigation system show that phosphate in all forms is absent from groundwater when the treated effluent passes through soil before it reaches the Laguna (Appendix 3).

The concentration of orthophosphate as P taken from samples of ground water at Subregional irrigation fields only exceeded the 0.1 mg/l level of resolution in one sample of 21 readings. This was 0.4 mg/l at the Lakeville South site. It should be noted that this was not the case with nitrate. Nitrate concentration often exceeded the public health safe guideline of 10 mg/L in groundwater. Nitrate will be discussed in more detail later.

The phosphate reduction documented in the Santa Rosa irrigation system sampling is consistent with a large body of information being developed on the use of "Side Stream Infiltration" for release of wastewater to natural water bodies. Because of adsorption and filtration by soil, water can achieve a high level of purity before it resurfaces as stream flow if it is administered in carefully designed infiltration systems. This technology is most advanced in Germany at this time but is increasingly being used elsewhere. One local example is a 3.1 acre redwood forest under design by Lescure Engineers for AVG Winery in Graton. Effluent will be disposed through a raised infiltration field that will have water applied directly to redwood tree roots using subsurface Ecochamber emitters. Water will be transpired directly by the tree roots at far higher levels than is possible using pasture irrigation, and any excess flow will recharge the adjacent Atascadero Creek with highly purified subsurface flow. An advantage of such recharge at AVG is that it keeps the water within the aquifer from which it was drawn to the maximum extent possible.

The city of Santa Rosa has demonstrated the effectiveness of this type of subsurface irrigation at a demonstration Redwood forest at Sonoma State University using its reclaimed water. An expanded system with this form of infiltration could be used by Santa Rosa to irrigate riparian forest corridors along the Laguna. With such a system it would be possible to virtually eliminate phosphate from release into the open water environment. By introducing the infiltrate through the root system of a riparian forest another advantage would be dramatic reductions in nitrate as the nitrogen is absorbed by the trees at a far higher rate than competitive ecosystems. Lowrance(1992) showed that riparian forest removed as much as 300 lb. of nitrogen per acre per year compared to only about 15 lb. in pasture. As mentioned earlier, nitrate is not removed from percolate by Santa Rosa's pasture irrigation system to the extent that phosphate is. This is either an indication that water is being applied at levels beyond that necessary to meet the limited transpiration and nutrient uptake capacity of pasture or that cattle manure at the sites is contaminating the applied water. It would be important to determine which was the case in subsequent studies of nutrient loading to the Laguna.

<u>Phosphate Sampling in the Laguna de Santa Rosa</u>

The North Coast RWQCB has conducted recent studies of phosphate in the Laguna but it is not clear whether these studies will continue. A substantial record of phosphate measurements now exist from both the NCRWQCB and Santa Rosa Subregional system sampling programs. Unfortunately, there has been little coordination between the two sampling programs and efforts to pinpoint phosphorus sources to the Laguna have yet to be undertaken. One aspect of phosphate loading of highest concern in Water Quality Board studies has been recycling of loaded phosphates from the sediments. This will be discussed in detail later.

We have collated as much of the existing data as was readily available and are including it in tabular form (see Appendices 2, 4, and 5). The city of Santa Rosa expresses phosphate concentration in mg/L as phosphorus, while the Water Quality Control Board expresses it as mg/L as phosphate (PO4) although the laboratory analysis were conducted for concentration as P.

Analyses of these data have been organized according to the following parameters:

1. Geographic variation in concentration over the Laguna watercourse.
   General spatial variation.
   Point by point upstream/downstream comparisons at discharge points.

2. Phosphate recycling from sediments
3. Phosphate/nitrate interactions and phytoplankton density

Geographic Variation

The most southerly sampling in the Laguna starts upstream at the intersection of the Laguna with Stony Point Road. Moving downstream samples have been taken at Llano Road, Todd Road, Highway 12, Occidental Road, Upstream of the confluence with Santa Rosa Creek, Guerneville Road, and Trenton-Healdsburg Road. Samples also have been taken from Santa Rosa Creek at Delta Pond and at Willowside Road, Mark West Creek, and from the Russian River both upstream and downstream of the confluence with the Laguna. Other samples include upstream and downstream of discharge at Roseland Creek and upstream and downstream of discharge from Kelly Pond into Duer Creek.

The Santa Rosa Subregional system releases to the Laguna between the Llano Road sampling point and the Todd Road intersection. They also release from Delta Pond just upstream of the confluence of Santa Rosa Creek as well as minor releases from the treatment marsh system at the Llano Road plant and from Kelly Pond just upstream of the Occidental Road sampling point.

While incidental data on phosphate concentration exists at most of these station, the only stations with any extensive systematic sampling are Stony Point Road, Todd Road, Occidental Road and Guerneville Road. Data sets containing measures of Total Phosphate concentration taken by both the city of Santa Rosa and the NCRWQCB over the period of 1989-1992 for the board and 1991-1994 for the City are presented in the City of Santa Rosa 1996 EIR (Appendix 4 - Santa Rosa and Appendix 5 - Regional Board).

Table 1. Ranges and averages for the regularly sampled stations are presented as mg/L Total Phosphate as P:

	City of Santa Rosa		Regional Board	
Sample Station	Range	Avg.	Range	Avg.
Laguna at Stony Pt.	.33 - 1.2	0.64	.22 -1.4	0.61
Laguna at Todd Rd.	.6-4.1	1.54	.32 -6.2	2.45
Laguna at Occidental Rd.	1.2-2.6	1.74	.07 -3.3	2.15
Lag.upstream S.R.Creek	.18-2.98	1.36	.02 -3.5	1.77
S.R. Creek at Willowside	.05-.73	0.20	.01 -2.9	0.36
Mark West at Slusser	.06-1.5	0.47	.00 -.49	0.10

The two data sets are in general agreement showing that phosphate concentration is lowest at the Stony Point station, upstream of the central portion of the Laguna, and upstream of any release of treated Santa Rosa effluent. A substantial increase in concentration occurs in the stretch between Stony Point and Todd, an area that encompasses the major release point from Pond D, the City's major storage pond at the Llano Road WWTP. The Regional Board data indicate a higher phosphate load, however, the series encompass different time frames and can be expected to vary somewhat in detail. Occidental Road samples are high in phosphate and a slight reduction occurs by the time one gets to the Laguna station just upstream of the confluence with Santa Rosa Creek.

Phosphate concentration is the lowest in either Santa Rosa Creek or Mark West Creek, when measured upstream of the confluence with the Laguna.

More current data are available from both sources. The City of Santa Rosa has implemented an automated sampling program at several stations in the Laguna and these data are available from the City of Santa Rosa web-site. We present these data as Appendix 2. The regional board has also continued it's monitoring program and these data have been provided and are included as Appendix 6.

Upstream-Downstream Discharge Point Comparisons

The NPDES permit for Santa Rosa discharges contain general restrictions against increasing concentration of plant nutrients due to discharge of treated effluent. Phosphate concentration measurements from identified upstream and downstream locations near effluent discharge points taken at the same time are presented in Appendix 7 for comparison. These sampling points include:

(7A) Upstream - 36" Discharge from Pond D.
Downstream - Todd Rd., nearest point downstream from Pond D.

(7B) Upstream - Roseland Creek

	Downstream -	Roseland Creek
(7C)	Upstream -	Duer Creek at Kelly pond discharge.
	Downstream -	Duer Creek at Kelly pond discharge.
(7D)	Upstream -	Santa Rosa Creek at Delta Pond discharge.
	Downstream -	Santa Rosa Creek at Delta Pond discharge.

These data from indicate that phosphate concentrations from downstream sampling points are frequently elevated over upstream concentrations (Table 2).

Table 2. Frequency of increase in phosphate concentration from upstream to downstream reading, downstream to upstream reading, and avg. increase in phosphate concentration in those instances with a positive increase downstream of discharge points.

Discharge Location	% Upstream to Downstream Increase	%Downstream to Upstream Increase	Avg. Increase in mg/L Phos. Downstream
D - Pond	65.0	5.0	.27
Roseland Creek	100.0	0.0	.60
Duer creek/Kelly Pond	97.1	2.9	1.01
S.R. Creek/Delta Pond	100.0	0.0	.84

Similar increases in Nitrate loading are seen at these same stations (Table 3).

Table 3. Frequency of increase in nitrate concentration from upstream to downstream, downstream to upstream, and avg. increase in nitrate concentration in those instances with a positive increase downstream of discharge points.

Discharge Location	% Upstream to Downstream Increase	%Downstream to Upstream Increase	Avg. Increase in mg/L NO3. Downstream
D - Pond	90.0	10.0	1.26
Roseland Creek	100.0	0.0	2.86
Duer creek/Kelly Pond	90.0	10.0	2.50
S.R. Creek/Delta Pond	100.0	0.0	2.36

It is evident from the above Santa Rosa monitoring data that increases in nutrients due to effluent releases are common and that the increase in concentration is significant. In the instance of Phosphate it should be pointed out that EPA 841-F-95-002 Watershed Protection: Clean Lakes Case Study (1995) discusses a phosphate end-point of .03 mg/L as the point that separates an impacted from a non-impacted lake. By these criteria the levels in the Laguna are extraordinarily high and the documented increases tracked to Santa Rosa discharges are above this level by one to two orders of magnitude depending on the water body.

One other set of upstream/downstream comparisons exists in the Santa Rosa data. This is the comparison between samples taken at Wohler Bridge in the Russian River, upstream of the confluence with the combined Laguna and Mark West Creek flows entering through the terminus of Mark West Creek, with downstream measures taken at Mirabel. Table 4 shows that nutrient loading from the combined Mark West and Laguna flow often results in increased nutrient concentrations in the Russian River at this point.

Table 4. Frequency of increase in phosphate and nitrate concentration from upstream Wohler Bridge to downstream Mirabel readings (in Mg/L).

% Upstream to Downstream Increase		%Downstream to Upstream Increase		Avg. Increase Downstream	
PO4	NO3	PO4	NO3	PO4	NO3
30%	52%	0%	0%	.08	.12

Mark West Creek receives effluent from both the Windsor WWTP and SCWA Airport WWTP. Monitoring data from neither of these systems was available for inclusion in this study so it is not possible to distinguish the source of the elevated nutrients.

An earlier study of nutrient loading to the Russian River (California Water Resources Bull 143-4: 1968) also identified Mark West Creek as a source of nutrient loading to the Russian River.

Table 5. Concentration of NO3, organic nitrogen, and phosphate in mg/L measured at various stations on the Russian River on August 19, 1966.

Station	NO3	Organic N	PO4
North of Cloverdale	0.0	.10	.06
Healdsburg	0.0	.20	.10
Mark West Cr. at Trenton	0.3	2.40	.26
Guerneville	0.0	.30	.59
Duncans Mills	0.0	.30	.35

Unfortunately these data derive from a single days sample and must be considered in that light, however, the reports conclusions are quoted verbatim below.

"The Orthophosphate from the Mark West Creek system increase the concentration downstream of the confluence by more than 100%. This is the principle reason for excessive phytoplankton growth in the lower Russian River."

"Prospects are that phosphate concentrations in the lower Russian River will increase and as a consequence there will be more extensive growth of phytoplankton. The discharge from the City of Santa Rosa sewage treatment plant presently contains about 1,300 lb.. of orthophosphate per day. About 30% of this discharge, containing 390 lb.. of orthophosphate per day, reaches the Russian River during the critical summer period."

This report goes on to specify an objective of reducing phosphate concentration to .25 mg/L at Guerneville.

From the monitoring data obtained recently it is clear that phosphate loading to the Russian River via the Laguna/Mark West Creek system has reduced dramatically. Most significant to this reduction has been the substitution of summer surface discharge of effluent by the City of Santa Rosa for land application of effluent through one of the states most extensive pasture irrigation systems.

Still, however, the nutrient signal at the confluence to the Russian River persists. Unfortunately the level of resolution of the current sampling is insufficient to accurately measure nutrient loading. As mentioned earlier EPA considers .03 mg/L the endpoint for impacted vs. non-impacted water bodies. In 74% of the samples phosphate concentration at Wohler Bridge was reported simply as <.1 mg/L. There are 17 instances when upstream is <.1 mg/L and downstream was <.1 mg/L. Therefore even an impacted Russian River at .03 mg/L at Wohler could have concentration tripled to .09 mg/L downstream, highly impacted by EPA standards, without it being measured by the current sampling program.

Phosphate Recycling in the Laguna

The NCRWQCB has conducted an extensive analysis of phosphate in the Laguna over the past several years (Peter Otis, 1999, personnel communication). These studies have not yet led to a TMDL program with regard to phosphate in the Laguna but do provide a starting point for moving toward such a goal.

One of the most important aspects of this study has been the role of phosphorus recycling from the sediments in the Laguna. Measurements taken from the sediments in both the Occidental Pond immediately to the south of the Occidental Road Bridge and the Sebastopol Pond downstream from the Highway 12 Bridge show that the sediments in these ponds sequester very high levels of phosphates. Concentrations range from 311 mg/kg to 2564 mg/kg in these sediments. Recirculation of these sediments into the water column can release significant quantities of phosphate for plant growth stimulation (Appendix 8).

Such recirculation is quite complex, however, and is governed by a wide variety of physical and biological factors. One such factor is the aerobic state in the sediments. When conditions become anoxic, phosphorus can be released from the sediment into the water column as phosphoric acid. This is seen at the Sebastopol Pond where scouring of phosphate from the sediments has occurred during periods where indicators of anoxic conditions in the sediments, such as increased H_2S concentration are seen. During such periods phosphate concentration in the sediments has decreased.

The Sebastopol Pond portion of the Laguna is densely covered by riparian forest and a good deal of organic detritus in the form of leaf litter falls in that area. This contributes to both a high carbon load as well as nitrogen loading from species of trees such as alders which fix atmospheric nitrogen. At the same time this riparian cover prevents winds from mixing the upper and lower water column and stratification occurs leading to anoxic conditions in the bottom sediments. Phosphate concentrations in the sediments have reduced considerably from 1997 to 1999 in the Sebastopol Pond from an average of 1197 mg/kg in 1997 to 986 mg/kg in 1998 to 588 mg/kg in 1999. This coincides with a period during which concentrated apple sugars coming from leaks at a local apple processing plant may have increased BOD in that section of the Laguna thereby increasing the rate of sediment scouring.

At the same time the reduction from 1998 to 1999 coincides with an extensive bacterial bioremediation implemented to counter the apple waste using *Pseudomonas* bacteria (D.E.Wickham, personal data). Wetzel (1968) discusses the ability of bacteria to inhibit algal growth by out-competing them for phosphate. He comments that while algae have a slightly higher membrane affinity for phosphate, the bacteria are so much smaller that the surface area/volume ratio shifts the advantage in phosphate uptake and utilization to the bacteria.

Sediment concentrations in Occidental Road Pond have stayed relatively stable, fluctuating in a narrow range from 1305 mg/kg in 1997 to 1465 mg/kg in 1998 to 1337 mg/kg in 1999. Occidental Pond experiences regular mixing due to wind during the midday. This maintains higher oxygen levels at the sediment interface preventing substantial phosphor releases. Nonetheless, the concentration of phosphate in the water column as indicated by the water monitoring program are always high enough that algae blooms persist in the Occidental Pond all summer. These blooms do not appear to deplete the sediment reservoir so either recycling is highly contained in the pond or continued loading from upstream is occurring.

Stratification is more common in Sebastopol Pond since the riparian forest prevents mixing and carbon load is high. The sediment data suggest that some movement of phosphates may occur from Sebastopol Pond to Occidental Pond, at least in 1998. Average sediment phosphate concentration in June was 1182 mg/kg in Sebastopol Pond and 1216 mg/kg in Occidental Pond. By September Sebastopol Pond had decreased to 791 mg/kg while Occidental Road concentration increased to 1713 mg/kg.

The data between Highway 12 and Occidental Road encompass a short period and are difficult to consider representative of the entire Laguna. Nevertheless they indicate phenomena of scientific interest as well as possibly of practical value in designing phosphate remediation programs throughout the Laguna. Much more information on the dynamics between sediment and water column with regard to phosphate transfer is necessary to understand this phenomenon.

The above data show that sequestration in the sediments is a significant sink for phosphates in the Laguna. Most phosphate readings in the water column of the

Laguna, particularly from Santa Rosa monitoring, are taken during the winter when the city is discharging. Phytoplankton production is low during such periods so biological uptake resulting in depletion of nutrients in the water column is less significant. In the case of phosphates, winter declines in concentration over space or time are more likely due to sedimentation than biological uptake.

Most phosphate released by the City of Santa Rosa is in the form of orthophosphate (dissolved P). This is the form most readily taken up by phytoplankton, but since plant production is low during the release season it has been assumed that most of these releases pass through the Laguna and into the Russian River where they then flow to the ocean with the high winter flow.

This is an important assumption that has never been tested. We can attempt to address this issue by analyzing phosphate concentrations measured during the winter when algal production is at its lowest level. Reductions in phosphate concentration from upstream to downstream Laguna stations would likely result from sediment deposition rather than algal uptake at that time since algae production is low (Table 6)

Table 6. Average concentrations of total phosphate in the pertinent Laguna stations derived from the 1990-94 data in the 1996 EIR for the months of November through March, when river flows are highest, and algae production is lowest.

Station	Total Phosphate Concentration
Stony Point Road	0.43 mg/L
Todd Road	1.83 mg/L
Highway 12	1.63 mg/L
Occidental Road	1.71 mg/L
Upstream Santa Rosa Cr.	1.40 mg/L
River Road	1.03 mg/L

These data suggest some sequestering of phosphorus as it passes through the Laguna even though the change in concentration seems slight. The reduction at River Road might be explained by dilution from Santa Rosa Creek and Mark West Creek which both enter upstream of that station and typically have lower phosphate concentrations.

It is evident from the data that substantial phosphate loading occurs between Stony Point and Todd Road. The reduction as it passes downstream appears to be slight, indicating that a large portion does in fact pass out of the Laguna during the discharge season. However, the flows at this time are very high and the total load, which can be calculated from the concentration times daily flow, during this season suggest that very large quantities of phosphate are contained in this water. A reduction of 0.43 mg/L from Todd Road to upstream of Santa Rosa Creek in flows typical of the Laguna in most winters is equivalent to several hundreds of pounds of phosphates being sequestered in the sediments each day. This is consistent with the high concentration of phosphates seen in the few sediment samples taken to date in Occidental and Sebastopol Ponds.

In an attempt to address Phosphate deposition more closely we collated all data points in which were taken on the same day from the following stations:

Todd Road
Occidental Road
Upstream Confluence of Laguna and Santa Rosa Creek

These data are presented in Appendix 9. They provide a rough index of loss of phosphate from the water column as it passes through the Laguna. Samples downstream of Santa Rosa Creek were not included since lowered concentration of phosphate there could be from dilution from Santa Rosa Creek, known to have lower concentrations, and not necessarily from deposition.

The grand averages for the data set indicate that phosphate concentration decreases from 1.91 mg/L at Todd to 1.36 mg/L near Santa Rosa Creek indicating sequestration of approximately .55 mg/L of phosphor within that reach of the Laguna.

Selecting only the winter (Nov-Apr) samples results in average concentration of phosphor of 2.0 mg/L at Todd Road declining to 1.25 mg/L near Santa Rosa Creek, or sequestration of .75 mg/L within that stretch. This suggests that phosphates, even though released during the high flow season are not necessarily voided from the Laguna. To the extent that these phosphates are recycled in the summer, they represent a load to the Laguna and Russian River even though they are not being discharged in the summer.

Sediment Control

Sediment loading has been identified as a major pollutant in the Laguna system and the Russian River. In fact the Russian River has been included in the EPA list of impaired watersheds for sediment pollution for 10 years. Loads of fine clay in suspended sediments alters the physical structure river bottoms by sealing the bottom gravel. Salmonids require clean gravel as habitat for egg development. Debate exists over whether the Laguna was ever more than a migratory pathway for these fish as they traveled upstream to tributaries for breeding. Clogging of bottom sediments with clay, however, will prevent filtration of water flowing through the river. This natural filtration is an important component to maintenance water quality. To the extent it is prevented, natural water purification by the stream habitat is impaired.

This sediment loading has an important impact on phosphate dynamics in the Laguna through its role in transporting and depositing adsorbed phosphates. Where they are deposited in bottom sediments they can be recycled into the water column later during periods of low flow. As mentioned, phosphate released from the Santa Rosa Subregional Treatment System is primarily in dissolved form. While this is the form most readily taken by plants most of the Santa Rosa releases are during the period of minimal phytoplankton growth. The primary mode of phosphate sequestration at this time is through adsorption by clay particles. This will occur both in the Laguna after effluent is discharged, as well as when sediment particles are flushed into the storage ponds with river flow during storm flow equilization. Some of the phosphate sequestered by this particulate matter will settle to the sediments of the Laguna. Reductions of sediment loads to the Laguna would minimize the quantity of phosphates retained in the deposits of the Laguna basin. A vigorous program to reduce erosion in the Laguna watershed would be the most direct method to maintain a higher level of washout of dissolved phosphate from Santa Rosa surface releases if that method is retained as the primary form of discharge. This, however, increases loads to the Russian River so sediment control to reduce phosphate deposition in the Russian River watershed might also be necessary.

A much more direct and effective method to reduce phosphate deposition in the waters of the Laguna would be for Santa Rosa to eliminate surface discharge of its treated effluent. Subsurface discharge either through infiltration galleries, or through ecochamber type forests, similar to the demonstration Redwood forest at SSU, would virtually eliminate all phosphate load from the Santa Rosa system to the Laguna. Distribution through a riparian forest system would, as earlier mentioned, help control nitrate contamination of groundwater, currently seen in the pasture irrigation system. If this same system were utilized in summer the city could direct a substantial flow to subsurface recharge of both groundwater in the Laguna basin as well as to recharge of stream flow to substantial advantage to habitat values of the aquatic environment.

The addition of substantial riparian habitat in the form of subsurface ecochamber galleries would act to further reduce the flow of sediments into the water column. Leaf litter and root permeation in forest soils is the most effective method to increase soil permeability. This system represents the most powerful sediment trap available and would do as much as any engineered sediment trap in increasing clarity of Laguna waters.

<u>Phosphate and Nitrate Interactions and Phytoplankton in the Laguna</u>

The most important technique for investigating adverse impacts of phosphate loads to the Laguna is to analyze phosphate concentrations in association with other nutrients and with the concentration of algae. Excessive growth of phytoplankton is the problem caused by phosphate stimulation so it is the most important parameter to measure in studies of eutrophication.

The City of Santa Rosa undertook an extensive series of measurements at various stations in the Laguna from 1990 through 1994 as a part of their 1996 EIR. These data are presented in Appendix 4. We selected the following parameters: NO3, NH3, Total P, Dissolved P, Chlorophyll a, and Phaeophytin, which are presented in Table 7. They were chosen because they represent the critical variables in understanding phytoplankton dynamics in the Laguna. Unfortunately a critical gap exists in these data. It is a measure of Total Nitrogen, which would reflect the nitrogen bound in the plant cells. Total nitrogen is taken in many of the other data sets included in this study. It is

unfortunate that in this series it was not measured since this is the one analy
is pertinent.

Table 7. Average values for nutrient concentration and plant photosynthetic p
stations along the Laguna. Nutrients are measured in mg/L while pigments are ...
in ug/L concentrations

Station	NO3	NH3	Total P	Dissolved P	Chlorophyll A	Phaeophytin	Combined Pigments
L/Stony Pt.	1.65	.13	.63	.45	22.80	10.56	33.36
L/Todd	2.91	.65	1.56	1.30	48.66	65.76	114.42
L/Occ.Rd	2.40	.37	1.73	1.26	81.89	26.72	108.61
L/SR Crk.	1.18	.18	1.28	.92	47.40	49.98	97.38
L/River Rd.	1.32	.16	.60	.49	39.69	34.10	73.79
SR Ck/Wlsd.	1.35	.09	.21	.12	5.48	8.36	13.84
MkWestCk.	1.55	.14	.50	.19	15.00	5.94	20.94

This table demonstrates a 1:1 correlation between average phosphate concentration and average combined plant pigment (Spearman - Rank Order Correlation coefficient = 1.00). The correlation with nitrate is slightly positive but not significant (Spearman Rank Order Correlation Coefficient = .43) These data, however, must be interpreted with caution since samples were taken at intervals of from nearly one month to several months. Nutrient dynamics in nature are highly complex since a nutrient loading event will be followed at some lag by a phytoplankton bloom which will then deplete those nutrients with a concomitant die-off of the phytoplankton. A random sample may be taken at the onset, during or at the end of such an event so the relationship between a nutrient concentration and a concentration of plant material can vary accordingly.

A more comprehensive data set exists taken by the Regional Board. This includes Phytoplankton cell density (a more direct measure of phytoplankton abundance) and TKN, an important parameter missing from the Santa Rosa data. These are presented as Appendix 10.

Correlation analysis using these data (Table 8) indicate that, while phosphate cannot be considered a limiting nutrient since it is never totally depleted, it can still acts as the "controlling nutrient". There exists a very highly significant correlation (p=.001) between either ortho-phosphate concentration or total phosphate concentration and the measure of phytoplankton cell density. At the same time the correlation between nitrate and phytoplankton density is insignificant.

Table 8. Correlation coefficients between plant nutrient concentrations and phytoplankton cell densities in the Laguna Regional Board data (n=41).

Comparison	Correlation Coefficient	Significance
OrthoPO4 vs. Cell Density	.544	>.001
TotalPO4 vs. Cell Density	.500	>.001
Nitrate vs. Cell Density	.162	NS
Ammonia vs. Cell Density	.158	NS
TKN vs. Cell Density	.687	>.001

Several other interesting correlations can be seen in these data that indicate the study of nutrient dynamics is not only vital to developing control measures for improving water quality but also that much significant basic research potential exists for students of limnology in the Laguna.

The rationale presented by the 1996 City of Santa Rosa EIR for its focus on nitrogen as the limiting nutrient in the Laguna is based on studies done on Algal Growth Potential (AGP) in waters taken from the Laguna at various times. An aliquot of water from a particular station is isolated and held for 14 days. Algae production is monitored and nutrient uptake is measured to see which nutrients are depleted first. In samples where nutrients were stimulatory it was found that growth discontinued when nitrogen was depleted. Phosphorus in these samples never reduced to levels where its lack inhibited plant growth.

These results are to be expected in that field monitoring showed that phosphate was found at high levels, especially when the ratio of P to N was considered, at all times and at all Laguna Stations. These experiments represent a totally artificial condition since extraneous sources of nitrogen, readily available in the field, were not included. Peter Otis of the Regional Board (personal communication, 1999) discussed instances in the Laguna during which dense blooms of blue-green algae correlated with very high levels of ammonia, even though nitrate was lacking. His conclusion was that this represented atmospheric nitrogen that was fixed by these algae. Blue green algae blooms are common in the Laguna, and in fact are considered indicator species for nutrient conditions in which phosphate is abundant but nitrate is limited, typical of the Laguna. Blue-green algae are often noxious species with little food value and their prevalence in polluted environments is one of the main reasons that ecologists have worked to control phosphate pollution in freshwater environments.

In the field nitrogen cannot become strictly limiting when phosphate is abundant since new nitrogen is introduced by a variety of means at all times. What is typically achieved is a steady state in which nitrogen continues to enter the system sustaining continued algal growth even though measurable dissolved nitrate is virtually nil. This is because new nitrogenous material is immediately incorporated into plant tissue and never becomes nitrified. The City of Santa Rosa data presentation omitted TKN which would have measured this form of nitrogen. The high correlation of TKN with phytoplankton density in the Regional Board data reflects the above dynamic. Attempting to control algal blooms by limiting nitrogen releases from wastewater is doomed to failure if phosphate is not also reduced, as is emphatically stated by the EPA document on phosphate loading mentioned earlier.

EPA-R3-72-001 discusses in detail experiments in Lake Washington where sewage load was diverted from the lake. Phosphate concentration in the water column reduced by 72% and algae concentration reduced by 80%. Nitrate concentration decreased only by 20% and bore no relationship to algal production. This shows that extraneous sources of nitrogen continued to load the system even though sewage loading of nitrogen had diminished by the same proportion as phosphate.

The positive message of this study was that reductions of phosphate resulted in immediate and direct reductions of eutrophication even though nitrate concentration did not decline by the expected amount.

Wetzler (1968) presents an extensive discussion of the central role that phosphate plays in freshwater plant nutrient dynamics. He reviews the extensive experimental demonstrations showing improved water quality following reductions of phosphate loading. He provides a detailed discussion of the importance of nitrogen fixation by blue-green algae, pointing out that these algae need high concentrations of phosphate to drive the incorporation of fixed nitrogen into the system.

His discussion is indirectly confirmed in the Regional Board data by the very highly significant correlation between TKN and phytoplankton cell density ($r=.687$, $p<.001$). While correlation analysis must always be considered in light of known causal mechanisms the following is a reasonable scenario.

Phosphate, by increasing phytoplankton abundance increases incorporation of nitrate into cells, thereby reducing nitrate concentration, leading to a shift in community structure to nitrogen fixing algae which are not limited by nitrate. These algae need the high phosphate concentration to drive fixation of nitrogen, thus, the phosphate, in effect "causes" the nitrogen loading. The biological reality of this sequence makes control of water quality through reductions in wastewater nitrogen loading to the Laguna impossible without first controlling phosphate loading.

Studies on Reclamation of Stone Lake, Michigan (EPA-600/3-76-106; 1976) discusses a scenario that is almost exactly that of the above hypothesis for a similar situation in which phosphate is not "limiting" but is controlling. *"In the beginning of June it would appear that nitrogen was limiting in Stone Lake, yet, at the same time, a large algae bloom begins to develop. The anomaly is explained by the theory that nitrogen-deficient conditions provide a competitive advantage to nitrogen fixing blue green algae."* Their analysis showed that, in fact, as green algae consumed nitrogen Anabaena, a blue green took over. Anabaena secretes inhibitory substances. The Anabaena bloom was short-lived but introduced enough nitrogen to allow green algae to bloom again. This same study showed that elimination of phosphate loading allowed the stores in the sediment to be depleted over an approximate 6-8 year period.

Phosphate Control

A very powerful technology for reducing phosphate loading exists that is not only consonant with the increasing public interest in restoration of the riparian habitat of the Laguna, but also would harness this riparian zone for nitrate reduction as well. It is clear from the ground water analysis at Santa Rosa irrigation sites that nitrate occurs at very high levels. This may or may not be due to the reclaimed water, and in fact is likely related to manures at the dairy sites where the irrigation is occurring.

Studies of nitrogen uptake by riparian forests show that 70-90% removal rates occur in the first 10 meters of passage by water through the root zone (Lowrence, 1992). Assays for bacterial denitrification enzymes demonstrated that this reduction was not due to bacterial denitrification in the soils but rather to direct uptake by the riparian vegetation. The demonstration subsurface forest irrigation project put in place at a redwood grove at SSU by the City of Santa Rosa provides an experimental site for investigating nitrate and phosphate uptake by forest systems as a comparison to their pasture irrigation systems.

Uptake studies (EPA Manual for Land Application of Sewage Sludge, 1982) show that pasture irrigation removes approximately 15 lb/Nitrogen/acre/year as opposed to forest ecosystems that remove from 150-300 lb/Nitrogen/acre/year. The only way to control groundwater nitrate pollution in a sprinkler irrigation system like that of the Santa Rosa pasture system is to carefully control the application rate so that the maximum possible water is taken actively by grass transpiration and is not allowed to leach beyond the root zone. Levels of nitrate greater than 10 mg/L, as measured in association with the Santa Rosa irrigation system, may represent a technical violation of the City's permit. A more thorough study of this phenomenon is advisable to determine the cause of the elevated nitrate levels at irrigation sites.

With trees this limitation is not as critical since not only do trees consume much higher volumes of water and nitrogen, their root systems penetrate to much greater depths increasing the uptake opportunity.

The subsurface system at the Sonoma State demonstration plot illustrated that Santa Rosa could enjoy the added advantage of discharging reclaimed water in winter when their surface irrigation system was inactive. They were able to discharge through subsurface forest irrigation, in almost pure adobe clay soil, at rates ranging from a low of over 8,000 gpd/acre in February 1999 to a high of over 15,000 gpd/acre in August of 1999. This compares to a rate of only 5,000 gpd/acre in the driest months of the summer and zero irrigation during almost 5 months for surface pasture irrigation. The redwood demonstration project at SSU unequivocally demonstrates that Santa Rosa could irrigate with all of its reclaimed water year around in the Laguna and does not need to restrict it to the summer season. By so doing phosphate loading by the Subregional system to the Laguna could be virtually eliminated, and nitrate loading would also be significantly reduced.

Significance of Phosphate Readings
It is undeniable that Phosphate levels in the Laguna are high, both relative to typical unpolluted freshwater worldwide, and relative to other streams within the same watershed. The important questions are:

1. Do the high concentrations and daily load released with treated Santa Rosa wastewater contribute significantly to the elevated levels of phosphorus in the Laguna?
This question cannot be answered since the required nutrient budget, which would include phosphorus, has regrettably never been conducted in the Laguna. Phosphate, however is such an important nutrient that levels as low as .03 mg/l can be considered as bordering on eutrophic by the EPA. In the past Santa Rosa released an equivalent of 315 kg/day. This would increase pure water with no phosphate to the above .03 mg/l in a volume of over 10.5 billion gallons. Even now with the reduced loading of about 75 kg/day in 1999 Santa Rosa loading would increase the concentration of 2.5 billion gallons to a similar highly enriched level.

Clearly the 0.03 mg/L endpoint is unrealistic and can probably never be achieved. These standards are for standing lake water where phosphate control needs to be more stringent. The Laguna and Russian Rivers are flowing water so a good portion of loaded phosphate is not captured in the system. However, discussion has arisen of the possible use of Lake Sonoma as a receiver for treated effluent generated by the SCWA treatment system. **A severe cautionary warning should be expressed at this time by the Regional Board to any phosphate loading to Lake Sonoma given the extreme sensitivity of lake water to phosphate increases.**

There can be no doubt that Santa contributes to phosphate load, even though it is not clear just what the proportion of the total is. Increases in phosphate concentration can be seen at most discharge points so, no matter what other sources may be involved, Santa Rosa wastewater is a significant contributor to loads. A more thorough study of the Laguna and its tributaries would be necessary to determine the allocation of current loading. Such a study is well past due since virtually every significant watershed in the United States has or is conducting similar studies. The role of phosphate in freshwater eutrophication has been understood for decades.

2. What are the other significant contributors to phosphorus loading to the Laguna?
As mentioned no study has ever attempted to determine the significant phosphate contributions to the Laguna. Candidates include sediment releases resulting from logging, home and industrial construction and development, vineyard planting, cattle ranching, sod farms along the Laguna, household phosphate uses such as detergents and lawn fertilizers, industrial cleaning with TSP or other phosphate compounds, flood control with resultant channelization and destruction of bioretention zones which are necessary to infiltration and settling of phosphate upstream, septic tank releases during the rare times that they occur at the surface, poultry farming, and several other sources that could easily be identified and quantified if the Regional Board implemented a program to do so.

3. Do the excessive loads of phosphate in the Laguna stimulate the excessive algae blooms typical in the Laguna?

The excessive phosphates in the Laguna may not stimulate algae blooms so much as rendering it impossible to avoid excessive algae blooms. The constant presence of superabundant phosphate makes any other control efforts, such as nitrate reductions, futile. Algae blooms continue to clot the Laguna despite decades of work in eliminating nutrients other than phosphate and the high correlation between phosphate concentration and phytoplankton density suggests it is the primary "controlling nutrient". Test-tube studies showing nitrate as a "limiting" nutrient have no relevance to conditions in the Laguna. Alternative sources for nitrogen are readily available "*in situ*" so the Laguna has no limiting nutrient in the traditional sense. Phosphate, as the only nutrient actually controllable by humans, should supersede nitrogen as the control point of choice.

4. Do releases of phosphate from the Laguna into the Russian River stimulate algae blooms in the River?

Phosphate probably does act as a limiting nutrient in the Russian River since levels are relatively low and more typical of clear flowing salmonid habitats. Phosphate loading in the past was identified as the single most important nutrient leading to excessive algal production in the lower Russian River. Conditions have improved but the signal of the Laguna can be seen in many samples when levels at Wohler Bridge upstream of the confluence are compared to Mirabel downstream. A doubling of concentration is common, even though levels are now lower than in the past. It is at these low levels that stimulation can be most apparent since the starting condition is relatively pure water with high visibility. Very slight increases in algal concentration become evident and are much more obvious. Unfortunately, again the sampling program is spotty and not at a high enough level of resolution to draw firm conclusions. For instance there is no sampling being conducted in Mark West Creek at Wohler Road. This would measure contributions from the Laguna and from Windsor and Airport. The Regional Board should require these dischargers to institute a more thorough monitoring program for nutrients, particularly phosphorus, since it has been identified as the primary nutrient of concern in the past.

5. What actions can be taken by the Subregional system or the other releasers to the Laguna to reduce phosphate loading?

The Subregional system has already made impressive progress in reducing its loading. The city should be encouraged to continue this effort by the development of targets consistent with other municipalities in the U.S. Santa Rosa has virtually eliminated phosphate loading in the summer by going almost exclusively to land based discharge where phosphate can be filtered as water passes through soil. Winter loading could be similarly eliminated if surface discharge were substituted with streamside infiltration galleries so that water received the same type of soil purification that a conventional leach system provides. If such systems incorporated riparian forest systems they would act to significantly reduce nitrate loading at the same time.

A first step in control of phosphate loads from surface discharge into the Laguna would be to restrict release to periods of maximum flow in the Laguna. Regulating releases to flows in the Russian River makes it impossible to control the sedimentation of phosphate in the Laguna. It is the sequestration of phosphate in the sediment that appears to be the main problem with winter releases. Avoiding such sequestration would be beneficial to eventual scouring of excessive phosphate from the sediments. Other obvious releasers such as the various county and city operated WWTP releasing to the Russian River tributaries should be brought into a similar management plan for phosphate reduction.

Small communities within the watershed should be actively discouraged by the Regional Board from developing conventional aerobic centralized treatment systems that use winter discharges to the rivers as part of their overall management. Well engineered community septic-step and leach systems are the most economical technologies capable of eliminating phosphate loading since they are based on soil filtration, the most powerful method to reduce phosphate load. Again incorporation of forest habitat into leach systems is the most effective way to also recapture the nutrient value from nitrogen and control concentration in the leachate.

6. Will such actions, if they successfully reduce phosphate concentration, lead to improved water conditions in the Laguna?

Phosphate exists at such high levels in the Laguna that improvements will take some time. However, correlation between phosphate and phytoplankton density in the open Laguna environment is highly significant. This suggests that continued reductions of load will allow some improvement. Phosphate stores in the sediments represent a serious problem, however, experience in most watersheds in the U.S. that have undertaken phosphate load reductions show that recovery can occur over periods of years to a decade. It should be remembered that a decade is a very short time in these situations, and most of us alive have seen many problems resolved successfully even if they do take decades.

Recommendations

Recommendations for action on phosphate loading to the Laguna and Russian River watersheds are presented in association with the previously cited conclusions of EPA-R3-72-001 (their comments in italics):

1. *It is affirmed that limiting phosphorus availability in lakes is the single, most important and necessary step to be taken now in eutrophication control.*

The Laguna data, as incomplete as it is, suggests strongly that phosphate concentration is the controlling nutrient for algal growth and that reductions in nitrate loading, in isolation, do not necessarily improve conditions. The Laguna is still highly eutrophic even though the City has vigorously pursued a strategy to reduce both their own nitrate loading and that of the dairies associated with them in the Laguna watershed.

Recommendation: The City and Regional Board should acknowledge the need to study phosphate as well as nitrate as a nutrient in the Laguna and implement programs to do so.

2. *The most effective way to do this is to reduce phosphorus inputs*. The most interesting observation coming from this study is recognition of the marked reduction in phosphate loading to the Laguna from the City of Santa Rosa's treated effluent, both as a result of increased irrigation to land, and in actual reductions in phosphate concentration in the releases. The city is to be commended for this and encouraged to mount a serious continued effort to limit phosphate releases. A much more exhaustive effort to reduce phosphate loading to the Laguna, as well as to the Russian River, from all sources is long overdue.
Recommendation: The Regional Board should make phosphate reduction an immediate priority in all watersheds under its purview.

3. *Because all inputs are additive, and therefore potentially significant, all should be considered for control.* The existence of high background phosphate levels do not excuse the City, or any other releaser, from reducing its contribution. Again the City should be commended for taking initiative on its own in this regard.
Recommendation: The Regional Board should implement a program to identify all sources of phosphate in the Laguna watershed.

4. *Municipal sewage is the major point source and should be treated to reduce levels to realistic levels*. The City of Las Vegas has shown that manipulation of a system similar to Santa Rosa's plant can reduce phosphate levels by an order of magnitude from Santa Rosa's current levels.
Recommendation: Santa Rosa should develop a program of phosphate removal at the plant that is equivalent to those achieved by similar systems in the US or develop disposal alternatives that will reduce phosphate loading to the Laguna.

5. *Phosphorus contributions to sewage should be reduced in every feasible way*. It is not clear whether Santa Rosa has made any attempt to reduce headworks concentration of phosphorus. Several extensive programs in the eastern and central United States have resulted in dramatic reductions in sewage phosphate loading.
Recommendation: The Santa Rosa Subregional System should implement a program to reduce headworks loading of phosphate consistent with similar programs already in effect throughout the US. This should incorporate industrial waste pretreatment as well as community outreach and conservation programs.

6. *Nutrient budgets should be established for all major lakes to facilitate curtailing nutrient inputs from all significant diffuse and point sources*. To date phosphate, the single most important plant nutrient in freshwater environments, has only received cursory attention in any attempt to develop a nutrient budget for the Laguna. The Regional Board as regulator for Laguna water quality, and the City of Santa Rosa as the major releaser of wastewater to the Laguna should begin a much more directed and

intensive study of all nutrients in the Laguna with a view to remediating conditions to the maximum extent possible. Without significant reductions in phosphate loading to the Laguna from all sources the substantial residual phosphate remaining in the sediments will never clear. Sedimentation during the winter is still substantial and acts as a major sink for keeping precipitated phosphate from leaving the Laguna with winter flows. The assumption that by releasing phosphate when algal growth is at its seasonal low will allow it to pass out of the Laguna is totally untested and likely not to be true due to substantial physical deposition in winter and recycling of sedimentary phosphate in summer.

Recommendation: The Regional Board should establish a program with the long term goal of determining a nutrient budget for the Laguna and Russian River watersheds. Such a nutrient budget should incorporate phosphate concentration and load as a central parameter. This budget should include methods to assess the fate of nutrients as well as their loads and concentrations.

7. *Technology, where not at hand, must be developed to effectively curtail phosphorus inputs from all significant point and diffuse sources*. The most powerful technology for phosphate removal from wastewater discharges is soil filtration. The City has demonstrated this with its summer irrigation program. It is now time to address winter discharges and to seek infiltration systems that function year round. The city of Healdsburg and Cloverdale release through infiltration pits and phosphate loading to the upper Russian River appears to be significantly lower. All releasers to the Laguna and Russian River system should be encouraged to implement programs to study streamside infiltration, subsurface forest irrigation, and riparian restoration along these watersheds as alternatives to the current practice of surface discharge. Systems should be developed to allow incorporation and facility sharing with the various agricultural inputs along the Laguna to maximize the return on investment in terms of phosphate reduction. Communities such as Healdsburg which currently use infiltration should be discouraged from changing their discharge method unless it can be proven to equally effective in phosphate removal.

Recommendation: Santa Rosa, and all other municipalities discharging to the Laguna or in the Russian River watershed, should institute pilot projects incorporating known methods to reduce phosphate loads from their winter discharges. The goal of these projects should be identification of economic methods to eliminate phosphate loads. An effort should be made to insure that such projects involve biological technologies that are consistent with ongoing efforts to restore native upland and riparian habitats.

8. *Where slow flushing impedes improvement from curtailed phosphorus inputs, accessory steps to inactivate, harvest, or otherwise retrieve nutrients from lakes must be considered.* Measurements of sediment concentration in Sebastopol Pond suggest that natural phenomena exist that stimulate release of phosphate from sediments. Attempts to manipulate these phenomena could be studied for feasibility. The reductions seen in Sebastopol pond are coincidental with bacterial bioremediation programs implemented to counter excessive carbon loading from apple waste spills in that region. These same bioremediation efforts may have inadvertently resulted in biological phosphate scouring.

Recommendation: The Regional Board should encourage experimentation on techniques, both physical, chemical and biological, to reduce sediment phosphate stores or releases from those stores, as long as such techniques do not exacerbate other remediation goals.

Further recommendations specific to the Russian River watershed include:
1. Any attempt to implement "toilet to tap" projects involving release and storage of treated wastewater in Lake Sonoma from any source must incorporate stringent nutrient controls, especially with regard to phosphate.

2. All applications from any proposed treatment system or expansions from existing treatment systems that involve surface discharge to the Laguna or any watershed leading into the Russian River should incorporate strict standards for phosphate loading.

3. Communities within the watershed of the Russian River, not already connected to conventional sewage treatment plants, should be encouraged to develop localized soil-based systems such as septic-step, community leach or wastewater forest systems that allow elimination of phosphate loading and localized recharge of watersheds. Such communities should be connected to regionalized systems only if they have aggressive phosphate removal programs, and only where it can be proven that local systems cannot function.

Summary

Because studies of the role of phosphate in pollution of the Laguna de Santa Rosa have always been conducted as an afterthought subsidiary to an interest in nitrate loading, the data at hand only begins to resolve questions regarding phosphate's role. Sampling is sporadic and long-term sequences in which all relevant parameters were measured in coordinated fashion are rare.

We can see from the above analysis, however, that extant data strongly indicate phosphate is the controlling nutrient and that efforts to reduce phosphate concentration will have beneficial effects on water quality in the Laguna de Santa Rosa and the Russian River.

The City of Santa Rosa has effected a substantial reduction in its loading to the Laguna as it has increased the overall efficiency of its treatment system. That the City has been able to do so almost as a side effect indicates that a more directed effort, which would include a more comprehensive attempt to identify and reduce the loads from all phosphate releasers to the Laguna, could reap tremendous improvements in the condition of the waters of the Laguna and the Russian River with regard to phosphate. The overwhelming weight of decades of study and experience with eutrophication in freshwater environments, both in the US and worldwide, show that phosphate is central to nutrient budgets and to remediation efforts. Attempting to improve conditions in the

Laguna by continuing to ignore this central role is doomed to failure. Reconfiguring the substantial efforts, both private and public, to restore the Laguna to include control of phosphate as a central goal will magnify the effectiveness of all such efforts.

It should be recognized that over a century went into degrading the Laguna environment and it may take several years to remedy this. The sooner that interested parties design a comprehensive program, including a more thorough understanding of the limnological principles at work, the quicker the public will see improvements and the more likely they will support continued effort.

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Appendix 3. Santa Rosa Reclaimed Water Routine Constituents, mg/L except as noted. *after a constituent indicates that it was below the detection limit. The number shown is the detection limit. Bolded areas indicate months when plant not nitrifying.

	Ammonia (mg N/L)			TKN (mg/L	Nitrite (mg N/L)			Nitrate (mg N/L)			Phosphate (mg P/L)		
Date	Avg	Min	Max	compos.	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max
Jan-91	2.9	0.1	10.1		1.33	0.1	2.5	15.7	11.6	20	5.4	4.9	5.8
Feb-91	1.4	0.1	4.8		0.65	0.15	2	15.2	11.2	23	5.9	5.5	6.7
Mar-91	1.7	0.1	6.4		0.34	0.04	0.8	13.8	6.1	19.3	3.1	2.2	3.9
Apr-91	0.7	0.1	9		0.43	0.07	1.76	18.3	8	24.8	4.7	4.4	5
May-91	0.8	0.1	5.5		0.52	0.18	1.4	18.4	15.4	20.4	6.1	5	7.1
Jun-91	2.3	0.6	9		0.95	0.6	1.46	18.1	12	28.2	5.7	5.1	6.3
Jul-91	**17.9**	**2.1**	**29.6**		**0.79**	**0.02**	**1.86**	**3.9**	**1.1**	**12.4**	**4.9**	**2.4**	**7.1**
Aug-91	**17.7**	**11.4**	**25.7**		**1.98**	**0.08**	**5**	**0.7**	**0.3**	**1**	**4.5**	**3**	**5.9**
Sep-91	**10**	**0.1**	**25.9**		**2.5**	**0.15**	**7.3**	**6.3**	**0.8**	**15.6**	**5.2**	**4.1**	**6.4**
Oct-91	**5.8**	**0.1**	**16.5**		**0.57**	**0.05**	**1.7**	**15.7**	**8.7**	**20.3**	**5.7**	**5.4**	**6.2**
Nov-91	2.4	0.1	8.9		0.13	0.05	0.27	20.8	14.6	34	5.7	5.2	6.1
Dec-91	0.9	0.1	5.2		0.36	0.04	1.75	17.9	8.4	22.5	6.2	5.8	7
Jan-92	1.3	0.2	7.1		0.93	0.03	3.3	15.1	7.6	23.4	4.8	4.5	5.3
Feb-92	1.6	0.1	8.9		0.78	0.11	2.1	15.7	8.9	38	3.4	2.7	4.7
Mar-92	0.5	0.1	2.6		0.32	0.04	0.96	15.3	8.6	25.1	3.8	2.3	4.8
Apr-92	0.9	0.1	4.4		0.58	0.01	1.3	15.8	11.6	20.9	4.7	3.3	6.2
May-92	0.1	0.1	0.7		0.15	0.01	1.06	16.6	11.4	20.4	6	5.2	7.1
Jun-92	0.6	0.5 *	1.9		0.13	0.01 *	0.6	19	15.4	24.5	6	5.1	7.7
Jul-92	0.9	0.5 *	1.8					19.2	16.7	21.5	6	4.6	8.4
Aug-92	0.9	0.5 *	2.6		0.03	0.01 *	0.16	16.1	12.6	20.7	5.6	5.2	6.2
Sep-92	2.5	0.5 *	7.8		0.15	0.01 *	1.6	16.5	9.7	23.1	6.4	5.2	7.8
Oct-92	2.7	0.9	8.5		0.08	0.01 *	0.42	22.3	10.7	37.8	4.5	3.9	5.4
Nov-92	3.8	1.1	14.9		0.15	0.01 *	0.6	23.8	16.1	34.4	5.4	4.4	6.2
Dec-92	3.4	0.5 *	14.5		0.02	0.01 *	0.14	24.1	14.9	44.4	5	4.3	6.5
Jan-93	2.7	0.6	7.8		0.02	0.01 *	0.07	16.7	9.5	28.6	4.3	3.2	6
Feb-93	2.1	0.5	5.4		0.01 *	0.01 *	0.03	16.6	8.8	21.6	3.6	2.6	4.1
Mar-93	2.2	0.5	5.9		0.06	0.01	0.64	18.5	12.9	24.3	4.2	3.6	4.8
Apr-93	2.4	0.5	7.5		0.02	0.01	0.09	17.7	12.6	22.4	4.1	3.1	4.8
May-93	**16.1**	**0.5**	**37**		**0.42**	**0.01**	**1.1**	**9.6**	**5.4**	**21.9**	**4.2**	**4**	**4.6**
Jun-93	**24.6**	**11.8**	**40.3**		**0.64**	**0.31**	**0.9**	**7.7**	**3.7**	**14.6**	**2.8**	**2.5**	**3.5**
Jul-93	**18.4**	**6.3**	**37.4**		**0.7**	**0.31**	**1.28**	**6.4**	**0.4**	**14.9**	**2.9**	**1.8**	**4.9**
Aug-93	1.9	0.5 *	3.7		0.19	0.01 *	2.5	20.9	15.1	27.4	5.3	4.1	8.1
Sep-93	1.9	0.7	4.3		0.01 *	0.01 *	0.05	21	16.2	26.4	3.8	3.4	4.3
Oct-93	1.9	1	4.2		0.02	0.01 *	0.11	20.2	15.1	27.8	3.6	3	4
Oct-93													
Nov-93	3	1.1	6.3		0.03	0.01 *	0.26	13.6	8.9	16.9	3.6	2	4.1
Dec-93	2.6	0.5 *	7.6		0.04	0.01 *	0.2	14.9	9.6	19.9	3.3	2.4	4.2
Jan-94	3	0.5 *	9.7		0.04	0.01 *	0.16	15.6	11.9	18.5	3.4	2.6	3.8
Feb-94	2.3	0.5 *	4		0.02	0.01 *	0.05	16.2	9.6	28.5	2.7	2.1	3.3
Mar-94	2.5	0.9	8.1		0.03	0.01 *	0.12	22.4	13.4	36.1	3.6	3.3	3.8
Apr-94	2.5	0.9	4.9		0.02	0.02	0.03	22	16.5	32.4	3.6	3.4	3.9
May-94	1.6	0.6	7.7		0.03	0.01 *	0.18	19.3	13.8	28.2	3.4	3.2	3.8
Jun-94	**7.8**	**1**	**19.3**		**0.24**	**0.01 ***	**0.54**	**9.6**	**4.5**	**23.4**	1.1	0.1	2.7
Jul-94	2.8	1.8	5.1		0.05	0.01 *	0.55	15.2	10.4	25.9	2.8	2.3	3.8
Aug-94	2.3	0.5	3.4		0.02	0.01 *	0.06	16.3	12.8	23.2	3.4	2.8	3.8
Sep-94	2.3	1.8	4		0.01 *	0.01 *	0.01	23.9	17.6	50.5	3.3	3.3	3.4
Oct-94	2.3	1.9	3.2		0.013	0.01	0.03	21.8	17	23.7	4.6	2.7	7.2
Nov-94	2.5	0.2	3.2	3.5	0.01	0.1 *	0.12	17.9	14.7	25.9	3.3	1.6	7.2
Dec-94	2.1	1	7.2		0.01	0.01 *	0.18	17.4	13	20.3	2.3	2	3
Jan-95	2.2	0.1 *	8.6		0.01	0.01 *	0.06	14.7	9.5	22.3	1.5	1	2.5
Feb-95				69.5									
		avg							avg				
	2.0	when nitrifying						18.1	when nitrifying				
	4.1	overall						16.3	overall				

Month and Day	Sampling site or pond	NH3	NO3	TON	PO4	Flow or Discharge
Oct-98						
28	Delta Pond 36" effluent		11.6	-0.1	3.7	18.7
16	Kelly Pond		1.8	2.7	1	17
21	Kelly Pond		2.4	0.8	1.2	19.01
16	Upstream Kelly Pond/Duer Crk.	0.3	1.2	1.3	1	
21		-0.1	-0.4	-0.1	0.8	
[illegible]	[illegible]	-0.1	-0.4	-0.1	0.8	
[illegible]	[illegible] Kelly Pond/Duer	-0.1	1.6	0.7	2	
[illegible]	[illegible]	-0.1	4.7	1.2	2	
[illegible]	[illegible]	0.2	5	0.5	3	
[illegible]	[illegible]	-0.1	0.4	-0.1	0.1	
[illegible]	[illegible]	-0.1	2.2	-0.1	0.6	
22	Laguna @ Trenton Healdsburg	-0.1	-0.4	-0.1	0.3	
7	RR at Wohler Bridge	0.2	-0.4	-0.1	-0.1	
14		-0.1	-0.4	-0.1	-0.1	
21		-0.1	-0.4	-0.1	-0.1	
28		-0.1	-0.4	-0.1	-0.1	
7	RR at Mirabel	0.3	-0.4	0.3	-0.1	
14		-0.1	-0.4	0.3	-0.1	
21		-0.1	-0.4	-0.1	-0.1	
28		-0.1	0.3	-0.1	-0.1	
Nov-98						
13	D-Pond 36"		3.5	1	2.9	1.4
18			3.1	0.8	3	4.2
24			4.9	1.8	3.4	34.3
4	Kelly Pond		6.1	0.6	3.2	1.1
12			7.3	1.5	3.1	0.9
18			6.4	1.1	3.1	0.8
24			3.4	2.4	2.3	0.9
4	Delta Pond 24" pipe		11	1.1	3.4	3.4
12			10.9	1	3.2	10
18			8	2.3	3.3	6
24			6.5	2.1	2.5	20
4	Laguna Wetlands		7.2	0.8	2.8	1.4
12			9.4	1.3	2.5	1.4
18			8.2	1.7	3.3	0.7
24			6.3	1.8	2.8	1.7
4	100 yd upstream Llano Rd. Brdg.	0.6	5.5	1.4	1.7	17.45
12		0.5	8.6	0.6	1.7	18.43
18		0.6	4.1	1.5	2.2	21.15
24		-0.1	1	0.8	0.6	23.49
4	Upstream D-Pond Incline Pump	1	3.6	0.9	2	
12		0.3	2.2	0.5	1	
18		0.5	1.3	0.9	1.2	
24		-0.1	1.2	1.1	0.7	
13	Upstream D-pond 36" discharge	0.2	1.9	0.4	1.1	
18		0.5	1.8	2	1.8	
24		-0.1	0.9	1.4	0.7	
13	Upstream Colgan Crk. at Laguna	0.4	0.6	0.9	0.5	
18		0.7	0.7	0.8	0.4	
24		0.1	1.4	1.9	0.8	
13	Laguna at Todd Rd.	0.4	2.3	1.2	1.7	
18		0.8	2.6	1.3	2.2	
24		0.2	2.3	1.8	1.6	
4	Upstream S.R. Crk at Delta	0.4	-0.4	0.2	-0.1	
12		0.2	0.5	0.4	0.1	

18		0.3	-0.4	0.4	-0.1	
24		-0.1	1.7	1	0.2	
4	Downstream S.R. Crk at Delta	0.4	4.8	0.4	1.4	
12		0.4	8.1	1.4	1.6	
18		0.6	4.4	1.8	1.6	
24		-0.1	3.7	2	1.2	
4	Upstream Duer Ck. at Kelly	0.6	0.4	0.9	1.2	
12		0.2	0.5	0.8	0.8	
18		0.4	0.5	0.8	0.5	
24		-0.1	-0.4	1.8	3.1	
4	Downstream Duer cr. & Kelly	0.5	4.4	0.9	2.6	
12		0.3	5.9	1.1	2.8	
18		0.3	5.9	1.4	3	
24		-0.1	2.7	3.2	2.2	
4	Russian River at Wohler Brdg.	0.3	-0.4	0.5	-0.1	
12		-0.1	-0.5	-0.1	-0.1	
18		0.2	-0.4	0.4	-0.1	
24		-0.1	0.6	1.2	0.5	
4	Russian River at Mirabel	-0.1	-0.4	-0.1	-0.1	
12		-0.1	-0.5	-0.1	0.2	
18		-0.1	-0.4	0.5	-0.1	
24		-0.1	0.8	0.8	0.5	
Dec-98						
1	D-Pond at 36"Discharge	0.9	6.3	1.5	3.3	38.7
9		0.5	6.5	2.2	2.3	24
16		0.5	7.4	0.7	2.2	4.9
22		0.3	7.3	1.3	2.1	3
29		0.2	7.4	1.5	2.1	1.9
9	Brown Pond	0.3	5	2.1	1.8	18.4
16		0.6	4.8	1.8	2.4	2.4
1	Kelly Pond	0.4	3.8	1.6	2.1	1.2
9		0.2	4.9	1.7	2.1	0.9
16		0.4	5.2	0.6	1	NA
22		0.2	6.2	1	1.8	0.9
29		0.1	7.7	1.5	2.3	1
1	Laguna Wetlands	1.2	6.2	1.1	2	1.5
9		0.9	8.3	0.7	1.8	1.2
16		0.5	7.4	0.8	1.9	1.4
22		0.4	9.7	1.2	2.1	1.5
29		0.8	9.1	0.5	3.2	1.7
2	Delta at 48" Discharge	0.5	-0.4	0.1	1.6	32.7
9		0.2	-0.4	2.1	1.1	8.1
1	100 yd Upstream Llano Bridge	0.8	3.1	2.3	1	28.11
9		0.2	3.2	1.2	0.5	21.61
16		1	4	1.9	0.6	21.09
22		0.4	1.5	0.3	0.5	19.98
29		0.3	1.3	0.6	0.3	17.41
1	Upstream D-pond Incline pump	0.8	3.2	2.2	1.1	
9		0.2	4	1.8	0.8	
16		0.7	2.4	0.5	1	
22		0.4	5.4	1.1	1.3	
29		0.4	5.7	0.4	0.8	
1	Upstream D-Pond 36" Discharge	0.9	3.1	1.3	1.1	
9		0.3	2.3	1.4	0.8	
16		0.5	3.8	1.2	0.9	
22		0.4	4.5	0.1	1.1	
29		0.3	5.2	0.9	1.7	
1	Colgan Ck Upstream Laguna	2.2	1.9	2.7	1.7	

9		1.4	1.8	2	1.1	
16		2.2	1.9	1.3	0.8	
22		11.8	3.1	6.9	2.5	
29		11.9	2.5	5.9	1.6	
1	Laguna at Todd Rd.	0.9	4	1.5	1.9	
9		-0.1	5	1.6	1.6	
16		0.5	4.8	1	1.2	
22		1	4.2	0.6	1.2	
29		1.4	5	1.5	1.6	
9	Laguna at Hwy 12	0.4	3.6	1.6	1.6	
16		0.5	3.5	0.8	1.1	
9	Upstream Duer at Kelly	0.5	1.1	1.1	0.9	
16		-0.1	0.8	1.3	0.5	
22		0.5	0.9	0.2	0.3	
29		0.2	1.4	0.4	0.2	
1	Downstream Duer/Kelly	0.6	1.9	0.8	1.3	
9		0.2	3.4	2.3	1.7	
16		0.5	4	0.6	1.5	
22		0.3	5.5	0.8	1.7	
29		0.3	3.9	1	1.6	
2	Laguna at La Franchi	0.5	1.3	0.7	1.3	
9		0.3	2	1.8	1.1	
2	Laguna upstream at Delta	0.5	1.4	1.6	1.5	
9		0.8	3.2	1.5	1.4	
2	Downstream SR Crk at Delta	0.4	1.5	0.3	0.2	
9		-0.1	1.3	1.1	0.1	
9	Russian River at Wohler Brdg.	0.3	0.4	0.4	0.4	
16		0.2	0.5	0.8	-0.1	
22		0.5	0.5	0.1	-0.1	
29		0.3	0.5	0.5	-0.1	
9	Russian River at Mirabel	0.5	0.7	0.6	0.4	
16		0.3	0.9	0.7	0.3	
22		0.4	0.7	0.2	0.1	
29		0.3	0.6	0.1	-0.1	
Jan-99						
13	Brown Pond	0.4	7.8	1.4	2.8	6.6
20		1.3	7.1	1.9	3.1	8.3
27		1.2	6.8	1.6	3.2	4.3
13	D-Pond 36" Discharge	0.5	7.5	1.5	2.2	5
20		0.7	8.2	2.1	2.4	48.2
27		0.8	8.3	0.9	2.5	27
6	Kelly Pond	0.3	3.3	0.1	2.6	1.1
13		0.2	7.6	0.9	2.7	0.9
20		0.3	6.3	1.4	2.8	0.7
27		0.3	8.1	0.6	2.9	0.8
6	Laguna Wetlands	0.6	4.2	0.3	2.7	1.3
13		0.7	9.8	0.6	3.6	1.7
20		1.4	8.9	2.4	3.3	1.3
27		0.3	8.5	1.3	2.8	1.6
13	Delta Pond 48" Discharge	0.6	4	1.8	2.7	4.1
20		0.7	3.3	1.9	1.4	2.7
27		0.3	6.6	2.4	2.4	23
6	100 yd upstream Llano Bridge	0.1	1	1.1	0.3	
13		0.1	-0.4	0.1	0.3	18.75
20		0.9	1.8	3.4	1	38.2
27		0.9	2	0.5	0.7	22.49
13	Colgan Creek upstream	3.2	2.8	2.6	0.8	
20		2.4	1.6	3.7	1.6	

27		1.8	1.4	1.1	0.9	
6	Upstream D-Pond Incline Pump	0.3	0.4	2	1.2	
13		0.6	6.3	0.9	1.9	
20		1.1	2	0.3	1.1	
27		0.8	2.5	1	0.9	
13	Upstream D-Pond 36" Discharge	0.5	4.9	1.1	1.9	
20		0.9	1.8	2.4	1.2	
27	.	0.4	2.5	1.4	0.7	
13	Laguna at Todd Rd.	0.5	6	1.1	1.9	
20		1.1	3	3.4	1.5	
27		0.7	5	1	1.5	
13	Laguna at Hwy 12	0.4	5.3	1.4	1.9	
20		0.7	2	3	1.3	
27		0.3	4.4	0.1	1.4	
6	Upstream Duer Creek/Kelly	0.3	7.1	1.7	0.9	
13		0.2	0.7	1	0.4	
20		0.4	1	2	0.7	
27		0.3	0.9	0.4	0.4	
6	Downstream Duer Creek/Kelly	0.6	10.1	0.1	1.5	
13		0.4	6.3	0.8	2.2	
20		0.3	1.1	2.2	0.8	
27		0.2	4.6	0.3	2.1	
13	Laguna at La Franchi	0.2	1.6	1.4	1	
20		0.5	0.7	1.2	0.4	
27		0.6	2.1	0.1	1.1	
13	Upstream Laguna at Delta	0.5	1.8	1.4	0.7	
27		0.6	2.5	1.2	1.3	
13	Downstream S.R. Creek/Delta	0.2	-0.4	0.4	-0.1	
20		-0.1	1.2	1.8	0.3	
27		0.2	1.1	0.1	-0.1	
6	Russian River at Wohler	0.1	-0.4	0.1	-0.1	643
13		0.2	-0.4	0.1	-0.1	502
20		-0.1	0.4	-0.1	0.5	2847
27		0.2	0.4	0.2	-0.1	3341
6	Russian River at Mirabel	0.1	-0.4	0.3	-0.1	
13		0.1	-0.4	0.3	-0.1	
20		0.3	0.6	1	0.6	
27		0.3	0.9	0.1	0.3	
Feb-99						
12	Alpha Pond	2.8	5	1.3	1.9	24.8
17		4.1	4.7	1.5	1.3	20
3	D-Pond 36" Discharge	1.6	7.3	1.9	2.5	17.2
10		2.3	6	1.5	1.7	49.7
17		2.8	NA	0.4	1.2	26.8
3	Kelly Pond	0.2	6.7	1.5	2.6	1
10		0.4	4.8	0.2	1.6	0.9
18		0.8	3.5	1.7	1.1	0.9
3	Laguna Wetlands	1.6	NA	1.7	2	
10		1.6	2.2	1.2	0.9	
17		0.7	1.2	0.1	0.9	
3	100 yd Upstream Llano Bridge	0.3	2	1.7	0.5	21
10		0.4	1.3	3.3	0.5	41.35
17		0.2	0.7	2.5	0.9	52.13
3	Colgan Creek Upstream	2.5	2.7	2.9	1.4	
10		0.7	1.2	3.2	1.2	
17		0.8	0.8	1.1	1	
3	D-Pond Upstream Incline Pump	0.6	2.6	1.6	0.7	
10		0.6	1.3	1.7	0.6	

17		0.6	0.8	1.1	0.8	
3	D-Pond Upstream 36" Discharge	0.3	2.4	2.1	0.7	
10		0.4	1.2	2.4	0.7	
17		0.6	0.7	1.5	0.8	
3	Laguna at Todd Rd.	1.4	4.4	0.9	1.4	
10		0.9	2.2	0.9	0.9	
17		NA	0.9	NA	NA	
12	Upstream Roseland Ck. at Llano	0.3	3.1	1.1	0.2	
17		0.1	1	2.1	0.6	
12	Downstream Roseland/Summer	2.1	4.5	1.3	1.6	
17		1.8	2.4	1.1	0.9	
3	Upstream Duer/Kelly	0.1	1	2.1	0.4	
10		-0.1	0.7	-0.1	0.4	
17		0.2	0.5	1.7	0.5	
3	Downstream Duer/Kelly	0.2	4.6	0.9	2	
10		0.4	1.7	0.2	0.9	
17		0.7	3.3	1.5	1.2	
3	Russian River at Wohler	-0.1	0.5	-0.1	-0.1	
10		-0.1	-0.4	0.3	0.3	
3	Russian River at Mirabel	-0.1	0.9	0.7	0.3	
10		0.3	0.6	0.7	0.4	
Mar-99						
3	Alpha Pond	2.1	5.7	4.4	0.8	19
10		5.4	4.3	1.5	0.5	15.9
17		1.5	6.5	0.6	0.9	5
24		1	7.5	1.3	1.1	4
3	D-Pond 36"Discharge	1.6	5.1	3.7	0.9	20.5
10		2.5	1.2	2	0.8	24
17		1.8	6.1	2.1	0.8	3
24		1	5.9	1.2	0.4	
3	Kelly Pond	-0.1	2.8	3.2	1.1	0.5
10		-0.1	3.7	1.1	1	0.6
17		-0.1	4.2	1.2	0.8	0.5
24		0.1	3.8	1.8	0.9	0.5
3	Laguna Wetlands	1.9	6.3	3.7	0.8	1.6
10		4.5	4	0.2	0.6	1.8
17		-0.1	6.7	2.4	0.8	1.6
24		0.9	7.6	1.3	0.9	1.6
3	Delta Pond 24" Discharge	0.8	2.3	4.4	1.5	2.5
10		-0.1	0.8	3.2	1.6	2
16		-0.1	0.8	2.5	1.8	0.5
3	100 Yd Upstream Llano Bridge	0.1	1.3	3.2	0.4	31.99
10		0.3	0.8	2.3	0.6	29.38
17		0.5	1	1.3	0.4	25.89
24		0.1	0.8	0.1	0.3	28.89
3	Colgan Creek Upstream	0.5	1.4	3.4	0.5	
10		0.5	1.3	2.6	0.9	
17		0.2	2.3	2.2	0.6	
24		2.9	1.6	10	1.5	
3	Upstream Roseland Ck. Llano	-0.1	1.3	4.1	0.3	
10		0.3	1.7	1.2	0.3	
17		-0.1	1.8	2.4	0.1	
24		0.8	1.3	-0.1	0.2	
3	Downstrm.Roseland Crk.Llano	1.2	4	4	0.6	
10		2.7	3.3	2.3	0.5	
17		0.3	5.1	2.3	0.7	
24		0.2	5.9	1.7	0.9	
3	Laguna Upstream Incline Pump	0.3	1.4	3	0.5	

10		0.5	1	0.8	0.6	
17		0.5	1.5	1.3	0.5	
24		-0.1	1.3	1	0.4	
3	Laguna Upstream 36" Discharge	0.3	1.4	3.3	0.6	
10		-0.1	1	2.4	0.6	
17		0.9	1.5	1.2	0.6	
24		0.4	1.3	0.4	0.4	
3	Laguna at Todd Road	0.5	2.1	3.2	0.6	
10		1	1.8	1.6	0.7	
17		0.9	1.9	2.6	0.6	
24		0.6	1.6	1.3	0.5	
3	Upstream Duer/Kelly	-0.1	0.4	3.1	0.4	
10		-0.1	0.4	1	0.4	
17		-0.1	0.5	1.1	0.3	
24		0.4	0.5	0.5	0.4	
3	Downstream Duer/Kelly	-0.1	1.6	3.3	0.8	
10		0.3	1.6	1.3	0.7	
17		0.2	3	1.1	0.7	
24		-0.1	2.2	4.3	0.7	
3	Upstream S.R. Ck /Delta	-0.1	0.9	2.2	0.1	
10		-0.1	0.7	0.8	0.1	
17		-0.1	0.5	0.2	-0.1	
3	Downstream SR Ck./Delta	-0.1	0.7	3	0.2	
10		-0.1	0.9	0.7	0.2	
17		-0.1	0.7	0.7	0.2	
3	Russian River at Wohler	-0.1	0.4	2.5	0.1	7,267
10		-0.1	0.4	1.2	0.2	8,529
17		0.2	0.4	0.4	-0.1	4,431
24		0.2	0.4	1.6	-0.1	2,623
3	Russian River at Mirabel	-0.1	0.6	2.1	0.2	
10		-0.1	0.7	0.7	0.2	
17		-0.1	0.5	0.6	-0.1	
24		-0.1	0.4	0.1	-0.1	
Apr-99						
7	D-Pond 36" Discharge	0.9	5.7	2.2	0.8	6.6
14		1.2	5.5	0.7	0.8	34.3
21		1.2	5.5	1.8	1	7
7	Kelly Pond	0.4	2.9	0.9	0.9	0.7
14		-0.1	2.7	1.4	1	0.6
21		-0.1	1.9	3.6	1.1	0.5
7	Laguna Wetlands	4.2	5.8	1.2	1.2	1.7
14		2.1	5.2	2.6	2.6	1.6
21		2	6.1	1	1	1.6
7	100 Yd upstream Llano Bridge	0.7	0.8	1	0.3	22.34
14		-0.1	0.9	0.9	0.4	25.63
21		0.2	0.6	1.6	0.3	20.91
7	Colgan Creek Upstream	0.9	2.1	1.5	0.4	
14		2.1	2	1.4	1	
21		0.3	2	1.3	0.2	
7	Laguna Upstream Incline Pump	1.1	1.5	1.1	0.4	
14		0.3	1.3	1.1	0.5	
21		0.5	1.7	1.1	0.5	
7	Laguna Upstream 36" Discharge	0.8	1.3	1	0.3	
14		-0.1	1.3	1.1	0.5	
21		2	1.4	0.4	0.6	
7	Laguna at Todd Road	0.7	2.5	1.3	0.5	
14		1	4	1	0.7	
21		0.4	3	1.7	0.6	

7	Upstream Duer/Kelly			0.6	-0.4	0.2	0.3	
14				-0.1	0.5	0.7	0.4	
21				-0.1	0.4	2.1	0.3	
7	Downstream Duer/Kelly			0.6	2.1	0.7	0.8	
14				-0.1	1.9	0.9	0.8	
21				0.2	1.5	2.6	1	
7	Russian River at Wohler			0.1	0.4	-0.1	-0.1	
14				0.1	-0.4	-0.1	-0.1	
21				-0.1	0.5	1.2	-0.1	
7	Russian River at Mirabel			0.3	0.5	-0.1	-0.1	
14				0.1	0.4	0.5	0.2	
21				-0.1	0.5	2.5	-0.1	
May-99								
5	Kelly Pond			0.2	1.5	1.2	1.7	0.3
11				-0.1	1.2	1.1	1.6	0.1
5	Laguna Wetlands			1.4	5.4	1	1.2	1.6
11				0.9	4.8	0.8	0.3	0.7
5	100 Yd upstream Llano Bridge			-0.1	-0.4	0.7	0.2	21.83
11				-0.1	-0.4	-0.1	0.2	19.9
5	Upstream D-pond Incline Pump			0.3	1.7	1	0.6	
11				0.1	1.8	1.1	0.3	
5	Upstream Duer/Kelly			-0.1	-0.4	-0.1	-0.1	
11				-0.1	-0.4	-0.1	0.5	
5	Downstream Duer/Kelly			0.2	1.2	0.9	1.6	
11				0.1	0.9	0.4	1.6	
5	Russian River at Wohler			0.2	-0.4	-0.1	-0.1	940
11				-0.1	-0.4	-0.1	-0.1	955
5	Russian River at Mirabel			-0.1	-0.4	-0.1	-0.1	
11				-0.1	-0.4	-0.1	-0.1	

Name	Sample Location	Total Dissolved Solids	Chemical Oxygen Demand	Fluoride	Chloride	Nitrite as Nitrogen	Nitrite as NO3	Nitrate as Nitrogen	Nitrate as NO3	Ortho-phosphorus as P	Ortho-phosphate as PO_4	Sulfate SO_4	Hardness as $CACO_3$	Hardness (grains/gallon)
d Area West of Sebastopol														
SBS	Sebastopol-South	NA	NA	<0.1	15.8	<0.1	<0.3	<0.1	<0.4	<0.1	<0.3	50.4	54	3.2
'SM	Sebastopol-Middle	260	<5	<0.1	9.71	<0.1	<0.3	<0.1	<0.4	<0.1	<0.3	8.84	140	8.3
	Average Value	260	<5	<0.1	12.8	<0.1	<0.3	<0.1	<0.4	<0.1	<0.3	30	97.0	5.8
lohnert Park														
lPS	Rohnert Park-South	340	<5	<0.1	30	<0.1	<0.3	5.6	16.9	<0.1	<0.3	21	200	12.0
lPS	Duplicate of MWRPS	340	<5	<0.1	30	<0.1	<0.3	5.4	24	<0.1	<0.3	21	200	12.0
	Ave of MWRPS & Dup	340	<5	<0.1	30	<0.1	<0.3	5.5	20.5	<0.1	<0.3	21	200	12
PM	Rohnert Park-North	250	<5	<0.1	14.6	<0.1	<0.3	1.2	<0.4	<0.1	<0.3	5.7	150	8.8
	Average Value	295	<5	<0.1	22.3	<0.1	<0.3	3.3	10.3	<0.1	<0.3	13	175	10.4
na Valley														
\S	Adobe-South	500	<5	<0.1	64	<0.1	<0.3	2.5	5.7	<0.1	<0.3	45.5	360	21
lP	North Petaluma	380	<5	<0.1	82	<0.1	<0.3	1	4.4	<0.1	<0.3	38	220	13.0
N	Adobe-North	350	<5	<0.1	53	<0.1	<0.3	<0.1	<0.4	<0.1	<0.3	10	190	11.0
	Average Value	410	<5	<0.1	66	<0.1	<0.3	1.2	3.4	<0.1	<0.3	31	257	15
le-Hillside, Tolay, Sears Point														
M	Lakeville-Middle	830	<5	<0.1	230	<0.1	<0.3	<0.1	<0.4	<0.1	<0.3	44	120	7
N	Lakeville-North	980	9	<0.1	330	<0.1	<0.3	12	50	<0.1	<0.3	8.4	740	43
	Lakeville-South	470	7	<0.1	110	<0.1	<0.3	8.2	36	0.4	1.2	48	200	12
	Average Value	760	6.2	<0.1	223.3	<0.1	<0.3	6.8	29	0.2	0.5	33	353	20.7
o Creek														
	Americano-Middle	410	<5	<0.1	55	<0.1	<0.3	<0.1	<0.4	<0.1	<0.3	74	230	13.0
	Duplicate of MWAM	410	<5	<0.1	45	<0.1	<0.3	<0.1	<0.4	<0.1	<0.3	55	250	15.0
	Ave of MWAM & Dup	410	<5	<0.1	50	<0.1	<0.3	<0.1	<0.4	<0.1	<0.3	65	240	14.0
	Americano-Lower	500	<5	<0.1	35	<0.1	<0.3	<0.1	<0.4	<0.1	<0.3	89	8	0.5
	Americano-Upper	300	16	<0.1	43	<0.1	<0.3	<0.1	<0.4	<0.1	<0.3	28	130	9.4
	Average Value	403	7.0	<0.1	43	<0.1	<0.3	<0.1	<0.4	<0.1	<0.3	61	126	8.0
Creek														
	Stemple-South	930	16	<0.1	220	<0.1	<0.3	33.0	150	<0.1	<0.3	57	490	29.0
	Stemple/Two Rock-Lower	1,240	12	<0.1	280	<0.1	<0.3	71.8	359	<0.1	<0.3	120	540	32.0
	Stemple/Huntley-Lower	3,530	<5	<0.1	100	<0.1	<0.3	<0.1	<0.4	<0.1	<0.3	27	24	1.4
J	Stemple/Two Rock-Upper	330	82	<0.1	16.4	<0.1	<0.3	<0.1	<0.4	<0.1	2.1	24.2	170	9.9
	Average Value	1,508	28	<0.1	154	<0.1	<0.3	26.2	127	<0.1	0.6	57	306	18.1
leclaimed Water		444	NA	0.22	NA	0.3	NA	16.3	NA	NA	4.3	NA	NA	NA
						1		10	45					
LC		500		4	250	1		10	45			250[1]		

dary MCL All concentrations reported in mg/L (milligrams per liter) NA = Not analyzed MCL = Maximum Contaminant Level

Appendix 2. Laguna de Santa Rosa and Tributaries: Physical-Chemical Data And Nutrients, 1990-1994. *indicates below the detection limit; number shown is one-half the detection limit. ND = undetectable, detection, limit not available.

Date	Time	Temp °C	Cond umho	DO ppm	pH	Turbid. FTU	Chl a µg/L	Phaeo µg/L	TDS mg/L	NO3-N mg/L	total NH3-N mg/L	un-ion NH3-N ug/L	Tot P mg/L	Diss P mg/L	TOC mg/L	DOC mg/L
Laguna de Santa Rosa at Stony Point Road																
24-Oct-90	1010	12.9	830	6.4	7.8	12	20		650	0.015 *	0.025 *		0.39	0.21	12	9.6
14-Dec-90	915	5.5	449	8.2	6.7	8.4	50.6		430	0.43	0.2	1.3	0.43	0.4	13	12
3-Apr-91	1030	15	366	8.3	7.35	6.9	6.8		290	0.89	0.025 *		0.4	0.29	9.1	9
12-Apr-91	1045	15	500	9.5	7.7					0.33	0.14	1.9				
30-Apr-91	1215	19.7	720	8.7	7.5	8.9	4.8	28.8	460	0.045	0.025 *			0.25	9	8.8
3-Jun-91	1230	21.2	1280	10.2	7.8	12	32	2	830	0.015 *	0.025 *		0.67	0.56	12	11
27-Jun-91	1205	18	1400	8.8	7.9	17	50	0	920	0.042	0.22	0.0058	0.68	0.4	12	11
20-Aug-91	1400	21.8	1230	7.8	7.9	6.4	16	3	810	0.015 *	0.058	1.75	0.83	0.66	12	12
11-Dec-91	1400	9.1	435	10.9	6.7	4.8	15		380	0.087	0.025 *		0.4	0.31	10	8.6
25-Mar-92	1448	17	413	9.2	7.8				280	0.7	0.19	3.74	0.59	0.57	11	11
29-Apr-92	1600	21	958	9.5	8.3	11	80	0.0003*	530	0.06	0.06	4.72	0.42	0.24	7	6.2
3-Jun-92	855	19	1072	3.1	7.9	70	60	12	650				0.66		13	10
1-Jul-92	1030	20	507	2.5	7.2	8.3	74	39	320	0.18	0.4	2.5	0.74	0.58	19	17
8-Sep-92	1300	22	1515	8.4	8.3				870	0.015 *	0.08	6.71	0.71		44	52
28-Oct-92	1130	16.5	105	6.8	7.3	99	13	38	85	0.43	0.37	2.25	0.82	0.23	13	8.3
16-Dec-92	1455	8	542	7.6	8.6	17	4	ND	350	2.4	0.36	19.6	0.51		11	7.4
17-Mar-93	1520	15	197	6.5	7.7	73	18.7	ND	210	0.61	0.3	3.72	0.68	0.55	22	19
14-Apr-93	1540	16	247	6.7	8.1	3.4	2.75 *	2.75 *	520	1.2	0.25	8.00	0.28	0.17	24	16
12-May-93	1350	19	819	10.7	8.1	19			500	0.03	0.025 *		0.73	0.21	14	9.8
16-Jun-93	1620	30	1260	7.8	6.8	22.7	18.7	7.48	340	0.015 *	0.025 *		0.33	0.24	12	12
18-Aug-93	920	20	1257	2.2	9.4	25	42.6	5.37	680	0.02	0.025 *		0.54	0.33	17	13
19-Oct-93	1355	21	712	6.8	7.6	11.2	13	2.78	433	0.9	0.2	2.982	1.12	0.6	17	17
14-Dec-93		10	240	6.7	7.6	33	4.6	5.1	185	26.7	0.3		1.00	0.56	12.0	12.0
22-Mar-94	1455	16.5	809	17.0	8.2	6.5	32.0	0.2 *	506	0.7	0.05 *		0.5	0.2	8.8	8.1
25-Apr-94	1545	14.5	391	5.6	7.4	25.5	6.9	1.7	226	0.4	0.05 *		0.52	0.34	10.0	13.0
24-May-94	1610	24.0	795	8.4	8.3	9.0	18.7	8.41	226	0.4	0.05 *		0.95	0.72	7.4	7.5
23-Jun-94	1623	23.2	1317	6.1	8.2	11.5	18.0	2.9	823	1.1	0.05 *		1.2	1.2	15.0	14.0
25-Aug-94	1730	18.8	1223	5.2	8.7	3.5	2.4	6.4	763	1.8	0.05 *		0.7	0.7		
25-Oct-94	1610	15.5	933	9.6	6.5	4.9	3.2	11.0	518	2.0	0.05 *		0.5	0.5	84	11.0
Laguna de Santa Rosa at Todd Road																
24-Oct-90	1040	12.5	960	3	8.3	5	46.5		760	0.015 *	0.62	26.78	1.7	1.4	24	23
14-Dec-90	1035	9.6	650	10.2	7.1	17	22.1		540	7.2	0.56	1.26	4.1	3.8	12	10
3-Apr-91	1130	18	434	9.4	7.3	13	38.8	24.6	330	5.3	0.22	1.5	1.8	1.7	11	11
30-Apr-91	1300	18.5	650	2.5	7.2	8	15.5	23.2	430	1.4	2.2	12.3		3.3	12	11
3-Jun-91	1254	21.5	980	6.8	7.8	12	24	11	640	0.21	2.4	0.065	2.2	1.9	18	16
27-Jun-91	1230	18	1000	7.6	8.1	17	117	2	670	0.042	0.025 *		1.4	1.3	20	16
20-[illegible]-91	1428	21	970	8.6	8.3	17	235	[illegible]	640	0.015 *	0.025 *		2.7	1.6	27	[illegible]

Appendix 2. Laguna de Santa Rosa and Tributaries: Physical-Chemical Data And Nutrients, 1990-1994. *indicates below the detection limit; number shown is one-half the detection limit. ND = undetectable, detection, limit not available.

Date	Time	Temp °C	Cond umho	DO ppm	pH	Turbid. FTU	Chl a µg/L	Phaeo µg/L	TDS mg/L	NO3-N mg/L	total NH3-N mg/L	un-ion NH3-N ug/L	Tot P mg/L	Diss P mg/L	TOC mg/L	DOC mg/L
11-Dec-91	1425	7.7	343	8.4	7.5	3.1	91	597	320	0.015 *	0.025 *		0.71	0.56	12	10
25-Mar-92	1505	17	523	6.6	7.5				340	5.4	0.38	3.79	2.3	2.3	11	11
29-Apr-92	1535	21	750	8.4	8.9	12	35	16	440	5.2	0.1	25.3	1.9	1.6	7.7	6.6
3-Jun-92	911	19	1096	0.4	8.1	40	147	64	650				1.4		25	17
1-Jul-92	1000	20	521	2.3	7.4	30	114	45	320	0.07	0.54	5.34	1.2	0.86	17	16
8-Sep-92	1240	23	1089	13.1	9.2				650	0.015 *	0.08	35.12	1.8		24	20
28-Oct-92	1645	17	205	7.2	7.5	22.6	0	2	420	0.015 *	0.07	0.7	2	1.6	18	16
16-Dec-92	1430	10	583	6.7	7.1	11	17.4	4.1	390	9.7	2.5	5.2	2		10	8
17-Mar-93	1700	15	217	5.8	7.7	55	16	4.5	220	0.95	0.41	5.08	0.9	0.83	18	15
14-Apr-93	1520	16	579	4.8	7.4	16.7	3.15 *	3.15 *	390	6.2	1.4	9.17	1.9	1.7	26	17
12-May-93	1425	16	898	6.9	7.7	33			540	0.85	2.4	31.16	1	0.91	29	9.2
16-Jun-93	1740	27	878	11.2	8.4	20.2	120	48.1	290	0.21	0.11	14.43	1.1	0.63	21	18
18-Aug-93	848	22	1055	2.5	9.3	47	96.1	17.5	600	0.028	0.064	28.769	1.1	0.66	34	22
19-Oct-93	1331	17	504	2.3	7.1	16.6	12.5	1.25	206	0.9	1	3.6594	1.51	0.8	22	18
14-Dec-93		10.5	212	6.9	7.9	29	13.4	0.05 *	168	22.9	0.7		1.50	0.80	12.0	10.0
22-Mar-94	1645	12.5	880	9.3	8.3	17.5	0.1 *	292	486	1.6	2.4		1.4	0.5	16.0	12.0
25-Apr-94	1600	14.9	484	6.8	7.5	15.2	21.4	19.0	228	0.9	0.2		0.51	0.44	14.0	14.0
24-May-94	1700	22.8	594	6.6	8.3	28.0	46.4	7.21	228	0.4	0.05 *		0.58	0.32	10.0	9.8
23-Jun-94	1607	23.1	822	4.2	8.3	15.0	32.0	6.1	490	0.6	0.05 *		1.1	1.0	13.0	12.0
25-Aug-94	1800	21.0	732	4.8	8.3	24.0	43.0	212	618	1.6	0.05 *		0.6	0.5		
25-Oct-94	1545	14.0	636	3.1	7.1	7.5	7.6	47.0	428	2.0	0.05 *		1.2	1.0	59	17.0
Laguna de Santa Rosa at Highway 12																
24-Oct-90	1135	12	169	2	6.9	4	15.8									
14-Dec-90	1110	6	580	9.7	6.1	9.2	38.8									
3-Apr-91	1150	18	430	11.4	7.3	18	11.1	67.8								
30-Apr-91	1400	18.2	550	9.2	7.5	16	100.8	135.8	400	0.15	0.059	0.6		1.1	14	13
3-Jun-91	1320	20	680	5.8	7.5	53	64	56								
27-Jun-91	1248	18	590	7.5	7.5	21	36	14								
20-Aug-91	1500	22.7	342	6.4	7.7	22	0	60								
11-Dec-91	1450	9.7	441	11.8	7.3	6.4	101	823								
25-Mar-92	930	14	473	5	7.4				280	2.2	0.24	1.52	1.8	1.9	14	14
1-Jul-92	1100	19	986	7.4	7.5	50			590	1.6	0.21	2.42	1.9	1.8	17	16
8-Sep-92	1220	18	680	4.9	7.8											
28-Oct-92	1630	17	647	7.5	7.2	24.5	137	17								
14-Apr-93	1405	20	620	5.2	7.6	45.4	17.6	15.2								
12-May-93	1320	15	646	8.5	7.7	81										
16-Jun-93	1500	26.5	816	3.8	6.9	61.3	3.325 *	103								
18-A[illegible]93	1013	21	1274	2.1	9.3	16	46.3	12								

Appendix 2. Laguna de Santa Rosa and Tributaries: Physical-Chemical Data And Nutrients, 1990-1994. *Indicates below the detection limit; number shown is one-half the detection limit. ND = undetectable, detection, limit not available.

Date	Time	Temp °C	Cond umho	DO ppm	pH	Turbid. FTU	Chl a µg/L	Phaeo µg/L	TDS mg/L	NO3-N mg/L	total NH3-N mg/L	un-ion NH3-N ug/L	Tot P mg/L	Diss P mg/L	TOC mg/L	DOC mg/L
19-Oct-93	1256	17	421	4.2	7.1		18.2	11								
14-Dec-93		10.5	411	6.2	7.8											
22-Mar-94	1425	16.2	709	13.6	8.6		0.1 *	246								
25-Apr-94	1440	15.4	580	10.2	7.6	26.0	64.1	13.4								
24-May-94	1535	24.0	438	1.9	8.2	34.0	30.3	16								
23-Jun-94	1548	16.8	713	7.8	3.4		14.0	11.0								
25-Aug-94	1650	17.2	461	3.5	7.9		8.2	45.0								
25-Oct-94	1520	14.0	723	3.3	6.9	10.5	29.0	137								
Laguna de Santa Rosa at Occidental Road																
24-Oct-90	1250	18.9	790	16.8	9.2	70	564		570	0.015 *	0.088	32.47	1.8	1.2	38	16
14-Dec-90	1130	8.4	600	8.4	6.7	22	27.9		530	1.6	1.1	0.91	1.9	1.8	15	14
3-Apr-91	1215	18.2	418	9.4	7.2	7.9	6.4	52.3	330	4.4	0.025 *		1.8	1.6	13	12
11-Apr-91	1615	17.6	481	14.2	8.3											
30-Apr-91	1430	22	590	17.5	8.8	26	155.9	37.7	380	0.015 *	0.025 *			1.3	15	11
3-Jun-91	1346	25	700	9.8	7.9	32	43	13	430	0.015 *	0.025 *		2.1	1.7	12	10
27-Jun-91	1305	21.5	730	11.4	8	29	85	0	440	0.051	0.071	0.003	1.3	1.2	12	11
20-Aug-91	1530	27	940	10.2	8.7	29	43	6	550	0.015 *	0.14	31.53	2.2	1.6	14	4.3
11-Dec-91	1520	9.6	415	6.2	7.5	22	66	303	390	0.015 *	0.063	0.36	1.3	1.2	15	13
25-Mar-92	1410	16	417	5.3	7.4				260	2.4	0.32	2.36	2.1	1.4	15	13
29-Apr-92	1500	20		5.6	7.8	30	67	36	370	0.015 *	0.1	2.44	1.8	1.1	15	13
3-Jun-92	955	24	738	3	7.6	85	84	31	460				1.6		14	14
1-Jul-92	910	20.5	802	4.8	7.6	45	100	0.0005*	490	0.015 *	0.14	2.25	1.3	0.86	12	11
8-Sep-92	1155	27	1150	8.8	8.3				720	0.015 *	0.025 *		2.3		23	22
28-Oct-92	1412	17.5	646	7.9	7.7	28.5	107	3	410	0.42	0.41	0.67	1.4	0.84	12	11
16-Dec-92	1310	10	554	4.4	6.8	12.4	5.4	25	360	8	2	2.15	2.6		13	11
17-Mar-93	1430	15	455	7.8	7.5	45	21.4	4.8	320	2.2	0.73	6.44	1.6	1	17	14
14-Apr-93	1250	15	623	6	8.2	14.5	94.4	3.15 *	330	3.2	0.13	0.13	1.3	1.2	22	20
12-May-93	1140	23	546	9	7.7	51			420	2	0.2	4.36	1.2	1	13	11
16-Jun-93	1337	24	585	3.7	7.3	77.6	33.4	27.4	140	0.05	0.26	2.50	1.3	1.2	14	16
18-Aug-93	1745	28	696	8.4	7.6	50	67.6	24.5	390	0.023	0.13	3.1569	1.8	1.4	37	17
19-Oct-93	1145	18	430	1.3	7	14.4	2.14	2.72	266	1.1	0.5	1.5689	1.95	1	20	17
14-Dec-93		10.5	403	4.7	7.7	47	13.4	0.05 *	239	36.6	1.2		2.30	1.40	13.0	13.0
22-Mar-94	1310	15.2	689	9.8	8.0	38.0	61.8	0.2 *	356	1.6	0.2		1.3	0.8	13.0	9.9
25-Apr-94	1335	14.2	603	13.5	8.6	39.0	105	12.0	326	0.5	0.05 *		1.6	1.09	7.5	13.0
24-May-94	1440	27.0	480	13.1	8.8	32.0	41.4	2.54	326	0.4	0.05 *		1.89	1.54	9.6	12.0
23-Jun-94	1512	31.1	566	7.9	8.3	22.5	15.0	6.7	347	0.4	0.2		1.9	1.8	10.0	10.0
25-A[illegible]94																
25-[illegible]4																

Appendix 2. Laguna de Santa Rosa and Tributaries: Physical-Chemical Data And Nutrients, 1990-1994. *indicates below the detection limit; number shown is one-half the detection limit. ND = undetectable, detection, limit not available.

Date	Time	Temp °C	Cond umho	DO ppm	pH	Turbid. FTU	Chl a µg/L	Phaeo µg/L	TDS mg/L	NO3-N mg/L	total NH3-N mg/L	un-ion NH3-N ug/L	Tot P mg/L	Diss P mg/L	TOC mg/L	DOC mg/L
Laguna de Santa Rosa Upstream of Santa Rosa Creek																
24-Oct-90	1340	17	177	4.3	7.4	42	11.9		190	0.45	0.39	3.09	0.64	0.36	5.7	3.4
14-Dec-90	1228	7	520	9.2	6.9	22	15.7		470	1.6	0.98	1.44	2.2	0.91	19	13
3-Apr-91	1430	18.6	299	4.45	6.9	18	7.3		250	1.6	0.11	0.3	1.6	1.5	15	14
30-Apr-91	1455	19	550	10.8	7.7	35	24.6	268.5	370	0.11	0.025 *			1.1	15	11
3-Jun-91	1435	23.2	472	8.3	7.5	29	46	33	330	0.25	0.088	0.0014	1.1	1.1	8.2	7.2
27-Jun-91	1348	20	230	6.5	7.5	53	14	56	210	0.18	0.31	0.0038	1.2	1.1	5.8	4.5
20-Aug-91	1610	24.5	219	11.8	8.8	30	32	43	190	0.077	0.073	18.4	1.5	1.7	5.2	14
11-Dec-91	1600	9	360	8	7.6	9.7	262	303	350	0.19	0.14	0.95	1.2	0.88	14	12
25-Mar-92	1330	16	463	4.6	7.3				280	3.5	0.2	1.17	1.6	1.6	13	12
29-Apr-92	1355	21	560	2.6	7.1	38	98	9	360	0.06	0.17	0.91	1.2	1.2	15	13
3-Jun-92	1030	21	511	2.7	7.1	130	134	25	570				2.6		19	16
1-Jul-92	845	19.5	398	4.6	7.3	3.5	13	0.0005*	250	0.18	0.07	0.53	0.18	0.16	7.9	8
8-Sep-92	1100	20	299	6.1	7.7				220	0.015 *	0.025 *		2		10	10
28-Oct-92	1320	16.5	592	4.8	7.3	36.5	54	0	380	0.28	0.4	2.4	1.2	0.72	12	11
16-Dec-92	1140	9	380	3.4	6.7	30	5.4	0.3	290	3.9	0.92	0.73	1.9		19	16
17-Mar-93	1300	15	189	7.4	7.9	59	26.7	ND	190	0.46	0.1	1.95	0.33	0.21	11	11
14-Apr-93	1141	15	434	9.6	8.1	23.4	86.6	2.55 *	310	1.3	0.025 *		1.2	0.85	22	18
12-May-93	1045	16	589	5.7	7.4	67			400	0.66	0.025 *		1.3	1.1	20	14
16-Jun-93	1156	24	622	3.6	6.9	51.5	160	12.7	150	0.2	0.14	0.54	1.6	1.5	20	20
18-Aug-93	1405	26	464	7.6	7.3	31	94.3	12.8	280	0.016	0.025 *		0.63	0.44	16	13
19-Oct-93	1039	18	464	0.07	7	9	2	1.07	261	0.4	0.025 *		2.98	0.9	25	18
14-Dec-93		10	146	9.7	7.6	59	10.7	0.05 *	116	12.1	0.1		0.48	0.19	8.7	8.2
22-Mar-94	1125	13.5	621	7.9	6.8	32.0	8.9	50.9	330	1.1	0.05 *		1.2	0.7	17.0	10.0
25-Apr-94	1245	14.2	193	8.3	7.7	11.4	3.7	1.9	48	1.0	0.05 *		0.23	0.12	7.2	ND
24-May-94	1338	20.0	469	2.0	7.7	37.0	51.6	15.7	48	0.5	0.1		2.46	1.96	9.9	11.0
23-Jun-94	1410	23.9	419	7.2	7.8	23.0	61.0	0.2 *	337	0.3	0.05 *		1.4	1.3	7.7	8.3
25-Aug-94	1510	22.5	259	8.2	8.2	35.5	48.0	173	219	0.7	0.05 *		2.2	1.8		
25-Oct-94	1325	14.8	475	7.2	6.8	22.9	0.1 *	66.0	281	1.6	0.1		0.7	0.5	46	8.8
Laguna de Santa Rosa at River Road																
24-Oct-90	1430	16.5	443	7.2	7.7	6.1	3.8		350	0.047	0.025 *		0.27	0.22	7	6.2
14-Dec-90	1330	7	394	10.2	7	5.5	11.4		380	1	0.47	0.69	0.81	0.75	16	9.2
3-Apr-91	1510	17.5	279	7.6	7.15	18	4		220	1.3	0.1	0.5	0.91	0.8	9.9	9.2
11-Apr-91	1520	15.5	392	10.2	7.4					2.9	0.057	0.4				
30-Apr-91	1545	20	474	8.6	7.7	17.5	37.1	29.1	320	0.22	0.09	1.8		0.61	7.9	6.3
3-Jun-91	1505	22.5	520	6.4	7.5	28	11	29	350	0.066	0.14	0.0021	0.61	0.43	4.6	4.9
27-Jun-91	1413	20	550	4.2	7.5	28	11	12	350	0.1	0.17	0.0021	0.58	0.4	3.9	4.1
20-Aug-91	1638	22	590	6.2	7.9	13	13	7	370	0.015 *	0.11	3.51	0.5	0.36	4.8	4.6

Appendix 2. Laguna de Santa Rosa and Tributaries: Physical-Chemical Data And Nutrients, 1990-1994. *indicates below the detection limit; number shown is one-half the detection limit. ND = undetectable, detection, limit not available.

Date	Time	Temp °C	Cond umho	DO ppm	pH	Turbid. FTU	Chl a µg/L	Phaeo µg/L	TDS mg/L	NO3-N mg/L	total NH3-N mg/L	un-ion NH3-N ug/L	Tot P mg/L	Diss P mg/L	TOC mg/L	DOC mg/L
11-Dec-91	1645	10	380	10.4	7.6	3.5	22		360	2.9	0.099	0.73	1.3	1.1	7.8	7.3
25-Mar-92	1103	14	428	5.4	7.6				260	2.3	0.06	1.6	1	0.93	8.7	8.2
29-Apr-92	1015	20	512	4.9	7.5	20	368	284	320	0.1	0.13	1.61	0.84	0.57	6.7	5
3-Jun-92	1100	21	570	3.5	7.5	55	20	6	350				0.65		6.6	5.6
1-Jul-92	750	17.5	356	5.6	7.5	19	27	0.0005*	230	0.28	0.15	1.55	0.4	0.29	11	11
8-Sep-92	1025	19	683	6.8	8				410	0.015 *	0.025 *		0.57		12	5.6
28-Oct-92	1125	16	576	7.8	7.7	11.4	21	9								
16-Dec-92	935	8	361	5.5	6.9	27	4	1.6								
17-Mar-93	1150	14	162	6.4	7.5	53	16	14.2								
14-Apr-93	1015	13	446	8.8	8.3	12.4	40.6	2.9 *								
12-May-93	938	16	520	6.3	7.8	40										
16-Jun-93	1028	22.5	738	3.4	7.4	30.9	4.45	8.01								
18-Aug-93	1118	22.5	604	2.8	7.5	26	12.8	0.29 *								
19-Oct-93	905	17	432	1.7	6.9		4	3.16								
14-Dec-93		9	169	9.3	7.4		8.0	0.1							11.0	9.9
22-Mar-94	1020	13.8	531	8.1	8.2		0.1 *	13.1								
25-Apr-94	1210	13.9	367	7.4	7.5	20.5	32.0	2.0	174	0.6	0.05 *		0.53	0.35	8.9	12.0
24-May-94	1305	19.0	494	5.2	8.1	15.0	17.2	2.76	174	0.8	0.05 *		0.79	0.62	7.0	6.9
23-Jun-94	1305	17.2	451	5.0	7.4	1.8	1.0	3.4	346	2.0	0.3		0.2	0.2	3.7	3.5
25-Aug-94	1410	17.5	832	7.4	7.3	2.0	0.5	1.7	566	8.7	0.2		0.4	0.4		
25-Oct-94	1250	13.0	541	4.4	6.7	0.8	0.6	4.1	360	1.7	0.3		0.2	0.2	51	3.3
Laguna de Santa Rosa at Trenton-Healdsburg Road																
24-Oct-90	1500	18.3	460	9.5	8.1	7.3	3.3									
14-Dec-90	1358	7	392	10.5	6.9	4.7	6.7									
3-Apr-91	1520	17.8	280	7.7	7.1	16	3.3									
30-Apr-91	1555	22	460	9.4	7.8	9.7	70.4	27.2	320	0.2	0.095	2:7		0.58	8	7.1
3-Jun-91	1518	22.5	520	7.6	7.7	17	21	23								
27-Jun-91	1423	20	520	7.6	7.5	15	16	10								
20-Aug-91	1700	22	580	7.8	7.9	12	8	1								
11-Dec-91	1655	9	375	10.5	7.5	3.1	25									
25-Mar-92	1122	14	420	6.9	7.6											
29-Apr-92	1030	20.5	510	6.2	7.6	18	4	9	310	0.14	0.11	1.77	0.8	0.57	6.8	4.9
3-Jun-92							20	10								
25-Apr-94	1150	14.0	336	8.2	7.7	29.5	11.0	2.8								
24-May-94	1225	19.0	484	6.3	8.2	18.0	18.2	2.03								
23-Jun-94	1225	21.8	599	6.2	8.0		1.0	9.0								
25-A[illegible]94	1345	19.2	652	5.8	7.8		0.3	1.8								
25-[illegible]94	1000	13.0	603	7.8	6.7	2.8	1.2	[illegible]								

Appendix 2. Laguna de Santa Rosa and Tributaries: Physical-Chemical Data And Nutrients, 1990-1994. *indicates below the detection limit; number shown is one-half the detection limit. ND = undetectable, detection, limit not available.

Date	Time	Temp °C	Cond umho	DO ppm	pH	Turbid. FTU	Chl a µg/L	Phaeo µg/L	TDS mg/L	NO3-N mg/L	total NH3-N mg/L	un-ion NH3-N ug/L	Tot P mg/L	Diss P mg/L	TOC mg/L	DOC mg/L
Santa Rosa Creek at Willowside Road																
24-Oct-90	1305	17.2	540	11	8.4	1.5	1.6		380	0.035	0.025 *		0.1	0.092	5.2	4.3
14-Dec-90	1157	7.5	325	11.2	7.5	1.8	6.7		320	0.29	0.025 *		0.14	0.14	5	4.7
3-Apr-91	1330	19	328	13.4	8.4	3.2	3.9		230	1	0.099	8.4	0.062	0.033	3.5	4.3
11-Apr-91	1555	17	377	16.9												
30-Apr-91	1515	19.5	495	9.5	8.1	2	7.7		310	0.35	0.056	2.5		0.11	4.5	4.4
3-Jun-91	1412	23.5	600	10.4	8.2	1.4	2	3	370	0.015 *	0.058	0.0044	0.14	0.14	2.8	3
27-Jun-91	1335	21	600	13	8.2	2.4	16	0	370	0.042	0.048	0.003	0.11	0.11	2.6	2.7
20-Aug-91	1550	26	660	12.5	8.8	1.3	3	0	380	0.015 *	0.057	14.7	0.13	0.096	4	3.6
11-Dec-91	1618	8.5	348	12.4	7.5	0.5	4		340	0.14	0.054	0.28	0.14	0.12	3.3	3.1
25-Mar-92	1307	16	425	14.6	8.7				250	0.66	1.4	180.6	0.47	0.34	9.1	6.4
29-Apr-92	1440	20	1561	12.2	8.5	2.2	10	34	330	0.04	0.025 *		0.13	0.04	3.4	2.8
3-Jun-92	1015	20	615	3.6	7.8	3.2	3	4	370				0.21		4.4	4
1-Jul-92	830	19	416	5.5	7.1	4.9	20	0.0005*	250	0.26	0.11	0.51	0.18	0.16	8.5	8.9
8-Sep-92	1130	23	692	9.3	8				410	0.015 *	0.025 *		0.13		3.5	4
28-Oct-92	1350	17	606	8.5	8.2	1	0	2	370	0.09	0.025 *		0.14	0.14	5.9	3.6
16-Dec-92	1106	8	391	10.6	7.7	7.6	5.2	ND	270	1.9	0.16	1.16	0.2		8.5	4.9
17-Mar-93	1330	15	350	7.8	7.4	52	18.7	ND	250	0.41	0.11	0.69	0.5	0.27	12	12
14-Apr-93	1214	13	559	11	8.6	1.2	2.8 *	2.8 *	270	0.3	0.025 *		0.07	0.03	25	21
12-May-93	1110	15	590	13.5	8.5	1.1			310	0.015 *	0.025 *		0.05	0.02	5.9	5.6
16-Jun-93	1243	26	770	9.4	8.3	2	1.48	1.11	200	0.015 *	0.025 *		0.23	0.08	6.1	6.4
18-Aug-93	1428	27	621	7.1	6.9	2.6			340	0.012	0.025 *		0.16	0.063	6.6	6.1
19-Oct-93	1115	17	562	7.75	7.8	4.3	10.1	1.82	319	1.4	0.025 *		0.73	<0.1	7.4	6.6
14-Dec-93		10.5	212	11.6	7.8	54	2.7	4.8	155	18.9	0.1		0.43	0.18		
22-Mar-94	1240	15.1	233	16.5	8.1	7.6	0.1 *	94.0	305	1.2	0.05 *		0.05 *	0.05 *	3.8	3.7
25-Apr-94	1305	15.0	281	11.3	7.8	9.2	4.3	2.8	98	0.9	0.05 *		0.27	0.19	11.0	10.0
24-May-94	1412	26.5	554	10.8	8.9	2.3	1.1	1.17	98	0.4	0.7		0.08	0.08	4.7	4.9
23-Jun-94	1438	29.0	611	12.3	8.5	1.8	2.1	0.2 *	361	0.3	0.05 *		0.1	0.1	4.2	5.0
25-Aug-94	1600	26.0	643	11.2	8.5	1.4	0.5	2.3	412	1.1	0.05 *		0.4	0.4		
25-Oct-94	1350	16.5	392	12.1	6.8	1.1	0.6	0.4	376	1.9	0.05 *		0.2	0.1	64	2.8
Mark West Creek at Slusser Road																
1-Jul-92	730	18.5	339	4.5	7.5	14	33	0.0005*	220	0.33	0.16	1.78	0.3	0.26	11	10
8-Sep-92	1000	19	680	3.3	7.8				400	0.015 *	0.07	1.6	0.61		5.1	5
28-Oct-92	1225	16	564	7	7.6	9.6	12	7	350	0.25	0.1	0.12	0.71	0.66	9	8.7
16-Dec-92	911	8	352	5	7.6	27	6.7	ND	300	3.5	0.61	3.53	1.5		14	10
17-Mar-93	1110	13	159	6.3	7.5	72	16	4.5	170	0.6	0.14	0.95	0.44	0.28	11	11
14-Apr-93	1048	13	286	9.4	8	2	2.9 *	2.9 *	210	0.15	0.025 *		0.14	0.09	13	13
12-May-93	953	12	337	10	7.7	1.1			250	0.07	0.025 *		0.06	0.12	3.8	2

Appendix 2. Laguna de Santa Rosa and Tributaries: Physical-Chemical Data And Nutrients, 1990-1994. *indicates below the detection limit; number shown is one-half the detection limit. ND = undetectable, detection, limit not available.

Date	Time	Temp °C	Cond umho	DO ppm	pH	Turbid. FTU	Chl a µg/L	Phaeo µg/L	TDS mg/L	NO3-N mg/L	total NH3-N mg/L	un-ion NH3-N ug/L	Tot P mg/L	Diss P mg/L	TOC mg/L	DOC mg/L
16-Jun-93	1045	19.2	540	6.9	7.5	0.4	1.48	0.37 *	81	0.015 *	0.18	2.08	0.22	0.05	4.5	4.5
18-Aug-93	1310	20.5	514	5.6	6.8	0.1	0.135 *	1.12	290	1.6	0.025 *		0.17	0.13	4.5	7.6
19-Oct-93	950	16	342	6.6	7.3	0.4	77.6	1.2	224	0.4	0.025 *		0.23	0.05 *	6	5.1
14-Dec-93		9	111	12.5	7.7	56	0.05 *	11.2	136	8.1	0.05 *		0.57	0.16	11.0	9.4
22-Mar-94	1040	11.4	326	13.0	7.0	0.9	0.1 *	31.1	114	0.6	0.05 *		0.7	0.05 *	3.0	2.7

Date	Time	Temp C	DO mg/L	pH	Cond umho/cm	TFR mg/L	TURB NTU	NO3 mg/L	NO2 mg/L	NH3 mg/L	TKN mg/L	Ortho PO4 mg/L	Total PO4 mg/L	TOC mg/L	DOC mg/L
Laguna de Santa Rosa at Stony Point Road															
17-Oct-89	1445	17.3	10.0	8.0	1115	650		0.070	0.001	0.025	0.93	0.36	0.43	9.3	9.6
14-Nov-89	1315	16.5	13.2	8.5	1247	720		0.030	0.008	0.070	0.80	0.18	0.23	8.3	8.7
22-Jan-90	1250	9.6		7.5	670			1.400	0.140	0.560	1.50	0.54	0.60		
26-Jan-90	1031	8.6		7.7	787			1.300	0.230	0.080	1.50	0.46	0.40		
31-Jan-90	1225	9.5		7.7	665			0.940	0.220	0.250	1.70	0.36	0.36		
2-Feb-90	1509	10.1		7.3	378			1.600	0.590	0.640	2.50	0.92	0.76		
7-Feb-90	1225	8.3		7.4	454			0.690	0.090	0.180	1.20	0.50	0.57		
14-Feb-90	1252	9.4		8.1	794			1.400	0.320	1.400	2.50	0.79	0.91		
20-Feb-90	1139	7.1		7.0	372			0.700	0.077	0.580	1.30	0.64	0.66		
21-Feb-90	1110	9.3		7.0	414			0.650	0.058	0.220	1.10	0.45	0.58		
28-Feb-90	1409	15.1		7.9	723			0.580	0.220	0.080	1.00	0.43	0.58		
6-Mar-90	1429	14.8		7.4	410			0.600	0.100	2.400	4.30	1.30	1.60		
14-Mar-90	931	12.7		7.9	534			0.430	0.040	0.240	0.81	0.39	0.38		
23-Mar-90	1050	16.6		7.8	908			0.150	0.074	0.060	1.70	0.49	0.54		
4-Apr-90	1318	22.0		8.1	1175			0.100	0.007	0.380	0.60	0.48	0.50		
10-Apr-90	1217	20.8		8.1	1211			0.620	0.007	0.120	0.90	0.06	0.64		
18-Apr-90	1302	20		7.6	1154			0.100	0.010	0.025	1.80	0.99	1.10		
25-Apr-90	1420	26.3			1091			0.050	0.001	0.060	1.20	0.64	0.91		
1-May-90	1345	22.4		8.0	1108			0.110	0.001	0.120	1.10	0.10	1.20		
9-May-90	1120	19.3		7.8	1164			0.120	0.001	0.025	0.90	1.20	1.40		
16-May-90	1224	21.9		8.2	2020			0.070	0.001	0.025	1.00	1.40	1.40		
24-May-90	1400	25.3	10.6		405	260	17.00	0.140	0.044	0.025	0.24	0.86	0.90	17.7	12.2
5-Jun-90	1315	27.3	10.2	8.2	774	430	7.00	0.050	0.025	0.030	1.10	0.56	0.57	11.9	12.6
12-Jun-90	1320	28	10.5		1055	620	10.00	0.050	0.001	0.030	1.00	0.73	0.83	11.1	9.6
19-Jun-90	1220	28	9.7	8.1	1157	630	8.30	0.030	0.001	0.030	1.20	1.10	1.70	8.5	8.6
4-Dec-90	1015							0.130	0.048	0.025	0.10	0.20	0.26	14.0	11.0
6-Dec-90	0930							0.120	0.043	0.025	0.30	0.17	0.22	13.0	12.0
11-Dec-90	0940							1.200	0.320	0.590	1.20	0.52	0.69	18.0	15.0
13-Dec-90	0925							0.800	0.230	0.100	0.20	0.51	0.59	11.0	13.0
18-Dec-90	1012							4.800	0.230	0.160	0.81	0.69	0.79	15.0	10.0
20-Dec-90	0920							0.860	0.092	0.110	0.29	0.15	0.44	9.6	8.1
27-Dec-90	0920							0.300	0.040	0.025	0.24	0.25	0.26	10.0	6.8
3-Jan-91	0925							0.290	0.025	0.025	0.05	0.23	0.23	11.0	6.1
10-Jan-91	1005	7.7	8.6	7.9	622			0.410	0.240	0.025	0.15	0.30	0.34	8.9	9.2
15-Jan-91	0930	11.2	8.2	7.9	645			0.080	0.020	0.025	0.15	0.28	0.34	9.3	8.8
23-Jan-91	0940							0.040	0.001	0.025	0.12	0.25	0.28	8.4	8.9
30-Jan-91	0955							0.040	0.001	0.025	0.05	0.18	0.23	9.0	11.0
2-Feb-91	1540	12.8		8.0	155			2.200	0.200	0.350	0.38	0.38	0.46		
8-Feb-91	1100	11.8	4.2	7.3	425			1.400	0.360	0.920	1.10	1.20	1.20	17.0	18.0
12-Apr-91	1050	14.8	10.0	8.2	521			0.370	0.034	0.025	1.00	0.16	0.27		
17-Apr-91	1320	18.4	10.0		610			0.410	0.070	0.025	0.80	0.16	0.22		
7-Jun-91	1330	24.8	9.8	8.2	1438			0.020	0.001	0.025	1.00	0.38	0.54		

Appendix 3-1. Laguna de Santa Rosa and Tributaries: Physical-Chemical Data and Nutrients, 1989-1992 (RWQCB data).

Date	Time	Temp C	DO mg/L	pH	Cond umho/cm	TFR mg/L	TURB NTU	NO3 mg/L	NO2 mg/L	NH3 mg/L	TKN mg/L	Ortho PO4 mg/L	Total PO4 mg/L	TOC mg/L	DOC mg/L
29-Jan-92	1050	9.9	8.5	8.0	802					0.100	1.10		0.38		
Laguna de Santa Rosa at Llano Road															
29-Jan-92	1155	9.6	5.0	7.7	930					7.900	14.00		0.82		
14-Feb-92	1100	11.2	7.0	7.5	360					5.000	8.81	0.00	1.40		
Laguna de Santa Rosa at Todd Road															
14-Nov-89	1345	14.4	4.4	7.4	484	320		0.550	0.076	0.830	2.30	0.80	0.91	11.8	10.8
22-Jan-90	1220	12.0		7.1	731			6.200	0.880	9.400	9.50	2.10	2.10		
26-Jan-90	1008	10.8		7.2	757			5.500	0.980	10.000	11.00	3.40	1.90		
31-Jan-90	1130	10.4		7.2	810			3.300	0.700	8.500	9.70	0.32	1.70		
2-Feb-90	1450	10.6		7.0	340			2.200	0.410	2.000	5.30	1.20	0.72		
7-Feb-90	1133	12.4		6.9	689			3.700	0.890	12.000	13.00	2.00	2.00		
14-Feb-90	1203	10.2		7.2	758			5.200	0.970	10.000	11.00	3.00	3.20		
20-Feb-90	1113	11.9		6.8	552			2.500	1.300	6.800	8.50	2.50	2.70		
21-Feb-90	1126	11.7		7.1	740			5.600	1.000	11.000	11.00	3.20	3.20		
28-Feb-90	1226	15.8		6.7	820			2.700	4.300	14.000	12.00	3.10	3.20		
6-Mar-90	1155	15.1		6.7	527			2.000	1.300	7.800	7.90	2.80	2.90		
14-Mar-90	958	15.4		6.5	751			5.600	2.600	13.000	12.00	3.10	3.30		
23-Mar-90	1024	17.7		6.7	892			7.400	3.000	15.000	19.00	4.80	5.60		
4-Apr-90	1241	19.0		6.8	876			5.300	2.000	9.600	13.00	3.80	4.10		
10-Apr-90	1155	16.7		7.2	990			0.670	0.470	11.000	17.00	3.50	3.70		
18-Apr-90	1142	17.6		7.0	1080			0.270	0.330	5.600	7.30	2.60	3.00		
25-Apr-90	1316	19.8			1148			0.250	0.500	4.500	6.90	1.60	2.00		
1-May-90	1326	20.3		7.8	1221			0.200	0.120	2.600	3.20	2.20	2.60		
9-May-90	1100	18.3		7.7	1442			0.170	0.020	12.000	16.00	4.80	6.20		
16-May-90	1155	20.5		8.2	2120			0.240	0.670	9.000	15.00	5.10	5.80		
24-May-90	1220	17.9	5.1	0.0	469	280	22.00	0.160	0.061	0.170	0.38	0.77	0.80	14.1	7.8
5-Jun-90	1220	21.7	6.1	7.2	608	380	10.00	0.200	0.340	2.000	4.80	1.20	1.10	17.8	16.0
12-Jun-90	1230	23.6	9.5		637	410	10.00	0.080	0.001	0.025	2.70	1.00	1.10	18.7	15.5
19-Jun-90	1125	23.5	8.5	7.7	685	380	9.80	0.070	0.001	0.025	2.50	0.85	0.87	17.1	21.6
4-Dec-90	0930							0.220	0.070	0.025	0.50	0.46	0.52	17.0	14.0
6-Dec-90	0900							6.200	0.290	0.660	1.00	4.00	2.60	15.0	13.0
11-Dec-90	0900							8.900	0.330	0.590	1.00	4.20	4.60	17.0	11.0
13-Dec-90	0855							6.300	0.220	0.360	0.60	2.90	3.40	10.0	13.0
18-Dec-90	0945							6.300	0.310	0.390	0.65	2.50	2.50	11.0	8.7
20-Dec-90	0855							10.000	0.400	0.420	1.20	3.70	3.70	9.9	7.3
27-Dec-90	0855							9.600	0.470	0.400	1.10	3.80	3.90	11.0	8.9
3-Jan-91	0910							10.000	0.400	0.270	0.71	3.80	3.70	12.0	10.0
10-Jan-91	920	7.1	6.9	7.6	543			0.810	0.140	0.210	0.46	0.66	0.73	10.0	11.0
15-Jan-91	0905	11.6	9.2	7.7	726			0.080	0.020	0.025	0.30	0.46	0.51	12.0	18.0
23-Jan-91	0920							0.060	0.001	0.025	0.30	0.48	0.54	11.0	10.0
30-Jan-91	0905							0.060	0.001	0.025	0.05	0.40	0.49	10.0	11.0
2-Feb-91	1430	11.8		7.8	294			1.600	0.400	0.320	0.22	0.39	0.65		
8-Feb-91	0950	10.9		7.3	422			1.600	0.400	0.960	1.10	1.30	1.30	17.0	19.0

Appendix 3-1. Laguna de Santa Rosa and Tributaries: Physical-Chemical Data and Nutrients, 1989-1992 (RWQCB data).

Date	Time	Temp C	DO mg/L	pH	Cond umho/cm	TFR mg/L	TURB NTU	NO3 mg/L	NO2 mg/L	NH3 mg/L	TKN mg/L	Ortho PO4 mg/L	Total PO4 mg/L	TOC mg/L	DOC mg/L
10-Apr-91	1445	15.6	6.2	7.7	666			1.100	0.360	1.400	2.00	1.30	1.20		
17-Apr-91	1230	15	5.6		571			0.360	0.200	0.025	2.40	0.86	0.93		
29-Jan-92	1130	11.2	8.8	7.4	779			0.000		2.200	4.60	0.00	4.50		
Laguna de Santa Rosa at Highway 12															
29-Jan-92	1210	8.7	5.2	7.5	1452					3.500	5.90		2.10		
14-Feb-92	1220	11.2	7.0	7.5	360					4.200	9.30		5.50		
Laguna de Santa Rosa at Occidental Road															
27-Sep-89	1140	19.5	9.2	7.3	504	350		0.570	0.070	0.100	4.30	1.10	0.53	18.0	17.0
14-Nov-89	1230	15.7	9.6	7.8	371	220		0.430	0.016	0.025	3.20	0.71	1.10	9.6	9.4
22-Jan-90	1150	9.7		7.0	647			5.600	0.310	5.200	5.60	1.90	1.90		
26-Jan-90	940	9.1		7.1	671			6.500	0.200	5.000	6.00	2.00	1.60		
31-Jan-90	1054	10.3		7.1	696			5.600	0.480	4.400	4.60	1.70	1.90		
2-Feb-90	1421	11.6		7.1	649			3.100	0.360	2.500	4.00	1.20	1.40		
7-Feb-90	1103	10.4		6.9	515			3.400	0.260	1.800	4.60	1.30	1.60		
14-Feb-90	1131	10.1		7.0	680			4.900	0.490	5.600	6.30	1.90	2.00		
20-Feb-90	1030	9.9		7.1	416			3.000	0.200	0.025	2.20	1.70	2.10		
21-Feb-90	1208	10.3		6.9	463			3.100	0.180	2.600	4.80	1.60	1.60		
28-Feb-90	1154	13.7		7.0	700			4.700	0.590	4.900	5.90	3.20	3.40		
6-Mar-90	1118	15.5		6.8	410			2.200	0.220	2.800	3.90	1.50	1.80		
14-Mar-90	1031	12.3		7.0	613			3.300	0.440	3.400	3.50	1.80	2.10		
23-Mar-90	956	16.6		7.1	749			3.800	0.720	4.200	8.50	2.70	3.00		
4-Apr-90	1216	18.8		7.0	771			10.000	1.500	2.900	61.00	3.00	3.10		
10-Apr-90	1127	18.0		7.8	751			7.600	1.030	2.500	4.20	2.50	2.60		
18-Apr-90	1115	19.5		8.5	711			4.700	0.710	0.530	3.80	2.20	2.70		
25-Apr-90	1251	21.1			682			1.900	0.480	0.060	1.30	1.90	2.60		
1-May-90	1304	20.4		8.2	692			0.750	0.280	0.230	2.10	2.70	2.90		
9-May-90	1041	19.9		7.9	704			0.110	0.014	0.100	1.10	3.20	3.40		
16-May-90	1140	21.5		8.3	1019			0.080	0.048	0.150	3.70	2.20	3.00		
24-May-90	1120	19.5	11.1		693	410	27.00	0.340	0.120	0.680	0.90	2.60	2.70	24.3	12.6
5-Jun-90	1145	23.2	19.2	8.4	363	300	16.00	0.110	0.076	0.030	3.00	1.80	1.60	19.1	17.3
12-Jun-90	1200	25.7	13.2		409	300	44.00	0.080	0.001	0.030	1.40	1.80	1.90	17.8	15.0
19-Jun-90	1040	25.9	12.2	8.7	446	290	28.00	0.090	0.001	0.030	2.50	2.30	2.60	17.5	16.4
4-Dec-90	1100							0.005	0.001	0.025	0.50	0.07	0.33	18.0	15.0
6-Dec-90	1000							0.005	0.001	0.025	0.30	0.09	0.27	24.0	19.0
11-Dec-90	1025							1.500	0.078	1.400	2.00	1.50	1.50	14.0	16.0
13-Dec-90	1000							2.400	0.082	0.910	1.40	1.50	1.80	12.0	16.0
18-Dec-90	1043							6.000	0.330	0.490	1.40	2.60	3.30	14.0	11.0
20-Dec-90	0950							7.300	0.460	0.550	1.40	2.40	2.90	14.0	20.0
27-Dec-90	0956							8.100	0.350	1.100	1.60	2.90	2.80	13.0	11.0
3-Jan-91	1000							9.700	0.390	0.140	0.68	3.30	3.40	16.0	12.0
10-Jan-91	1040	7.9	8.7	7.6	860			8.300	0.270	0.390	0.59	2.80	3.00	12.0	12.0
15-Jan-91	1010	10.6	6.4	7.7	921			6.300	0.320	1.900	2.70	2.60	2.70	16.0	14.0
23-Jan-91	1015							6.300	0.430	1.600	1.80	2.60	2.80	15.0	13.0

Appendix 3-1. Laguna de Santa Rosa and Tributaries: Physical-Chemical Data and Nutrients, 1989-1992 (RWQCB data).

Date	Time	Temp C	DO mg/L	pH	Cond umho/cm	TFR mg/L	TURB NTU	NO3 mg/L	NO2 mg/L	NH3 mg/L	TKN mg/L	Ortho PO4 mg/L	Total PO4 mg/L	TOC mg/L	DOC mg/L
30-Jan-91	1100							5.500	0.230	0.470	0.56	2.30	2.50	25.0	12.0
2-Feb-91	1615	11.0		7.8	760			4.200	0.160	0.170	0.25	2.10	2.20		
8-Feb-91	1150	12.3	6.5	7.3	400			1.400	0.320	0.420	0.63	1.50	1.60		
10-Apr-91	1415	17.2	14.0	8.3	575			3.900	0.140	0.025	0.99	1.80	1.90		
17-Apr-91	1215	17.6	13.8		524			1.800	0.200	0.900	2.10	1.40	1.20		
29-Jan-92	1310	10	7.1	7.3	770					0.270	2.10		3.00		
Laguna de Santa Rosa upstream of confluence with Santa Rosa Creek															
30-Aug-89	0915	18.6	2.7	7.2	234	160		0.800	0.007	0.500	0.90	0.31	0.02	2.0	2.6
18-Oct-89	1000	16.4	10.4	7.0	413	270		0.740	0.027	0.490	1.20	0.81	1.00	13.0	11.0
14-Nov-89	1120	14.8	7.4	7.1	353	210		0.400	0.022	0.025	1.60	0.52	0.73	8.8	9.1
22-Jan-90	1110	9.4		6.8	525			2.800	0.180	3.400	4.40	1.80	1.60		
26-Jan-90	910	8.8		6.9	610			3.400	0.150	4.000	4.40	1.60	1.40		
31-Jan-90	1054	9.40		7.0	652			4.700	0.330	3.200	3.30	0.31	1.20		
2-Feb-90	1353	12.2		6.9	539			2.400	0.430	2.600	3.30	1.20	0.70		
7-Feb-90	1027	9.30		6.6	399			1.400	0.190	2.000	3.40	1.10	1.30		
14-Feb-90	1047	8.60		7.0	599			2.700	0.340	4.400	5.60	1.50	1.60		
21-Feb-90	1422	12.6		6.6	309			1.700	0.080	0.030	0.88	1.14	1.30		
28-Feb-90	1110	12.7		6.9	641			3.900	0.460	2.800	2.90	0.95	1.50		
6-Mar-90	1030	13.7		6.8	521			2.900	0.410	3.600	3.50	1.70	1.80		
14-Mar-90	1149	12.3		6.9	599			3.300	0.420	3.600	4.10	1.70	1.90		
23-Mar-90	918	15.6		7.0	701			3.200	0.430	6.600	6.60	2.10	2.60		
10-Apr-90	1032	16.1		7.3	696			4.300	0.590	0.460	3.10	1.70	2.00		
18-Apr-90	0957	17.3		7.0	560			2.900	0.310	0.025	3.50	1.60	2.00		
25-Apr-90	1220	20.0			622			1.200	0.150	0.140	1.90	1.30	2.20		
1-May-90	1049	19.5			624			0.450	0.170	0.100	2.80	2.30	2.70		
9-May-90	955	18.6		7.5	470			0.150	0.020	0.003	2.70	2.40	2.50		
16-May-90	1010	19.6		7.2	625			0.590	1.000	0.250	1.30	1.80	2.20		
24-May-90	1100	17.2	8.0		564		13.00	0.350	0.104	0.700	0.80	2.20	2.30	12.2	12.2
5-Jun-90	1045	20.7	1.2	7.0	334	240	10.00	0.180	0.003	0.030	3.10	2.30	2.20	20.9	17.3
12-Jun-90	1050	22.1	16.6		419	300	29.00	0.290	0.051	0.030	2.80	2.20	2.50	17.3	13.2
19-Jun-90	1005	22	6.3	7.2	374	180	28.00	0.140	0.033	0.160	2.30	1.60	1.60	10.0	9.7
4-Dec-90	1220							1.200	0.050	0.440	0.20	0.20	0.26	3.2	1.9
6-Dec-90	1030							1.300	0.034	0.120	0.20	0.19	0.26	5.3	3.7
11-Dec-90	1100							0.560	0.056	0.290	0.40	0.45	0.51	8.7	10.0
13-Dec-90	1035							2.300	0.100	0.880	1.50	1.20	1.40	14.0	14.0
18-Dec-90	1136							6.100	0.320	0.320	1.60	2.20	2.30	14.0	11.0
20-Dec-90	1025							6.100	0.410	0.380	1.10	2.00	2.70	12.0	11.0
27-Dec-90	1030							8.000	0.330	0.800	1.40	2.70	2.70	12.0	11.0
3-Jan-91	1035							9.800	0.380	0.130	0.52	3.20	3.20	14.0	9.4
10-Jan-91	1105	7.6	8.8	7.6	803			8.400	0.350	0.320	0.64	2.40	2.50	12.0	12.0
15-Jan-91	1040	11.0	7.4	7.6	866			6.500	0.350	1.500	1.60	2.30	2.60		
23-Jan-91	1050							5.700	0.450	1.100	1.50	2.10	2.50	12.0	13.0
30-Jan-91	1215							7.200	0.240	0.180	0.23	2.00	2.20	11.0	19.0

Date	Time	Temp C	DO mg/L	pH	Cond umho/cm	TFR mg/L	TURB NTU	NO3 mg/L	NO2 mg/L	NH3 mg/L	TKN mg/L	Ortho PO4 mg/L	Total PO4 mg/L	TOC mg/L	DOC mg/L
8-Feb-91	1225	12.3	4.2	7.4	434			1.100	0.450	0.450	0.75	1.50	1.60	16.0	13.0
10-Apr-91	1345	16	8.1	7.7	546			2.500	0.130	0.120	0.98	1.60	1.60		
17-Apr-91	1143	16.0	7.6		485			1.400	0.160	0.100	1.80	1.20	1.40		
31-May-91	1210	22.2	9.8	7.7	510			0.220	0.100	0.025	2.80	0.98	0.72		
7-Jun-91	1520	24.1	9.4	8.0	502			0.050	0.001	0.025	1.80	0.87	1.10		
17-Jun-91	0920	19.1		6.8	290			0.110	0.040	0.025	1.10	2.00	2.00		
29-Jan-92	1530	10.9	8.2	7.4	715					0.330	1.60		3.50		
Laguna de Santa Rosa at River Road															
5-Jun-90	1245	23.2	10.2	7.6	554	230	8.00	0.100	0.001	0.030	1.80	1.20	1.20	13.6	14.2
12-Jun-90	1255	23.4	8.0		668	280	37.00	0.130	0.030	0.030	1.00	0.48	0.53	6.7	6.2
19-Jun-90	1155	23.4	6.8	7.6	861	280	34.00	0.050	0.044	0.030	0.70	0.36	0.44	4.0	3.7
Santa Rosa Creek at Melita Road															
30-Aug-89	1215	17.1	4.1	8.1	486	430		0.500	0.006	0.050	0.05	0.06	0.01	1.7	1.7
17-Oct-89	1310	16.2	12.5	8.1	495	300		0.240	0.001	0.300	0.28	0.07	0.06	2.6	2.2
14-Nov-89	1500	13.0	14.5	8.4	496	280		0.030	0.120	0.050	0.05	0.05	0.04	2.2	1.9
2-Feb-91	1245							0.810	0.001	0.025	0.13	0.11	0.33	14.0	
30-Jan-92	0920	7.2	8.8	8.3	452					0.055	0.40		0.03		
Santa Rosa Creek at Willowside Road															
30-Aug-89	1000	19.2	7.6	7.9	635	360		0.040	0.003	0.050	0.10	0.09	0.06	2.8	3.9
16-Sep-89	1215	17.2		7.8	346			0.890	0.050	0.440	5.80	0.16	0.84	24.0	24.0
16-Sep-89	950	18.5		7.9	648			0.050	0.002	0.250	1.20	0.10	0.11	5.5	4.6
27-Sep-89	1030	19.8	8.1	7.6	584	400		0.050	0.002	0.025	0.58	0.10	0.09	4.0	1.3
18-Oct-89	1040	16.7	10.1	8.1	618	360		0.040	0.003	0.120	0.30	0.10	0.06	2.4	3.2
14-Nov-89	1200	14.2	11.2	8.4	570	340		0.040	0.003	0.025	0.05	0.04	0.07	2.4	2.5
22-Jan-90	1040	7.9		7.8	446			1.600	0.022	0.025	0.42	0.10	0.12		
26-Jan-90	835	8.7		7.6	490			0.800	0.020	0.070	0.27	0.08	0.09		
29-Jan-90	2100			8.4	494			0.830	0.014	0.025	0.29	0.06	0.08		
30-Jan-90	1020			7.8	432			0.890	0.060	0.025	0.29	0.10	0.14		
30-Jan-90	1430			8.3	393			0.740	0.052	0.025	0.17	0.11	0.18		
31-Jan-90	945	9.0		7.6	407			0.860	0.030	0.025	0.58	0.06	0.10		
2-Feb-90	1325	11.6		7.9	355			0.840	0.060	0.025	0.70	0.16	0.14		
7-Feb-90	950	7.6		7.5	360			0.930	0.020	0.030	0.48	0.10	0.09		
14-Feb-90	1012	6.8		7.9	480			0.550	0.016	0.025	0.05	0.04	0.05		
20-Feb-90	1018	8.2		7.7	319			0.910	0.022	0.260	0.69	0.12	0.17		
21-Feb-90	1347	13.1		7.9	352			0.970	0.022	0.025	0.55	0.16	0.17		
28-Feb-90	1025	12.4		7.6	445			0.630	0.020	0.025	0.29	0.05	0.01		
6-Mar-90	944	12.5		7.4	211			0.790	0.030	0.260	0.87	0.21	0.20		
14-Mar-90	1206	11.6		6.9	599			0.260	0.010	0.160	0.24	0.06	0.06		
23-Mar-90	840	15.1		7.8	490			0.070	0.020	0.160	0.53	0.08	0.11		
4-Apr-90								0.640	0.040	0.150	7.20	0.06	0.08		
10-Apr-90								0.350	0.041	0.025	0.30	0.70	0.08		
18-Apr-90	1018	17		7.8	552			0.280	0.020	0.570	1.20	0.05	0.08		
25-Apr-90	1157	21.6			500			0.070	0.012	0.130	0.40	0.16	0.21		

Appendix 3-1. Laguna de Santa Rosa and Tributaries: Physical-Chemical Data and Nutrients, 1989-1992 (RWQCB data).

Date	Time	Temp C	DO mg/L	pH	Cond umho/cm	TFR mg/L	TURB NTU	NO3 mg/L	NO2 mg/L	NH3 mg/L	TKN mg/L	Ortho PO4 mg/L	Total PO4 mg/L	TOC mg/L	DOC mg/L
1-May-90	1118	19.1			559			0.015	0.001	0.070	0.30	0.06	0.07		
9-May-90	1010	18.7		7.6	470			0.040	0.001	0.025	0.30	0.08	0.10		
16-May-90	1105	20.0		8.0	866			0.050	0.001	0.025	0.70	0.08	0.20		
24-May-90	1020	17.6	9.6		336		4.00	0.540	0.033	0.025	0.11	0.11	0.13	5.6	6.3
5-Jun-90	1115	21.0	12.0	8.0	476	290	2.00	0.170	0.015	0.030	0.60	0.01	0.04	3.9	4.6
12-Jun-90	1130	21.8	7.0		532	320	1.20	0.010	0.001	0.030	0.40	0.05	0.02	3.1	3.0
19-Jun-90	0925	21.0	6.7	8.0	564	290	3.00	0.030	0.001	0.030	0.30	0.08	0.11	2.9	2.9
4-Dec-90	1200							0.005	0.001	0.025	0.05	0.05	0.05	2.9	3.0
6-Dec-90	1100							0.005	0.001	0.025	0.05	0.04	0.05	3.7	4.7
11-Dec-90	1050							0.660	0.230	0.170	0.30	0.11	0.26	9.6	12.0
13-Dec-90	1020							0.170	0.013	0.025	0.05	0.08	0.09	7.1	8.0
18-Dec-90	1116							1.100	0.041	0.025	0.33	0.31	0.31	5.9	5.5
20-Dec-90	1015							0.250	0.010	0.025	0.16	0.08	0.10	3.9	4.4
27-Dec-90	1015							0.250	0.015	0.025	0.05	0.05	0.06	3.3	2.4
3-Jan-91	1020							7.200	0.280	0.520	0.69	2.70	2.80	7.1	4.7
10-Jan-91	1055	8.0	10.8	8.0	556			6.700	0.220	0.460	0.60	2.00	2.00	6.5	5.9
15-Jan-91	1025	10.2	11.0	8.3	663			6.600	0.190	0.680	0.88	2.00	2.10		
23-Jan-91	1035							0.005	0.001	0.025	0.05	0.03	0.05	3.2	3.4
30-Jan-91	1115							0.440	0.030	0.025	0.05	0.16	0.19	3.2	3.8
2-Feb-91	1710	13.1		7.0	161			2.000	0.110	0.100	0.10	0.25	0.40	6.3	
2-Feb-91	0830	14.6		7.8	171			1.500	0.100	0.025	0.15	0.38	0.74	18.0	
2-Feb-91	1030							1.600	0.090	0.200	0.16	0.19	0.35	11.0	
8-Feb-91	1210	11.4	10.8	7.8	644			8.800	0.250	0.460	0.68	2.80	2.90	7.4	5.9
10-Apr-91	1325	15.5	12.4	7.9	558			7.500	0.150	0.290	0.69	1.70	0.69		
17-Apr-91	1130	15.3	12.4		461			7.500	0.180	0.100	0.70	1.70	1.70		
31-May-91	1155	21.1	10.0	8.3	598			0.040	0.011	0.025	1.40	0.06	0.07		
7-Jun-91	1500	24.6	9.2	8.3	615			0.050	0.001	0.025	0.42	0.08	0.09		
17-Jun-91	0850	18.7		7.5	634			0.005	0.001	0.160	1.60	0.06	0.07		
30-Jan-92	0820	10.4	8.3	7.9	489					0.310	0.83		0.15		
14-Feb-92	1030	11.3	9.8	7.7	255					0.170	1.30		0.28		
Mark West Creek at Slusser Road															
30-Aug-89	0840	16.3	3.0	6.6	575	330		1.400	0.012	0.100	0.20	0.08	0.01	1.7	2.4
17-Oct-89	0930	12.1	9.0	6.7	355	230		0.060	0.001	0.025	0.24	0.07	0.07	4.1	3.8
14-Nov-89	1030	10.8	10.1	7.5	363	230		0.005	0.003	0.025	0.10	0.10	0.10	2.8	1.1
10-Apr-91	1215	13.3	9.4	7.9	213			0.240	0.006	0.025	0.15	0.04	0.05		
17-Apr-91	1112	13.1	11.6	8.2	231			0.130	0.001	0.025	0.20	0.02	0.06		
30-May-91	1520							0.040	0.001	0.025	0.21	0.07	0.07		
18-Jun-91								0.000	0.001	0.025	0.70	0.08	0.00		
30-Jan-92	1055	8.8	11.2	8.0	319					0.025	0.35		0.05		
14-Feb-92	1300	10.8	10.4	7.7	131					0.060	1.40		0.49		

STATION	DATE	AMMONIA NITROGEN	NITRATE	TKN	ORGANIC NITROGEN	TOTAL PHOS	NPRATIO
LSP	07/23/1997	0.025	0.0531			0.234	
LOR	07/23/1997	0.025	0.025			1.79	
LGR	07/23/1997	0.0695	0.025			0.15	
LTH	07/23/1997	0.025	0.0965			0.224	
SRCWS	07/23/1997						
LSP	08/05/1997	0.025	0.025	1.060	1.035	0.349	3.18
LGR	08/05/1997	0.025	0.025	1.130	1.105	0.22	5.36
LTH	08/05/1997	0.025	0.025	0.798	0.773	0.294	2.88
SRCWS	08/05/1997						
LSP	08/21/1997	0.025	0.0927			0.665	
LOR	08/21/1997	0.025	0.095			0.832	
LGR	08/21/1997	0.025	0.396			0.307	
LTH	08/21/1997	0.025	0.432			0.216	
SRCWS	08/21/1997						
LSP	09/02/1997	0.025	0.0536	0.893	0.868	0.626	1.55
LOR	09/02/1997	0.025	0.0593	5.900	5.875	1.37	4.37
LGR	09/02/1997	0.025	0.0654	1.370	1.345	0.462	3.16
LTH	09/02/1997	0.025	0.0953	1.020	0.995	0.652	1.75
SRCWS	09/02/1997						
LSP	09/17/1997	3.24	0.025			0.523	
LOR	09/17/1997	0.105	0.025			0.847	
LGR	09/17/1997	1.3	0.025			0.493	
LTH	09/17/1997	0.117	0.0761			0.211	
SRCWS	09/17/1997						
LSP	10/01/1997	0.156	0.025	0.564	0.408	0.366	1.68
LOR	10/01/1997	0.84	0.025	2.510	1.670	0.739	3.46
LGR	10/01/1997	0.182	0.025	0.610	0.428	0.262	2.52
LTH	10/01/1997	0.135	0.0561	0.362	0.227	0.342	1.30
SRCWS	10/01/1997						
LSP	10/15/1997	0.119	0.025			0.27	
LOR	10/15/1997	0.6	0.108			0.612	
LGR	10/15/1997	0.275	0.025			0.494	
LTH	10/15/1997	0.269	0.0526			0.359	
SRCWS	10/15/1997						
LSP	10/28/1997	0.919	0.025	0.640		0.186	3.71
LOR	10/28/1997	0.528	0.025	2.400	1.872	0.525	4.67
LGR	10/28/1997	0.534	0.025	1.050	0.516	0.252	4.37
LTH	10/28/1997	0.678	0.0615	0.834	0.156	0.259	3.55
SRCWS	10/28/1997						
LSP	11/10/1997	1.28	0.523	0.709		0.248	5.07
LOR	11/10/1997	1.13	0.025	1.720	0.590	0.611	2.90
LGR	11/10/1997	0.55	0.602	1.020	0.470	0.331	4.98
LTH	11/10/1997	0.587	0.0907	0.400		0.25	2.06
SRCWS	11/10/1997	1.29	0.496	0.969		0.309	4.82
LSP	11/24/1997	1.05	0.508			0.751	
LOR	11/24/1997	0.025	2.7			1.49	
LTH	11/24/1997	0.786	0.66			0.87	
SRCWS	11/24/1997	0.178	0.9			0.112	
LSP	12/10/1997	0.025	2.84			0.554	
LOR	12/10/1997	0.338	3.02			1.13	
LTH	12/10/1997	0.174	2.11			0.993	
SRCWS	12/10/1997	0.025	1.48			0.106	
LSP	12/23/1997	0.025	2.25	0.386	0.361	0.404	6.59
LOR	12/23/1997	0.025	2.32	0.793	0.768	0.874	3.59
LTH	12/23/1997	0.025	1.79	0.652	0.627	0.559	4.41
SRCWS	12/23/1997	0.025	1.46	0.100	0.075	0.0814	19.47
LSP	01/07/1998	0.792	1.26			0.656	
LOR	01/07/1998	0.0893	1.58			0.852	
LTH	01/07/1998	0.025	1.34			0.43	
SRCWS	01/07/1998	0.025	0.871			0.16	
LSP	01/21/1998	0.385	1.82	0.749	0.364	0.487	5.33

STATION	DATE	AMMONIA NITROGEN	NITRATE	TKN	ORGANIC NITROGEN	TOTAL PHOS	NPRATIO
LOR	01/21/1998	0.496	2.74	1.020	0.524	0.872	4.34
LTH	01/21/1998	0.354	1.18	0.835	0.481	0.614	3.32
SRCWS	01/21/1998	0.025	1.08	0.100	0.075	0.0932	12.93
LSP	02/03/1998	0.227	0.025			0.679	
LOR	02/03/1998	0.233	0.11			0.927	
SRCWS	02/03/1998	0.113	0.198			0.603	
LTH	02/03/1998	0.0723	0.256			0.456	
LSP	02/18/1998	0.165	0.949	1.040	0.875	0.518	3.94
LOR	02/18/1998	0.544	1.03	1.790	1.246	0.976	2.97
LTH	02/18/1998	0.238	1.45	0.990	0.752	0.573	4.37
SRCWS	02/18/1998	0.025	0.616	0.360	0.335	0.135	7.41
LSP	03/04/1998	0.0833	1.95			0.232	
LOR	03/04/1998	0.206	5.22			0.911	
LTH	03/04/1998	0.263	2.14			0.506	
SRCWS	03/04/1998	0.025	0.85			0.025	
LSP	03/18/1998	0.025	0.609	0.679	0.654	0.113	11.62
LOR	03/18/1998	0.025	2.55	1.360	1.335	0.894	4.45
LTH	03/18/1998	0.0509	1.53	0.993	0.942	0.32	7.96
SRCWS	03/18/1998	0.025	0.555	0.374	0.349	0.025	38.16
LSP	04/01/1998	0.446	0.476			0.428	
LOR	04/01/1998	0.106	3.98			1	
LTH	04/01/1998	0.239	0.426			0.259	
SRCWS	04/01/1998	0.025	0.311			0.0702	
LSP	04/13/1998	0.424	0.519	1.980	1.556	0.556	4.66
LOR	04/13/1998	0.329	2.93	1.650	1.321	0.863	5.41
LTH	04/13/1998	0.229	0.422	0.734	0.505	0.142	8.32
SRCWS	04/13/1998	0.133	0.376	0.712	0.579	0.0976	11.70
LSP	04/30/1998	0.202	0.568			0.297	
LOR	04/30/1998	0.15	3.05			1.07	
LTH	04/30/1998	0.0686	0.373			0.571	
SRCWS	04/30/1998	0.025	0.355			0.05	
LSP	05/11/1998	0.0854	0.624	0.423	0.338	0.216	5.15
LOR	05/11/1998	0.025	1.84	0.992	0.967	0.817	3.60
LTH	05/11/1998	0.0531	0.335	0.538	0.485	0.318	2.92
SRCWS	05/11/1998	0.025	0.476	0.231	0.206	0.05	14.64
LSP	05/28/1998	0.112	0.453			0.208	
LOR	05/28/1998	0.296	0.124			0.668	
LTH	05/28/1998	0.0574	0.24			0.184	
SRCWS	05/28/1998	0.109	0.434			0.182	
LSP	06/09/1998	0.0944	0.421	0.499	0.405	0.17	5.56
LOR	06/09/1998	0.0667	0.0748	0.943	0.876	1.03	1.01
LTH	06/09/1998	0.025	0.059	0.489	0.464	0.294	1.95
SRCWS	06/09/1998	0.025	0.0705	0.353	0.328	0.025	17.94
LSP	06/25/1998	0.28	0.41			0.22	
LOR	06/25/1998	0.18	0.025			0.73	
LGR	06/25/1998	0.05	0.025			0.025	
LTH	06/25/1998	0.06	0.025			0.34	
SRCWS	06/25/1998						
LSP	07/09/1998	0.1	0.05	0.500	0.400	0.46	1.30
LOR	07/09/1998	0.1	0.05	3.100	3.000	2	1.60
LGR	07/09/1998	0.1	0.05	1.500	1.400	0.46	3.48
LTH	07/09/1998	0.1	0.05	1.500	1.400	0.47	3.40
SRCWS	07/09/1998						
LSP	07/24/1998	0.633	0.025			0.518	
LOR	07/24/1998	0.127	0.025			0.651	
LGR	07/24/1998	0.186	0.025			0.218	
LTH	07/24/1998	0.352	0.153			0.343	
SRCWS	07/24/1998						
LSP	08/04/1998	0.124	0.025			0.381	
LOR	08/04/1998	0.025	0.025			0.478	
LGR	08/04/1998	0.134	0.025			0.264	

STATION	DATE	AMMONIA NITROGEN	NITRATE	TKN	ORGANIC NITROGEN	TOTAL PHOS	NPRATIO
LTH	08/04/1998	0.165	0.132			0.341	
SRCWS	08/04/1998						
LSP	08/19/1998	0.025	0.025			1.06	
LOR	08/19/1998	0.025	0.025			0.888	
LGR	08/19/1998	0.119	0.025			0.461	
LTH	08/19/1998	0.225	0.17			0.914	
SRCWS	08/19/1998						
LSP	09/04/1998	0.05	0.025	0.512	0.462	0.668	0.84
LOR	09/04/1998	0.025	0.025	0.953	0.928	1.66	0.60
LGR	09/04/1998	0.025	0.079	0.449	0.424	0.351	1.58
LTH	09/04/1998	0.025	0.116	0.489	0.464	0.626	1.01
SRCWS	09/04/1998						
LSP	09/14/1998	0.025	0.025			0.29	
LOR	09/14/1998	0.16	0.025			1.15	
LGR	09/14/1998	0.0605	0.025			0.181	
LTH	09/14/1998	0.0878	0.141			0.301	
SRCWS	09/14/1998						
LSP	09/29/1998	0.072	0.025	0.754	0.682	0.257	3.13
LOR	09/29/1998	1.95	0.122	2.310	0.360	0.951	2.58
LGR	09/29/1998	0.0854	0.066	0.505	0.420	0.19	3.14
LTH	09/29/1998	0.103	0.14	0.460	0.357	0.387	1.61
SRCWS	09/29/1998						
LSP	10/14/1998	0.025	0.025			0.189	
LOR	10/14/1998	0.549	0.447			0.755	
LGR	10/14/1998	0.025	0.129			0.23	
LTH	10/14/1998	0.0683	0.161			0.327	
SRCWS	10/14/1998						
LSP	10/29/1998	0.025	0.317	1.030	1.005	0.608	2.26
LOR	10/29/1998	0.208	0.788	1.190	0.982	0.795	2.57
LGR	10/29/1998	0.254	2.28	1.040	0.786	0.988	3.45
LTH	10/29/1998	0.153	1.18	0.860	0.707	0.606	3.48
SRCWS	10/29/1998						
LSP	11/12/1998	0.102	0.372			0.384	
LOR	11/12/1998	0.206	1.41			0.206	
LGR	11/12/1998	0.245	3.19			1.33	
LTH	11/12/1998	0.124	2.62			0.803	
SRCWS	11/12/1998						
LSP	11/25/1998	0.28	1.35	0.873	0.593	0.533	4.38
LOR	11/25/1998	0.235	1.31	1.020	0.785	1.18	2.05
LTH	11/25/1998	0.215	1.59	0.499	0.284	0.422	5.11
SRCWS	11/25/1998	0.025	1.49	0.336	0.311	0.0841	22.01
LSP	12/03/1998	0.672	2.92			0.847	
LOR	12/03/1998	0.526	2.97			1.63	
LTH	12/03/1998	0.233	1.24			0.776	
SRCWS	12/03/1998	0.0557	1.07			0.227	
LSP	12/15/1998	1.08	2.83	2.270	1.190	0.466	11.13
LOR	12/15/1998	0.565	4.46	1.520	0.955	1.23	4.88
LTH	12/15/1998	0.159	1.7	0.546	0.387	0.663	3.43
SRCWS	12/15/1998	0.025	1.14	0.337	0.312	0.1	15.02
LSP	12/30/1998	0.0593	0.964			0.196	
LOR	12/30/1998	0.36	2.93			0.815	
LTH	12/30/1998	0.12	0.47			0.167	
SRCWS	12/30/1998	0.025	0.47			0.025	
LSP	01/14/1999	0.025	0.145	0.782	0.757	0.111	8.58
LOR	01/14/1999	0.215	3.06	0.972	0.757	1.06	3.83
LTH	01/14/1999	0.192	1.53	0.815	0.623	0.859	2.76
SRCWS	01/14/1999	0.025	0.104	0.214	0.189	0.025	13.72
LSP	01/27/1999	0.23	1.15			0.383	
LOR	01/27/1999	0.173	4.69			1.46	
LTH	01/27/1999	0.213	1.74			0.8	
SRCWS	01/27/1999	0.025	0.933			0.084	

STATION	DATE	AMMONIA NITROGEN	NITRATE	TKN	ORGANIC NITROGEN	TOTAL PHOS	NPRATIO
LSP	02/12/1999	0.191	2.07	0.480	0.289	0.243	10.60
LOR	02/12/1999	0.34	2.63	0.917	0.577	0.792	4.60
LTH	02/12/1999	0.138	0.859	0.655	0.517	0.457	3.48
SRCWS	02/12/1999	0.025	0.983	0.010		0.071	14.34
LSP	02/25/1999	0.125	0.611			0.518	
LOR	02/25/1999	0.29	1.5			0.858	
LTH	02/25/1999	0.128	0.509			0.391	
SRCWS	02/25/1999	0.025	0.427			0.223	
LSP	03/11/1999	0.025	1.25	0.580	0.555	0.297	6.25
LOR	03/11/1999	0.216	2.04	1.290	1.074	0.674	5.03
LTH	03/11/1999	0.102	1.18	0.950	0.848	0.351	6.07
SRCWS	03/11/1999	0.025	0.601	0.100	0.075	0.066	11.00
LSP	03/23/1999	0.0691	0.927			0.231	
LOR	03/23/1999	0.0881	2.3			0.617	
LTH	03/23/1999	0.0518	0.495			0.174	
SRCWS	03/23/1999	0.025	0.415			0.112	
LSP	04/05/1999	0.181	1.04	0.506	0.325	0.123	12.77
LOR	04/05/1999	0.025	1.63	0.683	0.658	0.431	5.42
LTH	04/05/1999	0.104	0.575	0.625	0.521	0.28	4.38
SRCWS	04/05/1999	0.025	0.524	0.283	0.258	0.105	7.92
LSP	04/22/1999	0.159	0.552			0.12	
LOR	04/22/1999	0.235	1.97			0.897	
LTH	04/22/1999	0.0519	0.347			0.272	
SRCWS	04/22/1999	0.025	0.025			0.025	
LSP	05/05/1999	0.161	0.414	0.470	0.309	2.98	0.31
LOR	05/05/1999	0.025	0.576	0.510	0.485	0.566	1.96
LTH	05/05/1999	0.025	0.098	0.430	0.405	0.253	2.19
SRCWS	05/05/1999	0.025	0.223	0.810	0.785	0.025	42.32
LSP	05/20/1999	0.141	0.159			0.205	
LOR	05/20/1999	0.0527	0.063			0.694	
LTH	05/20/1999	0.107	0.153			0.237	
SRCWS	05/20/1999	0.0741	0.188			0.025	
LSP	06/03/1999		0.088	0.930		0.143	
LOR	06/03/1999	0.14	0.057	0.820		0.599	
LGR	06/03/1999		0.056	0.490		0.025	
LTH	06/03/1999		0.141	0.390		0.23	
SRCWS	06/03/1999						
LSP	06/17/1999	0.025	0.025			0.508	
LOR	06/17/1999	0.025	0.025			0.926	
LGR	06/17/1999	0.025	0.025			0.298	
LTH	06/17/1999	0.0616	0.076			0.327	
SRCWS	06/17/1999						
LSP	06/29/1999	0.025	0.025	0.662	0.637	0.626	1.14
LOR	06/29/1999	0.025	0.093	0.541	0.516	0.274	2.41
LGR	06/29/1999	0.0892	0.153	0.410	0.321	0.27	2.18
LTH	06/29/1999	0.0956	0.141	0.567	0.471	0.371	1.98
SRCWS	06/29/1999						
LSP	07/14/1999	0.025	0.0899			0.71	
LOR	07/14/1999	0.025	0.118			0.623	
LGR	07/14/1999	0.025	0.0863			0.144	
LTH	07/14/1999	0.0672	0.183			0.263	
SRCWS	07/14/1999						
LSP	07/27/1999	0.025	0.132	0.570	0.545	0.553	1.31
LOR	07/27/1999	0.025	0.166	1.270	1.245	0.64	2.28
LGR	07/27/1999	0.111	0.05	0.250	0.139	0.209	1.56
LTH	07/27/1999	0.025	0.221	0.250	0.225	0.278	1.78
SRCWS	07/27/1999						
LSP	08/12/1999		0.025			0.514	
LOR	08/12/1999		0.025			0.429	
LGR	08/12/1999		0.098			0.2	
LTH	08/12/1999		0.147			0.248	

STATION	DATE	AMMONIA NITROGEN	NITRATE	TKN	ORGANIC NITROGEN	TOTAL PHOS	NPRATIO
SRCWS	08/12/1999						
LSP	08/24/1999	0.025	0.025	0.548	0.523	0.629	0.95
LOR	08/24/1999	0.025	0.025	0.646	0.621	0.495	1.41
LGR	08/24/1999	0.025	0.025	0.250	0.225	0.201	1.49
LTH	08/24/1999	0.025	0.025	0.025	0.000	0.265	0.28
SRCWS	08/24/1999						
LSP	09/09/1999	0.025	0.025			0.461	
LOR	09/09/1999	0.025	0.025			0.476	
LGR	09/09/1999	0.025	0.025			0.186	
LTH	09/09/1999	0.025	0.025			0.223	
SRCWS	09/09/1999						
LSP	09/21/1999						
LOR	09/21/1999						
LGR	09/21/1999						
LTH	09/21/1999						
SRCWS	09/21/1999						

In 65% of the samples downstream at Todd
upstream at the 36" discharge pipe.
In 5% the reverse occurred.

Day	Sampling site or pond	NH3	NO3	TON	PO4	Discharge	Upstream 36"Discharg	Downstream Todd Rd.	
Nov-98-13	Upstream Incline Pump	0.3	2.2	0.5	1	1.4	1.1	1.7	0.6
18		0.5	1.3	0.9	1.2	4.2	1.8	2.2	0.4
24		-0.1	1.2	1.1	0.7	34.3	0.7	1.6	0.9
13	Upstream D-pond 36" discharge	0.2	1.9	0.4	1.1		1.1	1.9	0.8
18		0.5	1.8	2	1.8		0.8	1.6	0.8
24		-0.1	0.9	1.4	0.7		0.9	1.2	0.3
13	Laguna at Todd Rd.	0.4	2.3	1.2	1.7		1.1	1.2	0.1
18		0.8	2.6	1.3	2.2		1.7	1.6	-0.1
24		0.2	2.3	1.8	1.6		1.9	1.9	0
Dec-98-1	Upstream D-pond Incline pump	0.8	3.2	2.2	1.1	38.7	1.2	1.2	0
9		0.2	4	1.8	0.8	24	0.7	0.7	0
16		0.7	2.4	0.5	1	4.9	0.7	1.4	0.7
22		0.4	5.4	1.1	1.3	3	0.7	0.9	0.2
29		0.4	5.7	0.4	0.8	1.9	0.6	0.6	0
1	Upstream D-Pond 36" Discharge	0.9	3.1	1.3	1.1		0.6	0.7	0.1
9		0.3	2.3	1.4	0.8		0.6	0.6	0
16		0.5	3.8	1.2	0.9		0.4	0.5	0.1
22		0.4	4.5	0.1	1.1		0.3	0.5	0.2
29		0.3	5.2	0.9	1.7		0.5	0.7	0.2
1	Laguna at Todd Rd.	0.9	4	1.5	1.9		0.6	0.6	0
9		-0.1	5	1.6	1.6			Avg. Diff.	0.265
16		0.5	4.8	1	1.2				
22		1	4.2	0.6	1.2				
29		1.4	5	1.5	1.6				
Jan-99-06	Upstream D-Pond Incline Pump	0.3	0.4	2	1.2				
13		0.6	6.3	0.9	1.9	5			
20		1.1	2	0.3	1.1	48.2			
27		0.8	2.5	1	0.9	27			
13	Upstream D-Pond 36" Discharge	0.5	4.9	1.1	1.9				
20		0.9	1.8	2.4	1.2				
27		0.4	2.5	1.4	0.7				
13	Laguna at Todd Rd.	0.5	6	1.1	1.9				
20		1.1	3	3.4	1.2				
27		0.7	5	1	0.7				
Feb-99-03	D-Pond Upstream Incline Pump	0.6	2.6	1.6	0.7	17.2			
10		0.6	1.3	1.7	0.6	49.7			
3	D-Pond Upstream 36" Discharge	0.3	2.4	2.1	0.7				
10		0.4	1.2	2.4	0.7				
3	Laguna at Todd Rd.	1.4	4.4	0.9	1.4				
10		0.9	2.2	0.9	0.9				
Mar-99-03	Laguna Upstream Incline Pump	0.3	1.4	3	0.5	20.5			
10		0.5	1	0.8	0.6	24			
17		0.5	1.5	1.3	0.5	3			
24		-0.1	1.3	1	0.4				
3	Laguna Upstream 36" Discharge	0.3	1.4	3.3	0.6				
10		-0.1	1	2.4	0.6				
17		0.9	1.5	1.2	0.6				
24		0.4	1.3	0.4	0.4				
3	Laguna at Todd Road	0.5	2.1	3.2	0.6				
10		1	1.8	1.6	0.7				
17		0.9	1.9	2.6	0.6				
24		0.6	1.6	1.3	0.5				
Apr-99-07	Laguna Upstream Incline Pump	1.1	1.5	1.1	0.4	6.6			
14		0.3	1.3	1.1	0.5	34.3			
21		0.5	1.7	1.1	0.5	7			
7	Laguna Upstream 36" Discharge	0.8	1.3	1	0.3				
14		-0.1	1.3	1.1	0.5				
21		2	1.4	0.4	0.6				
7	Laguna at Todd Road	0.7	2.5	1.3	0.5				
14		1	4	1	0.7				
21		0.4	3	1.7	0.6				

In 97% of the samples downstream exceeded Upstrea

Comparison of downstream and upstream samples on same day

Day	Sampling site or pond	NH3	NO3	TON	PO4	Discharge	Upstream	Downstream	Diff.
Oct-98-16	Upstream Kelly Pond/Duer Crk.	0.3	1.2	1.3	1	17	1	2	1
21		-0.1	-0.4	-0.1	0.8	19.01	0.8	2	1.2
28		-0.1	-0.4	-0.1	0.8		0.8	3	2.2
16	Downstream Kelly Pond/Duer	-0.1	1.6	0.7	2		1.2	2.6	1.4
21		-0.1	4.7	1.2	2		0.8	2.8	2
28		0.2	5	0.5	3		0.5	3	2.5
Nov-98-04	Upstream Duer Ck. at Kelly	0.6	0.4	0.9	1.2	1.1	3.1	2.2	-0.9
12		0.2	0.5	0.8	0.8	0.9	0.9	1.7	0.8
18		0.4	0.5	0.8	0.5	0.8	0.5	1.5	1
24		-0.1	-0.4	1.8	3.1	0.9	0.3	1.7	1.4
4	Downstream Duer cr. & Kelly	0.5	4.4	0.9	2.6		0.2	1.6	1.4
12		0.3	5.9	1.1	2.8		0.9	1.5	0.6
18		0.3	5.9	1.4	3		0.4	2.2	1.8
24		-0.1	2.7	3.2	2.2		0.7	0.8	0.1
Dec-98-09	Upstream Duer at Kelly	0.5	1.1	1.1	0.9	1.2	0.4	2.1	1.7
16		-0.1	0.8	1.3	0.5	0.9	0.4	2	1.6
22		0.5	0.9	0.2	0.3	NA	0.4	0.9	0.5
29		0.2	1.4	0.4	0.2	0.9	0.5	1.2	0.7
1	Downstream Duer/Kelly	0.6	1.9	0.8	1.3	1	0.4	0.8	0.4
9		0.2	3.4	2.3	1.7		0.4	0.7	0.3
16		0.5	4	0.6	1.5		0.3	0.7	0.4
22		0.3	5.5	0.8	1.7		0.4	0.7	0.3
29		0.3	3.9	1	1.6		0.3	0.8	0.5
Jan-99-06	Upstream Duer Creek/Kelly	0.3	7.1	1.7	0.9	1.1	0.4	0.8	0.4
13		0.2	0.7	1	0.4	0.9	0.3	1	0.7
20		0.4	1	2	0.7	0.7	-0.1	1.6	1.7
27		0.3	0.9	0.4	0.4	0.8	0.5	1.6	1.1
6	Downstream Duer Creek/Kelly	0.6	10.1	0.1	1.5		0.6	1.8	1.2
13		0.4	6.3	0.8	2.2		0.8	2.1	1.3
20		0.3	1.1	2.2	0.8			Avg.diff.	1.010345
27		0.2	4.6	0.3	2.1				
Feb-99-03	Upstream Duer/Kelly	0.1	1	2.1	0.4	1			
10		-0.1	0.7	-0.1	0.4	0.9			
17		0.2	0.5	1.7	0.5	0.9			
3	Downstream Duer/Kelly	0.2	4.6	0.9	2				
10		0.4	1.7	0.2	0.9				
17		0.7	3.3	1.5	1.2				
Mar-99-03	Upstream Duer/Kelly	-0.1	0.4	3.1	0.4	0.5			
10		-0.1	0.4	1	0.4	0.6			
17		-0.1	0.5	1.1	0.3	0.5			
24		0.4	0.5	0.5	0.4	0.5			
3	Downstream Duer/Kelly	-0.1	1.6	3.3	0.8				
10		0.3	1.6	1.3	0.7				
17		0.2	3	1.1	0.7				
24		-0.1	2.2	4.3	0.7				
Apr-99-07	Upstream Duer/Kelly	0.6	-0.4	0.2	0.3	0.7			
14		-0.1	0.5	0.7	0.4	0.6			
21		-0.1	0.4	2.1	0.3	0.5			
7	Downstream Duer/Kelly	0.6	2.1	0.7	0.8				
14		-0.1	1.9	0.9	0.8				
21		0.2	1.5	2.6	1				
May-99-05	Upstream Duer/Kelly	-0.1	-0.4	-0.1	-0.1	0.3			
11		-0.1	-0.4	-0.1	0.5	0.1			
5	Downstream Duer/Kelly	0.2	1.2	0.9	1.6				
11		0.1	0.9	0.4	1.6				
Nov-99-10	Upstream Duer/Kelly	-0.1	-0.4	-0.1	0.6				
17		0.5	-0.4	1.5	0.8				
10	Downstream Duer/Kelly	-0.1	1.5	-0.1	1.8				
17		-0.1	1.4	2	2.1				

				In 100% of the samples downstream exceeded upstream.						
								Comparison of daily samples		
Day	Sampling site or pond			NH3	NO3	TON	PO4	Upstream	Downstream	
Oct-98-28	Upstream Santa Rosa Crk.			-0.1	0.4	-0.1	0.1	0.1	0.6	0.5
28	Downstream S.R. Creek			-0.1	2.2	-0.1	0.6	-0.1	1.4	1.5
Nov-98-04	Upstream S.R. Crk at Delta			0.4	-0.4	0.2	-0.1	0.1	1.6	1.5
12				0.2	0.5	0.4	0.1	-0.1	1.6	1.7
18				0.3	-0.4	0.4	-0.1	0.2	1.2	1
24				-0.1	1.7	1	0.2	0.1	0.2	0.1
4	Downstream S.R. Crk at Delta			0.4	4.8	0.4	1.4	0.1	0.2	0.1
12				0.4	8.1	1.4	1.6	-0.1	0.2	0.3
18				0.6	4.4	1.8	1.6		Avg. Diff.	0.8375
24				-0.1	3.7	2	1.2			
Mar-99-03	Upstream S.R. Ck /Delta			-0.1	0.9	2.2	0.1			
10				-0.1	0.7	0.8	0.1			
17				-0.1	0.5	0.2	-0.1			
3	Downstream SR Ck./Delta			-0.1	0.7	3	0.2			
10				-0.1	0.9	0.7	0.2			
17				-0.1	0.7	0.7	0.2			

In 100% of the samples Downstream exceeded Upstream

Day	Sampling site or pond	NH3	NO3	TON	PO4	Comparison Upstream	Downstream	
Feb-99-12	Upstream Roseland Ck. at Llano	0.3	3.1	1.1	0.2	0.2	1.6	1.4
17		0.1	1	2.1	0.6	0.6	0.9	0.3
12	Downstream Roseland/Summer	2.1	4.5	1.3	1.6	0.3	0.6	0.3
17		1.8	2.4	1.1	0.9	0.3	0.5	0.2
Mar-99-03	Upstream Roseland Ck. Llano	-0.1	1.3	4.1	0.3	0.1	0.7	0.6
10		0.3	1.7	1.2	0.3	0.2	0.9	0.7
17		-0.1	1.8	2.4	0.1	0.3	1	0.7
24		0.8	1.3	-0.1	0.2		Avg. Diff.	0.6
3	Downstrm.Roseland Crk.Llano	1.2	4	4	0.6			
10		2.7	3.3	2.3	0.5			
17		0.3	5.1	2.3	0.7			
24		0.2	5.9	1.7	0.9			
Dec-99-01	Upstream Roseland Creek	-0.1	0.7	0.9	0.3			
1	Downstream Roseland Creek	0.5	2.2	1.2	1			

In 30% of the samples Mirabel was higher in PO4 than Wohler. In no instances did t

Comparison of Wohler and Mirabel on days when both sampled.

Day	Sampling site or pond	NH3	NO3	TON	PO4	Wohler	Mirabel	Mirabel excess
Oct-98-07	RR at Wohler Bridge	0.2	-0.4	-0.1	-0.1	-0.1	-0.1	0
7	RR at Mirabel	0.3	-0.4	0.3	-0.1	-0.1	-0.1	0
14		-0.1	-0.4	-0.1	-0.1	-0.1	-0.1	0
14		-0.1	-0.4	0.3	-0.1	-0.1	-0.1	0
21		-0.1	-0.4	-0.1	-0.1	-0.1	-0.1	0
21		-0.1	-0.4	-0.1	-0.1	-0.1	0.2	0.3
28		-0.1	-0.4	-0.1	-0.1	-0.1	-0.1	0
28		-0.1	0.3	-0.1	-0.1	0.5	0.5	0
Nov-98-04	Russian River at Wohler Brdg.	0.3	-0.4	0.5	-0.1	0.4	0.4	0
4	Russian River at Mirabel	-0.1	-0.4	-0.1	-0.1	-0.1	0.3	0.4
12		-0.1	-0.5	-0.1	-0.1	-0.1	0.1	0.2
12		-0.1	-0.5	-0.1	0.2	-0.1	-0.1	0
18		0.2	-0.4	0.4	-0.1	-0.1	-0.1	0
18		-0.1	-0.4	0.5	-0.1	-0.1	-0.1	0
24		-0.1	0.6	1.2	0.5	0.5	0.6	0.1
24		-0.1	0.8	0.8	0.5	-0.1	0.3	0.4
Dec-98-09	Russian River at Wohler Brdg.	0.3	0.4	0.4	0.4	-0.1	0.3	0.4
16		0.2	0.5	0.8	-0.1	0.3	0.4	0.1
22		0.5	0.5	0.1	-0.1	0.1	0.2	0.1
29		0.3	0.5	0.5	-0.1	0.2	0.2	0
9	Russian River at Mirabel	0.5	0.7	0.6	0.4	-0.1	-0.1	0
16		0.3	0.9	0.7	0.3	-0.1	-0.1	0
22		0.4	0.7	0.2	0.1	-0.1	-0.1	0
29		0.3	0.6	0.1	-0.1	-0.1	0.2	0.3
Jan-99-06	Russian River at Wohler	0.1	-0.4	0.1	-0.1	-0.1	-0.1	0
13		0.2	-0.4	0.1	-0.1	-0.1	-0.1	0
20		-0.1	0.4	-0.1	0.5	-0.1	-0.1	0
27		0.2	0.4	0.2	-0.1	-0.1	-0.1	0
6	Russian River at Mirabel	0.1	-0.4	0.3	-0.1	-0.1	-0.1	0
13		0.1	-0.4	0.3	-0.1	0.2	0.2	0
20		0.3	0.6	1	0.6		Avg. diff.	0.07666667
27		0.3	0.9	0.1	0.3			
Feb-99-03	Russian River at Wohler	-0.1	0.5	-0.1	-0.1			
10		-0.1	-0.4	0.3	0.3			
3	Russian River at Mirabel	-0.1	0.9	0.7	0.3			
10		0.3	0.6	0.7	0.4			
Mar-99-03	Russian River at Wohler	-0.1	0.4	2.5	0.1			
10		-0.1	0.4	1.2	0.2			
17		0.2	0.4	0.4	-0.1			
24		0.2	0.4	1.6	-0.1			
3	Russian River at Mirabel	-0.1	0.6	2.1	0.2			
10		-0.1	0.7	0.7	0.2			
17		-0.1	0.5	0.6	-0.1			
24		-0.1	0.4	0.1	-0.1			
Apr-99-07	Russian River at Wohler	0.1	0.4	-0.1	-0.1			
14		0.1	-0.4	-0.1	-0.1			
21		-0.1	0.5	1.2	-0.1			
7	Russian River at Mirabel	0.3	0.5	-0.1	-0.1			
14		0.1	0.4	0.5	0.2			
21		-0.1	0.5	2.5	-0.1			
May-99-05	Russian River at Wohler	0.2	-0.4	-0.1	-0.1			
11		-0.1	-0.4	-0.1	-0.1			
5	Russian River at Mirabel	-0.1	-0.4	-0.1	-0.1			
11		-0.1	-0.4	-0.1	-0.1			
Nov-99-03	Russian River at Wohler	-0.1	-0.4		-0.1			
10		-0.1	0.4	-0.1	-0.1			
17		-0.1	-0.4	-0.1	-0.1			
3	Russian River at Mirabel	-0.1	-0.4					
10		-0.1	0.5	-0.1	-0.1			
17		-0.1	-0.4	-0.1	-0.1			
Dec-99-01	Russian River at Wohler	0.1	0.5	0.3	0.2			
1	Russian River at Mirabel	-0.1	0.5	0.3	0.2			

Laguna S	diment Phosphate Concentration		(mg/kg)				
Stations - Occidental Pond (LOR) and Sebastopol Pond (SEB)							
		Ortho-	Total				Avg.
	Date	Phosphate	Phosphate	Nitrate	Ammonia	Sulfide	T Phos.
LOR 1	Oct 1/97	ND	1331.00	0.50	654.90	N/S	
LOR 2	Oct 1/97	ND	1215.00	0.50	647.89	N/S	
LOR 3	Oct 1/97	ND	1369.00	0.50	641.38	N/S	1305.00
SEB 1	Oct 1/97	ND	1326.00	0.50	1186.00	N/S	
SEB 2	Oct 1/97	ND	1198.00	0.50	1083.00	N/S	
SEB 3	Oct 1/97	ND	1068.00	0.50	1063.00	N/S	1197.00
LOR 1	Jun 1/98	61.00	1662.00	0.50	5.00	N/S	
LOR 2	Jun 1/98	12.83	891.00	4.53	81.78	N/S	
LOR 3	Jun 1/98	15.69	1095.00	3.91	5.00	N/S	1216.00
SEB 1	Jun 1/98	10.30	1448.00	0.50	5.00	N/S	
SEB 2	Jun 1/98	18.40	1268.00	0.50	5.00	N/S	
SEB 3	Jun 1/98	24.30	830.00	2.70	5.00	N/S	1182.00
LOR 1	Sep 1/98	1.90	2122.00	0.50	69.30	594.00	
LOR 2	Sep 1/98	1.79	611.00	0.50	5.00	1192.00	
LOR 3	Sep 1/98	2.00	2407.00	0.50	100.29	923.00	1710.00
SEB 1	Sep 1/98	ND	731.00	0.50	349.00	2088.00	
SEB 2	Sep 1/98	0.50	938.00	0.50	933.00	3057.00	
SEB 3	Sep 1/98	ND	703.00	0.50	676.00	2072.00	791.00
LOR 1	Jun 1/99	5.28	1050.00	0.50	6.12	1082.00	
LOR 2	Jun 1/99	2.72	2564.00	0.50	22.13	1245.00	
LOR 3	Jun 1/99	4.24	724.00	0.50	19.93	1685.00	1466.00
SEB 1	Jun 1/99	ND	315.00	11.40	90.98	3137.00	
SEB 2	Jun 1/99	ND	649.00	9.70	215.64	3379.00	
SEB 3	Jun 1/99	ND	799.00	0.50	72.55	2941.00	588.00

Samples where Todd, Occidental and Laguna upstream SR Creek all are sampled.										
		Todd	Occidental	SR Creek			Todd	Occidental	SR Creek	
Date	Nov14/89	0.8	0.71	0.52	0.28	Nov14/89	0.8	0.71	0.52	0.28
	Jan 26/90	3.4	2	1.6	1.8	Jan 26/90	3.4	2	1.6	1.8
	Jan31/90	0.32	1.7	0.31	0.01	Jan31/90	0.32	1.7	0.31	0.01
	Feb2/90	1.2	1.2	1.2	0	Feb2/90	1.2	1.2	1.2	0
	Feb7/90	2	1.3	1.1	0.9	Feb7/90	2	1.3	1.1	0.9
	Feb14/90	3	1.9	1.5	1.5	Feb14/90	3	1.9	1.5	1.5
	Feb21/90	3.2	1.6	1.14	2.06	Feb21/90	3.2	1.6	1.14	2.06
	Feb28/90	3.1	3.2	0.95	2.15	Feb28/90	3.1	3.2	0.95	2.15
	Mar6/90	2.8	1.5	1.7	1.1	Mar6/90	2.8	1.5	1.7	1.1
	Mar14/90	3.1	1.8	1.7	1.4	Mar14/90	3.1	1.8	1.7	1.4
	Mar23/90	4.8	2.7	2.1	2.7	Mar23/90	4.8	2.7	2.1	2.7
	Apr10/90	3.5	2.5	1.7	1.8	Apr10/90	3.5	2.5	1.7	1.8
	Apr18/90	2.6	2.2	1.6	1	Apr18/90	2.6	2.2	1.6	1
	Apr25/90	1.6	1.9	1.3	0.3	Apr25/90	1.6	1.9	1.3	0.3
	May1/90	2.2	2.7	2.3	-0.1	Oct24/90	1.4	1.2	0.36	1.04
	May9/90	4.8	3.2	2.4	2.4	Dec4/90	0.46	0.07	0.2	0.26
	May16/90	5.1	2.2	1.8	3.3	Dec6/90	4	0.09	0.19	3.81
	May24/90	0.77	2.6	2.2	-1.43	Dec11/90	4.2	1.5	0.45	3.75
	Jun5/90	1.2	1.8	2.3	-1.1	Dec13/90	2.9	1.5	1.2	1.7
	Jun12/90	1	1.8	2.2	-1.2	Dec14/90	3.8	1.8	0.91	2.89
	Oct24/90	1.4	1.2	0.36	1.04	Dec18/90	2.5	2.6	2.2	0.3
	Dec4/90	0.46	0.07	0.2	0.26	Dec20/90	3.7	2.4	2	1.7
	Dec6/90	4	0.09	0.19	3.81	Jan3/91	3.8	3.3	3.2	0.6
	Dec11/90	4.2	1.5	0.45	3.75	Jan10/91	0.66	2.8	2.4	-1.74
	Dec13/90	2.9	1.5	1.2	1.7	Jan15/91	0.46	2.6	2.3	-1.84
	Dec14/90	3.8	1.8	0.91	2.89	Jan25/91	0.48	2.6	2.1	-1.62
	Dec18/90	2.5	2.6	2.2	0.3	Jan30/91	0.4	2.3	2	-1.6
	Dec20/90	3.7	2.4	2	1.7	Mar/10/91	1.3	1.8	1.6	-0.3
	Jan3/91	3.8	3.3	3.2	0.6	Mar17/91	0.86	1.4	1.2	-0.34
	Jan10/91	0.66	2.8	2.4	-1.74	Apr3,91	1.7	1.6	1.5	0.2
	Jan15/91	0.46	2.6	2.3	-1.84	Dec11,91	0.56	1.4	0.88	-0.32
	Jan25/91	0.48	2.6	2.1	-1.62	Mar25/92	2.3	1.1	1.6	0.7
	Jan30/91	0.4	2.3	2	-1.6	Mar17,93	0.83	1.2	0.21	0.62
	Mar/10/91	1.3	1.8	1.6	-0.3	Apr14/93	1.7	1	0.85	0.85
	Mar17/91	0.86	1.4	1.2	-0.34	Oct19/93	0.8	1.4	0.9	-0.1
	Apr3,91	1.7	1.6	1.5	0.2	Dec14/93	0.8	0.8	0.19	0.61
	Jun3,91	1.9	1.2	1.1	0.8	Mar22/94	0.5	1.09	0.7	-0.2
	Jun27,91	1.3	1.6	1.1	0.2	Apr23/94	0.44	1.54	0.12	0.32
	Aug20/91	1.6	1.2	1.7	-0.1		Avg.	Avg.	Avg.	Avg.
	Dec11,91	0.56	1.4	0.88	-0.32		1.999211	1.718421	1.254737	0.744474
	Mar25/92	2.3	1.1	1.6	0.7					Sum
	Mar17,93	0.83	1.2	0.21	0.62					28.29
	Apr14/93	1.7	1	0.85	0.85					
	May12/93	0.91	1.2	1.1	-0.19					
	Jun16/93	0.63	1.4	1.5	-0.87					
	Aug18/93	0.66	1	0.44	0.22					
	Oct19/93	0.8	1.4	0.9	-0.1					
	Dec14/93	0.8	0.8	0.19	0.61					
	Mar22/94	0.5	1.09	0.7	-0.2					
	Apr23/94	0.44	1.54	0.12	0.32					
	May24/94	0.32	1.8	1.96	-1.64					
	Dec27/95	1.4	1.3	0.2	1.2					
		Avg.	Avg.	Avg.	Avg.					
		1.9112	1.7518	1.3572	0.572692					
					Sum					
					29.78					

Phytoplankton and Chlorophyll Data (RWQCB Data)

Station	Date	Phyto Density mil cells/L	%DIA	%GRN	%BG	%DINO	Ortho PO4	Total PO4	NO3	NH3	TKN	Turbidity
Laguna at	10/17/89	0.3500	89	1	1	9	0.36	0.43	0.07	0.025	0.93	
Stony Pt.	11/14/89	0.1070	82	2	0	16	0.18	0.23	0.03	0.07	0.8	
	05/24/90	0.2500	45	0	55	0	0.86	0.9	0.14	0.025	0.24	17
	06/05/90	0.3400	96	3	0	0	0.56	0.57	0.05	0.03	1.1	7
	06/12/90	0.0022	100	0	0	0	0.73	0.83	0.05	0.03	1	10
	06/19/90	0.0730	94	6	0	0	1.1	1.7	0.03	0.03	1.2	8.3
Laguna at	11/14/89	0.3130	26	70	0	4	0.8	0.91	0.55	0.83	2.3	
Todd Rd.	05/24/90	0.4000	100	0	0	0	0.77	0.8	0.16	0.17	0.38	22
	06/05/90	0.7800	63	35	0	0	1.2	1.1	0.2	2	4.8	10
	06/12/90	0.1500	94	6	0	0	1	1.1	0.08	0.025	2.7	10
	06/19/90	0.8000	97	3	0	0	0.85	0.87	0.07	0.025	2.5	9.8
Laguna at	09/27/89	2.4000	31	0	0	68	1.1	0.53	0.57	0.1	4.3	
Occidental	11/14/89	1.5500	1	4	0	95	0.71	1.1	0.43	0.025	3.2	
Rd.	05/24/90	0.8900	52	48	0	0	2.6	2.7	0.34	0.68	0.9	27
	06/05/90	0.1000	25	46	29	0	1.8	1.6	0.11	0.03	3	16
	06/12/90	0.4500	14	16	70	0	1.8	1.9	0.08	0.03	1.4	44
	06/19/90	1.4000	7	54	39	0	2.3	2.6	0.09	0.03	2.5	28
Laguna	08/30/89	0.0087	100	0	0	0	0.31	0.02	0.8	0.5	0.9	
Upstream	10/18/89	0.2600	77	1	1	21	0.81	1	0.74	0.49	1.2	
Santa Ros	11/14/89	0.9450	2	3	1	95	0.52	0.73	0.4	0.025	1.6	
Creek	05/24/90	0.9700	64	36	0	0	2.2	2.3	0.35	0.7	0.8	13
	06/05/90	0.4600	22	69	9	0	2.3	2.2	0.18	0.03	3.1	10
	06/12/90	0.8600	47	22	31	0	2.2	2.5	0.29	0.03	2.8	29
	06/19/90	0.8700	35	22	43	0	1.6	1.6	0.14	0.16	2.3	28
Laguna at	06/05/90	0.4400	40	42	18	0	1.2	1.2	0.1	0.03	1.8	8
River Rd.	06/12/90	0.1300	70	13	17	0	0.48	0.53	0.13	0.03	1	37
	06/19/90	0.4000	60	19	21	0	0.36	0.44	0.05	0.03	0.7	34
S.R.Creek	08/30/89	0.0039	99	0	1	0	0.06	0.01	0.5	0.05	0.05	
at Melita	10/17/89	0.0710	99	0	0	1	0.07	0.06	0.24	0.3	0.28	
	11/14/89	0.0024	100	0	0	0	0.05	0.04	0.03	0.05	0.05	
S.R. Creek	08/30/89	0.0310	99	1	0	0	0.09	0.06	0.04	0.05	0.1	
at	09/27/89	0.1000	94	1	1	4	0.1	0.09	0.05	0.025	0.58	
Willowside	10/18/89	0.0100	97	1	1	1	0.1	0.06	0.04	0.12	0.3	
Rd.	11/14/89	0.0340	95	3	1	1	0.04	0.07	0.04	0.025	0.05	
	05/24/90	0.2100	100	0	0	0	0.11	0.13	0.54	0.025	0.11	4
	06/05/90	0.1100	100	0	0	0	0.01	0.04	0.17	0.03	0.6	2
	06/12/90	0.0044	0	50	50	0	0.05	0.02	0.01	0.03	0.4	1.2
	06/19/90	0.0180	100	0	0	0	0.08	0.11	0.03	0.03	0.3	3
Mark West	08/30/89	0.0037	99	0	0	1	0.08	0.01	1.4	0.1	0.2	
at Slusser	10/17/89	0.0088	96	1	1	2	0.07	0.07	0.06	0.025	0.24	
	11/14/89	0.0043	54	16	16	30	0.1	0.1	0.005	0.025	0.1	
				0.544437	Ortho PO4 vs Phyto density							
Correlation coefficients				0.500451	Total PO4 vs. Phyto density							
				0.162426	NO3 vs Phyto density							
				0.686792	TKN vs. Phyto density							
				0.157609	NH3 vs. Phyto density							
				0.400542	Phyto density vs. Turbidity							