PRELIMINARY REPORT

AN EVALUATION OF

WASTEWATER DISPOSAL AND WATER QUALITY

IN THE SAN LORENZO RIVER WATERSHED

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Environmental Health Service

Health Services Agency

County of Santa Cruz

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1 EXECUTIVE SUMMARY

This report evaluates the conclusions of past studies in relation to the findings of the San Lorenzo Wastewater Management Program which has been conducted by the Santa Cruz County Health Services Agency since 1985. The program has included water quality monitoring, sanitary surveys, lot-by-lot investigations of septic system performance, and required upgrade of inadequate wastewater disposal systems. The report provides an analysis of water quality of surface water and groundwater in the San Lorenzo River Watershed, with a specific emphasis on water quality conditions which are affected by wastewater disposal in the Watershed. It also presents an analysis of the effectiveness of current methods of wastewater disposal, evaluates the potential for improvements, and makes recommendations for future wastewater management in the Watershed.

The report is currently being circulated as a preliminary report with opportunity for interested parties to comment on the findings and conclusions. Following a thirty day review period, comments will be considered and revisions or refinements will be made, as appropriate.

Following is a summary of the major findings of the report. The sections of the summary are generally organized to parallel the organization of key sections of the report.

1.1 Setting and History

The San Lorenzo River Watershed supports a moderately dense suburban population, much of which is concentrated in small communities along the River and its tributaries. Except for the City of Scotts Valley, all wastewater is disposed within the Watershed, almost exclusively by onsite septic systems. Septic system performance is potentially limited by small lots, age of systems, steep slopes, high winter groundwater, areas of clay soils, and areas of very permeable sandy soils. In much of the Watershed, groundwater is used for water supply, and the River provides stream-based recreation, fishing, and municipal water supply for over 80,000 people.

There has long been concern that improperly functioning septic systems may be adversely affecting water quality. Many investigations of this concern have been performed over the years. These studies have presented divergent findings on the severity of the problems, and have made widely divergent recommendations regarding the need and feasibility of sewering the area. The recent program by the County, which is the subject of this report, provides the most detailed and comprehensive investigation of the actual impacts of wastewater disposal that has been carried out for this area. This work has refined findings from past studies and sheds new light on current conditions.

1.2 Water Quality

1.2.1 Bacterial Contamination

Bacterial contamination of surface waters is widespread within developed areas in the Watershed. This is indicated by levels of fecal coliform and fecal streptococcus bacteria which are orders of magnitude above natural background levels, and which frequently exceed established standards for safe swimming. During the past 15 years of water quality monitoring there have been wide annual variations in fecal coliform levels, without any significant longterm increase or decrease. Bacteria levels are strongly affected by the seasonal factors of rainfall, temperature, and streamflow.

Much work has been performed to determine the proportion of the bacterial contamination that results from wastewater discharge versus the amount that results from other sources such as animal contamination, birds, garbage, and urban runoff. Although the types of bacteria used in water quality investigations have potential limitations for use in confirming wastewater contamination, work in the San Lorenzo River has shown that combined use of fecal coliform and the fecal coliform/fecal strep ratio does have good utility for indicating the potential source of contamination. Follow-up investigations and sanitary surveys have also been used in conjunction with water quality monitoring to identify the specific causes of many of the occurrences of high bacteria levels.

It is apparent that approximately 75% of the high bacterial levels in the San

Lorenzo Watershed result not from wastewater disposal, but are derived primarily from the background bacterial contamination which is associated with dense development and disturbance in close proximity to stream channels. The predominance of this non-sewage contamination is indicated by low fecal coliform/fecal strep ratios, and supported by the findings of sanitary surveys and water quality sampling in problem areas. This is also consistent with water quality conditions found in streams in other developed areas of the County which are served by sewers rather than septic systems.

Background contamination notwithstanding, improper wastewater disposal has at times caused episodes of high bacterial contamination, as indicated by periodically elevated fecal coliform levels with relatively high fecal coliform/fecal strep ratios. These episodes have frequently been associated with confirmed septic system failures. It is estimated that significant wastewater contamination is present in 6-12% of all the samples collected during the past three years. Many of episodes of wastewater contamination are short-lived and reflect occasional, intermittent discharges. Many of the sources of these discharges have been identified and corrected. There does not appear to be chronic, widespread, cumulative fecal contamination of streams resulting from onsite wastewater disposal systems in the Watershed.

1.2.2 Summary of Stream Water Quality

Based on an evaluation of water quality data from the specific parts of the San Lorenzo Watershed for the last three years, the water quality of various stream locations can be described as follows:

- Stream locations which showed high levels of bacterial contamination apparently unrelated to wastewater disposal were: Kings Creek, San Lorenzo River at Brookdale, San Lorenzo River at Felton, and Carbonera Creek.

- Stream locations which showed high levels of bacterial contamination usually unrelated to wastewater disposal, but occasionally influenced by wastewater were: Bear Creek, Lompico Creek, Upper Zayante Creek, Bean Creek, Bull Creek, Branciforte Creek, and the San Lorenzo River in Santa Cruz.

- Stream locations where occasional high bacteria levels were primarily caused by wastewater contamination were: San Lorenzo River below Boulder Creek, Newell Creek, San Lorenzo River below Glen Arbor, and Shingle Mill Creek.

- Stream locations which typically met body contact standards and which showed no significant indication of wastewater contamination were: San Lorenzo River at Waterman Gap, Boulder Creek at Boulder Creek, Love Creek, San Lorenzo River at Ben Lomond, Fall Creek, Gold Gulch and Lower Zayante Creek.

- Stream locations which showed high nitrate levels were: Boulder Creek, Newell Creek, San Lorenzo River below Glen Arbor, Lower Zayante Creek, Bean Creek, Shingle Mill Creek, Carbonera Creek, and Branciforte Creek.

1.2.3 Septic System Influence on Shallow Groundwater Quality

An analysis of water quality data collected in 1981-82 from shallow groundwater affected by septic systems in a variety of soil types and groundwater conditions, indicated that there was no statistically significant bacterial contamination of shallow groundwater at distances greater than 25 feet from septic systems. At greater distances, bacteria levels were quite low and no greater than the background levels found where there was no septic influence. Soils were able to provide adequate removal of bacteria, even under saturated conditions. There was, however, a significant release of nitrate from septic systems, increasing nitrate levels fourfold above background levels even at large distances from individual systems.

These findings have been supported by groundwater sampling in the downtown Boulder Creek area during the County's current monitoring program. The absence of fecal coliform bacteria in shallow groundwater underlying developed areas provides further indication that the incidents of bacterial contamination of surface water by septic systems do not result from any cumulative contamination of groundwater, but instead result from failures and discharges to the ground surface from individual systems.

1.2.4 Nitrate Impact on Groundwater Supply

Nitrate release from septic systems has contributed to elevated nitrate levels in groundwater that have approached or exceeded the safe drinking water standard and seriously threatened municipal groundwater supplies in two areas

of the San Lorenzo Watershed: Quail Hollow and a part of Scotts Valley. In both areas, this resulted from residential development of lots smaller than one half acre in areas overlying the Santa Margarita sandstone aquifer. Surface soils are excessively permeable and nitrate originating from septic systems, residential fertilizers, and other sources is transmitted to the underlying groundwater body with limited treatment.

Computer modelling of the Quail Hollow Basin indicated that the amount of nitrate in individual wells is directly related to the number of homes impacting each well. Nitrate levels also increase in response to greater pumping rates, and periods with low rainfall. Following some sudden peaks in the fall of 1986, which brought nitrate levels to more than 60% of the drinking water standard, mean nitrate concentrations in the Quail Hollow wells have stabilized around 30% of the standard, and have even dropped to lower levels following the rains of 1989. In Scotts Valley nitrate in several wells reached levels which periodically exceeded the drinking water standard beginning in 1981. Most of the overlying area was sewered in 1987 but nitrate levels have not yet significantly declined in most of the wells.

The episodes in Quail Hollow and Scotts Valley are indicative of the nitrate contamination of groundwater that can result from overlying development and onsite wastewater disposal in areas of highly permeable soil. In order to prevent a worsening of the situation in those areas or other locations, it is necessary to ensure limited density of development to provide for adequate dilution and treatment of contaminants, particularly in groundwater recharge areas. The County's policy of a one-acre minimum lot size for new development throughout the Watershed, and a 10 acre minimum for creation of new lots in

recharge areas appears to provide the necessary protection, in conjunction with good system design. There is an additional need to explore the use of septic system designs for repairs and new systems, which would provide better nitrate removal, particularly in highly permeable sandy soils.

1.2.5 Nitrate Impact on Surface Water

As a result of development in the Watershed and in-basin wastewater disposal, nitrate concentrations in the San Lorenzo River have increased two to three times over background levels. It is estimated that 50-80% of this increase is attributable to nitrate from wastewater. Most of the observed increase occurred in 1960 through 1975 and there has been no significant increase in nitrate levels in the River since the mid 1970's. Approximately two thirds of the nitrate load in the River comes from the area of the Watershed underlain by the highly permeable Santa Margarita sandstone.

The increase of nitrate in the River has probably resulted in a low to moderate increase in growth of algae in parts of the River and its tributaries. Although the algae occurs naturally and is more strongly affected by other factors such as shading, stream bottom character, and water chemistry, algae growth in the San Lorenzo Watershed may have increased by as much as 15-30% in some areas as a result of increased nitrate in the water.

Existing levels of algae growth have had no observed adverse effect on the stream ecosystem or the fishery. Low to moderate potential impacts on stream-based recreation have been noted, although much of this may be

attributable to natural levels of algae growth. Algae growth and decay is believed to be at least partly responsible for the taste and odor problems which periodically occur in the City of Santa Cruz drinking water which is taken from the River. When these problems are severe, substantial costs are incurred for treatment to reduce the odor. The problems are intermittent and further study will be needed to fully evaluate the problem.

In order to prevent impacts from algae growth, the State Regional Water Quality Control Board has established a nitrate objective for the San Lorenzo River. The purpose of the objective is to guide management actions for discharge of wastewater and other activities in the Watershed. The current objective is set at a level that is 80% below prevailing nitrate levels in most of the River, and is even below mean levels in the headwater areas. It appears to be unreasonable and the Regional Board has directed their staff to review it. The County's current work will be augmented by additional studies to be funded by the State Water Resources Control Board, which should provide the information necessary to develop an appropriate objective and a plan for attaining that objective.

Until such time as a revised nitrate objective is developed, wastewater management decisions should be guided by a need to prevent any significant increase of nitrate in surface water of the Watershed, and so prevent an increase in problematic algae growth.

1.2.6 Water Quality and Wastewater Management

The water quality investigations have provided a good indication of the extent to which wastewater disposal has impacted water quality in the Watershed, and the approaches which are needed to reduce those impacts. Although widespread cumulative bacterial contamination is not occurring, failures of isolated, individual systems have caused episodes of bacterial contamination at some locations. This points out the need for a program to identify and correct system failures on an ongoing, lot-by-lot basis.

There has been a significant cumulative release of nitrate from septic systems in the Watershed, particularly in areas underlain by sandy soils. Addressing this issue will require the maintenance of area-wide policies for development density and appropriate design of disposal systems to minimize nitrate release. The County's wastewater management program addresses both of the needs for water quality protection identified above. In addition, the program promotes regular inspection, pumping, and maintenance of all systems, and provides for the repair and/or replacement of failing systems.

Due to the widespread occurrence of water quality degradation that is unrelated to wastewater disposal, an effective wastewater management program will not result in complete improvement of quality, particularly in areas that are severely affected by background contamination. The effectiveness of the wastewater management program will best be judged by the number of systems successfully upgraded, the extent to which the rate of failures is reduced, and the localized improvements in water quality that will thus result. Ongoing water quality monitoring will be directed to specifically identify

problems and assist the management efforts.

1.3 Evaluation of Wastewater Disposal

1.3.1 Methodology for Evaluating Existing Disposal System Performance

The current program has sought to measure the adequacy of onsite wastewater disposal on a parcel-by-parcel basis. This has been done by evaluating the performance of each system, determining the potential site constraints of each parcel, and determining the most appropriate approach for long-term disposal for that parcel. This approach includes: a computerized database to record and organize information for each parcel; specific investigations of soil type and groundwater depth; parcel-by-parcel surveys to evaluate system performance; and, monitoring of system improvements to measure the effectiveness of those improvements.

The database currently contains records for over 4000 parcels, 30% of the developed parcels in the study area. It contains information on septic system size and design, physical constraints on the parcel, and records of system performance from County files. Information obtained from investigations conducted under previous (Class II) studies is also included. For most parcels, the available information for soils and groundwater depth is limited, and has been augmented by installation of over 70 soil borings throughout the study area. Findings from these boreholes have been extrapolated for nearby parcels.

A key element of the current program is the physical inspection of parcels to determine how well the septic systems are performing during the wet winter months. Over 1500 parcels have been surveyed since the beginning of 1986. Although most of the recent winters have been drier than normal, the surveys have only been conducted when conditions were typical of normal winter periods, as indicated by groundwater levels in monitoring wells in the survey areas. During the survey, systems are identified which are failing or which have a greywater bypass. Repairs are required to correct any problems found.

A substantial number of system repairs have been required as a result of the survey. These repairs and the repairs made for other reasons throughout the San Lorenzo Watershed have been monitored to determine the extent to which onsite systems can be upgraded in the study area. A set of repair criteria have been established by the County to guide system improvements, and to ensure that repairs provide an adequate level of water quality protection.

1.3.2 Existing Septic System Characteristics and Performance

The characteristics of existing septic systems that have been evaluated include: age, system size, lot size, groundwater separation, soil constraints, depth to bedrock, stream setback, and slope. Although the amount of data is somewhat limited, enough information is available to estimate the proportion of systems which may be affected by particular limitations, as follows:

- Forty percent of the existing systems are over 20 years old and 25% are under 10 years old.
- Two thirds of the existing systems do not meet the current repair criteria

for leachfield size.

- Approximately 60% of the developed parcels are less than 15,000 square feet in size (but 90% of all developed parcels appear to have adequate room and conditions for a system replacement in accordance with current repair criteria).
- It is estimated that as many as 30-50% of the parcels experience winter groundwater levels less than 10 feet from the surface, and 3-6% have groundwater less than 3 feet from the surface.
- About 14% of the systems are located within 100 feet of a stream, and 2% are less than 50 feet from a stream.

Although the existing septic systems are subject to a number of technical constraints, the large majority have performed adequately, as indicated by previously reported water quality data, survey results, and rates of system repair. During the County's parcel-by-parcel survey of 1500 parcels in the areas of Kings Creek, Boulder Creek, Brook Lomond, Ben Lomond, and North Felton, 85% of the systems have been found to be performing satisfactorily. Six percent had leachfield failures and 9% had greywater bypasses. Of these failing systems, 80% were systems with no record of previous problems, but which were now reaching the end of their useful lifetime. The other failing systems, 3% of all systems surveyed, were systems with prior problems generally resulting from site constraints.

All of the failures identified by the survey have been repaired or otherwise improved. These repairs amounted to about 15% of the total repair activity in the Watershed from January 1986 through June 1989. Currently, the annual repair rate is about 3-5%, which is double the rates that prevailed prior to

1986. Most of this increase is attributed to a significant increase in voluntary repair efforts initiated by the property owners. About 75% of the repair actions have been for systems that were installed prior to 1970, or for which the installation date is unknown, which again indicates that these systems were reaching the end of their expected useful lifetime.

1.3.3 System Improvements Made

Since the beginning of the County's current program, approximately 20% of the systems in the study area have been subject to improvement. The proportion of parcels subject to repair action was higher in the areas that had been surveyed, with almost one third of all parcels in the Kings Creek area being improved. Repair actions have included leachfield replacements (60% of the total actions), leachfield additions (6%), greywater connections (14%), installation of greywater sumps (4%), installation of wastewater reduction measures (6%), plumbing repairs (2%), and other miscellaneous actions or inspections.

These repairs resulted in substantial improvements over the previous systems, with the average newer system being much larger, and of more shallow depth (less than 5 feet), to provide for better effluent treatment. All but about 8-16% of the repair actions have resulted in a system that can adequately meet the County's repair criteria. Even where systems cannot meet the criteria, the repairs have provided significant improvements over the previous systems, and they remain subject to increased monitoring and management by both the County and the property owner, to ensure adequate performance. Recent repairs

have satisfactorily corrected 80-90% of the systems which had a history of past chronic problems in the files.

Despite the current repair efforts, it appears that 5-10% of the systems in the Watershed might be expected to have long-term chronic problems due to severe site constraints, usually a combination of high groundwater, clay soils, and small lot size. Half of these can probably be corrected through use of non-conventional technologies for onsite disposal, such as a mounded bed or pressure distribution system. The remaining 2-5% of the systems will eventually need to utilize haulaway systems or off-site solutions such as cluster systems or community disposal projects. This is currently being evaluated for downtown Boulder Creek, and will be further investigated for other areas as needed.

The continued effective performance of onsite disposal systems in the Watershed, particularly given the presence of the significant technical limitations, is dependent on adequate system monitoring and maintenance by the property owners and the County. The current County program includes elements to enhance both those efforts. The greatly increased rate of repairs initiated by property owners is indicative of improved maintenance practices.

The County's management program has resulted in some improvements and anticipated improvements in water quality. Elimination of failing septic systems under the current program has resulted in significant improvements of bacterial quality in the San Lorenzo River in the Boulder Creek area. Identification of problems through the survey process, and improvements in design through current repairs should result in reduced occurrence of future

failures. Increased usage of shallow systems for repairs should also help to reduce the nitrate contribution from septic systems.

The current wastewater management program also includes special requirements for septic systems to serve new development so that they do not contribute to existing impacts resulting from wastewater disposal. These requirements include a one acre minimum lot size, prohibition of seepage pits, and use of shallow leachfields.

1.3.4 Comparison of Findings to Previous Studies

The efforts of the County's current wastewater management program have resulted in findings substantially different from those of previous studies conducted in the early 1980's. These new conclusions have resulted from the compilation and analysis of much greater volumes of data on water quality and individual system performance. Use of this data resulted in development of an improved set of repair criteria, and a more encouraging interpretation of the significance of system repairs.

Because the mangement program has not found chronic, cumulative water quality impacts from existing septic systems, the County developed a more attainable set of repair criteria which allow continued onsite disposal, provide for significant system improvements, and ensure adequate protection of water quality. Each parcel was evaluated on its own merits with regard to its suitability for onsite disposal, and it was found that the current performance and potential for improvements on the large majority of parcels had little

relationship to the broadly defined Class I and Class II area designations.

The prior studies concluded that a majority of the septic systems in the San Lorenzo Valley could not be upgraded to provide for adequate onsite sewage disposal. The findings of the current program indicate that most systems are performing satisfactorily, that there is good potential for upgrading system performance, and that for at least 95% of the systems, onsite disposal is a viable long-term method of wastewater disposal, under the auspices of an ongoing management program.

1.4 Ongoing Wastewater Management

1.4.1 Alternatives for Wastewater Disposal

The major types of alternatives for long-term wastewater disposal that have been considered for the San Lorenzo River Watershed include individual onsite disposal, community disposal systems, and valleywide sewering with export of sewage out of the Valley. Previous overall management approaches have proposed a combination of all three different elements, applied to different properties in the Watershed. The specific programs, outcomes, costs, and impacts of alternative management schemes would be highly dependent on the criteria utilized to determine the feasibility of onsite repair, and guide the repair and maintenance of onsite systems. Properties which could not meet the repair criteria would be required to utilize other solutions, usually at increased cost.

Determination of the best management approach must take into account technical feasibility, impacts on water quality, environmental impacts, financial impacts on the residents, and long-term effectiveness. The evaluation should also consider incremental benefits of an approach in relation to incremental costs.

Based on the findings of this report, continued and improved onsite disposal is technically feasible for at least 90-95% of the parcels in the Watershed. The remaining parcels could be served by cluster systems, community disposal systems, or individual haulaway systems. In conjunction with an ongoing management program, this approach would result in protection and improvement in water quality, and would not result in substantial increased costs for sewage disposal for most property owners.

Valleywide sewering is another alternative that has been considered in comparison to the onsite wastewater management alternative. This is technically feasible, but would result in substantial costs for all property owners in the developed areas. Sewering would provide for a significant reduction in nitrate levels in surface water and groundwater, but the improvements in bacterial quality would probably not be significant, particularly in the long term, due to the presence of background bacterial contamination, the potential for sewer leaks, pump failures, and line breakages. The additional increment of water quality improvement to be provided by sewering does not appear to be necessary, and could probably not justify the substantial additional cost required.

1.4.2 Ongoing Wastewater Management Program

Based on the findings of this report, it is recommended that the County pursue and expand its program for wastewater management which includes: periodic inspections, compliance with adequate repair standards for system upgrades, property owner education, property owner assistance, and promotion of community solutions as needed in some areas. This program, together with a one acre minimum lot size and strong design standards for new systems, forms a complete package of actions to protect and improve water quality in the San Lorenzo Watershed.

It is proposed that the County's program be refined and enhanced to provide for more investigation of specific instances of water quality degradation and to increase the inspection efforts to provide for a physical inspection of each parcel once every five years. The County Board of Supervisors has already initiated an effort to strengthen and augment the wastewater management program through establishment of a county service area, which could provide additional resources for inspections of properties on a more intensive basis, facilitate more financial assistance for system repairs, promote adequate frequencies of septic tank pumping, and generally enhance ongoing management efforts.

1.4.3 Basin Plan Amendment

Based on the County's review of the past fifteen years of studies, and the County's own original research which has significantly refined the findings of the previous studies, it now appears that the prohibitions on onsite

wastewater discharge in specific areas of the San Lorenzo Valley which are presently contained in the Basin Plan do not currently represent an appropriate or effective approach to wastewater management in the Watershed. The prohibitions focus on the specific Class I and Class II areas, and do not provide much guidance for wastewater management in other areas which are also adversely affecting water quality. The prohibitions on discharges in Class I areas appear to unnecessarily restrictive, and deny property owners reasonable use of their property, even though no significant impact can be shown to result from wastewater disposal on the majority of Class I properties.

Following from the findings of this Evaluation Report and the ongoing management efforts, it is recommended that the Basin Plan provisions regarding wastewater discharges in the San Lorenzo Watershed be amended to:

- Specify a management area to include the entire San Lorenzo River Watershed.
- Remove the designations of Class I and Class II parcels.
- Require a comprehensive wastewater management program for the Watershed which includes periodic inspection of all developed properties, required upgrade of system in conformance with established repair criteria, promotion of adequate system maintenance, and promotion of offsite disposal systems as needed.
- Require more stringent requirements for septic systems to serve new development, including a one acre minimum lot size, shallow system depth, and limitation of excessive soil percolation rates.

2 INTRODUCTION

There has been a long history of concern about potential degradation of water quality resulting from discharge of domestic wastewater in the San Lorenzo River Watershed. Over the years there have been numerous studies and proposals to address the perceived problems. Most recently, in mid 1985, the Santa Cruz County Health Services Agency embarked on a program to investigate the situation in some detail, and to simultaneously bring about needed improvements in wastewater disposal practices in the Watershed.

This report has been prepared to discuss the findings of these current efforts in relation to the past findings, and to establish the technical basis for effective, long-term, cooperative approaches to dealing with the problems at hand. The first section of the report presents an overview of the setting and the past investigations of water quality and wastewater management that have been conducted in the San Lorenzo Watershed. The second section evaluates the water quality impacts of wastewater disposal. The third section evaluates the observed performance of existing systems and analyzes the effectiveness of current efforts to improve methods of wastewater disposal. Based on the findings of this report, the final sections make recommendations for ongoing wastewater management in the San Lorenzo Watershed.

3 BACKGROUND

3.1 Setting

The study area for this report encompasses the entire San Lorenzo River Watershed, including all the streams which drain into the River before it flows into the Pacific Ocean. Many of the past studies have focused exclusively on the San Lorenzo Valley, which can be defined as the developed corridor that fills the valley floor of the River and its major tributaries located north of Henry Cowell State Park. However, there are significant influences on water quality which originate from outside of the San Lorenzo Valley proper. Although of necessity the San Lorenzo Valley will receive greater attention, the entire Watershed will be addressed in this report. For a map of the area see Figure 1 in Section 3.2.)

The San Lorenzo River drains a 138 square mile Watershed, which extends from the crest of the Santa Cruz Mountains to Monterey Bay in the City of Santa Cruz. The Watershed area is mountainous and forest-covered, and still provides a sense of rural living, despite the high levels of development that have taken place. The River is a designated State Protected Waterway, and has long been a valuable resource for water supply, fishing, swimming, and streamside recreation.

The aesthetics of the area made the San Lorenzo Valley a popular destination for summer and weekend vacations in the early part of this century. At that time the Valley experienced extensive development of small parcels for summer

homes in communities along the River and its major tributaries. Communities of the Valley include Felton, Ben Lomond, Brookdale, Boulder Creek, Zayante, Lompico, Wildwood, Riverside Grove, and San Lorenzo Park.

By the mid 1970's, most of the summer homes had been converted to year-round use. While the houses were remodeled and expanded, frequently improvements to the old, substandard sewage disposal systems lagged far behind the conversion to full time use. Although many improvements to individual disposal systems have subsequently been made over the years, septic systems in the Valley are frequently operating under constraints of old age, small lot size, high groundwater, clay soils, excessively sandy soils, and/or steep slopes. The large majority of development in the Valley continues to utilize onsite systems for wastewater disposal. For at least the past 15 years, new septic systems which have been installed have had to meet strict siting and operating standards, as established by the County.

3.2 Historical Investigations

The high density of potentially marginal wastewater disposal systems in close proximity to the River and its tributaries has led to concerns that water quality is degraded to the detriment of public health and beneficial uses of the River. A number of investigations of this issue have been carried out, and proposals have been made to improve the situation. These efforts began at least as early as the 1940's, and have resulted in about twenty individual studies or reports. The conclusions of the studies have followed a somewhat cyclical pattern of contradicting each other regarding the severity of water

quality degradation and the need for sewering of the Valley.

These efforts to investigate and solve the potential wastewater disposal problems are summarized in chronological order in the following descriptions. These descriptions present the major conclusions of each study, and actions that were taken to improve wastewater disposal. This provides a historical perspective of the wastewater issue in the San Lorenzo Valley. Specific findings and conclusions from the relevant recent studies will also be discussed in more detail in the sections on water quality, and wastewater disposal methods.

Charles Hyde and George Sullivan, Santa Cruz County Sewage Disposal Survey, 1946-1947. This report was prepared for the County Planning Commission to identify facilities needed for sewage collection, treatment, and disposal for all unincorporated areas of the county, including the entire San Lorenzo Valley. Proposed projects were identified and cost estimates provided. Although there was no discussion of existing conditions, the report stated that "the need for a sewage collection and disposal system to serve certain portions of the areas under discussion {in the San Lorenzo Valley} is urgent and immediate. ...Much of the area in the San Lorenzo River water shed (sic) has developed to the point where sewerage service must be provided if the territory is to develop further."_This report recommended ultimate sewering of the area from San Lorenzo Park to the Santa Cruz City limits, including the present Boulder Creek Country Club area, Zayante and Lompico. Conveyance of sewage to Santa Cruz was recommended, as treatment and disposal in Felton was considered "improper and inexpedient."

L. Cedric Macabee, Consulting Engineers, Report on the Sanitation Problems of the San Lorenzo Valley, for the San Lorenzo Valley Chamber of Commerce, 1949. Although the report contains no supporting information, it states that "sewage has contributed to the pollution of the San Lorenzo River and will soon destroy its value for recreational purposes....the area must be provided with sewage facilities if development of the area is not to be retarded." The report recommended the collection of sewage from an area extending from Felton to three miles north of Boulder Creek, with conveyance to Felton for treatment, and discharge to a land disposal site between Graham Hill Road and Henry Cowell Park (the same site proposed by the San Lorenzo Valley Water District in 1984). An application was made by the County Board of Supervisors to the State Board of Public Health, and subsequently to the Central Coast Regional Water Pollution Control Board for permission to proceed with the project (see following study).

Bureau of Sanitary Engineering, Department of Public Health, State of California, A Report on Proposed Waste Discharges in the San Lorenzo Valley and Their Effect Upon Beneficial Uses of the San Lorenzo River, 1950-51. This report presented a detailed review by State agencies of conditions in the San Lorenzo Valley, relative to the application for permission to construct sewage facilities, as outlined above. Over 200 stream samples were collected from various locations in the Watershed and analyzed for total coliform. The median total coliform level was reported as 3.9 MPN/100ml; current guidelines for safe body contact are generally set at 1000 MPN/100ml. No indications of

sewage discharge were found, which was confirmed by extensive sanitary surveys by County and State personnel, mostly in the winter time, when occupancy levels were low. The report concluded that the proposed sewage facilities would increase the potential for pollution of the River due to the numerous stream crossings of the lines, potential for pump failure, and the inadequacy of the proposed disposal site to absorb all the effluent.

Santa Cruz County Division of Sanitation, 1951. Work was done in conjunction with the Bureau of Sanitary Engineering to evaluate sewage nuisances in Boulder Creek, and to further evaluate the overall need to provide public sewerage to the Valley. This report stated that the Macabee report "was the cause of certain political factions to take sides in the issue. This resulted in many public meetings and a considerable loss of time." The nuisances in Boulder Creek were attributed to the persistent discharge of sewage to the old, abandoned Boulder Creek sewer system. It was concluded that "private sewage disposal systems can and do work satisfactorily within the valley area and that most sewage disposal difficulties are experienced by commercial establishments." The recommendation was to "promote a semi-public sewer system which would solve the difficulties involving the commercial areas of Boulder Creek."

Bureau of Sanitary Engineering, Department of Public Health, State of California, Report of San Lorenzo River Survey (two reports: 1961 and 1962). The Santa Cruz County Health Department requested the State to conduct surveys "to determine the extent of sewage contamination of the San Lorenzo River and

the urgency and need for an engineering study for sewering the Valley." Bacteriological and chemical samples were collected and stream corridors were inspected for failing systems in April and May, 1962. Approximately 12 seepages of suspected sewage origin were found, but the survey "indicated that no large volumes of sewage were entering the San Lorenzo River or its tributaries at the time of the study."

Bowman and Williams, Civil Engineers, A Report on the Collection, Treatment, and Disposal of the Sewage of the San Lorenzo Valley, for the San Lorenzo Valley County Water District, 1965. This report presented another proposal and cost estimate for sewerage of the entire Valley, with transmittal of the sewage to Santa Cruz for treatment and disposal. The need for the project was indicated by the presence of "impervious soils" unsuitable for septic system use in "most areas of the valley". Results of the County's water quality sampling program were presented for April 6 to October 19, 1964. Sixteen locations were sampled 7-8 times each and median total coliform values ranged generally from 240 to 620 MPN/100ml, depending on the location. (Total coliform guidelines for water contact sports are 1000 MPN/100ml.)

California Department of Water Resources, 1966, San Lorenzo River Watershed Water Quality Investigation. Monthly stream sampling was done during September, 1963 through October, 1964 at 24 stations for a broad range of parameters, including nitrate and total coliform. The study found that coliform densities were elevated at low flows due to heavy recreation use and wastewater disposal. However the investigators indicated that the bacterial

sampling was inadequate to draw valid conclusions.

Santa Cruz County Health Department, A Study of Fecal Coliform Organisms in the San Lorenzo River, August 1968-August, 1969. This was one of the first studies using analyses for fecal coliform. Weekly samples were taken at 6 locations. This study found that there was "evidence of significant fecal contamination of the San Lorenzo River." Fifteen percent of the summer samples had values over 200/100ml, the recommended standard for safe swimming.

Engineering and Financial Report on Sewage Collection, Treatment and Disposal for County Service Area No. 8 including Felton and Mount Hermon, 1971, 1972. A preliminary design and cost estimate was made for collecting and treating sewage for the Felton area of the San Lorenzo Valley. This work did not include any assessment of need, as this was already taken for granted. The project was not pursued due to the high cost.

California Regional Water Quality Control Board, Central Coast Region, Bacteriological Survey of the San Lorenzo River Watershed, June-September, 1974. This study utilized biweekly sampling of 18 stations, with intense follow-up of trouble spots. Fecal coliform, fecal strep, and total coliform were analyzed. Bacterial standards were regularly exceeded only along Boulder, Zayante, and Carbonera Creeks. A recommendation was made to expedite plans to sewer the Valley.

Santa Cruz County Health Department, Streamside Septic System Inspection Program, 1975-1978 (and again in 1980-81). Approximately 1690 parcels within 100 feet of streams in the San Lorenzo Watershed were inspected for overt failure, greywater bypass, and the condition of the septic tank. Eleven percent of the systems were found to have overt failures or greywater bypasses, 44% of the tanks needed pumping. These conditions were corrected as a part of the project. In the follow-up inspection program five years later, 4.3% of the systems were found to have failures or greywater bypasses, and 30% of the tanks needed pumping.

U.S. Geological Survey, Stream Quality in the San Lorenzo River Basin, 1978 (Sylvester and Covay). This study included monthly sampling of 15 stations from October, 1974 to September, 1975. Stations on Zayante, Bean, Carbonera, and Branciforte Creeks were identified as having excessive fecal coliform and or nitrogen levels, probably resulting from improper sewage disposal.

Santa Cruz County Planning Department, San Lorenzo River Watershed Management Plan, 1979. Investigations for this report included monthly sampling of 13 stations from October 1975 to September, 1978; investigations of instream biota; a review of other water quality data from earlier studies, including samples collected by the County Environmental Health Service for the same time period; and an evaluation of Environmental Health file records for septic system installation and repair. Most sampling was done during a drought period. Conclusions of this report included the following:

- Bacterial contamination was identified as a major problem, with "severe" contamination on Branciforte Creek, Carbonera Creek, Love Creek, Two Bar Creek, and the San Lorenzo River Mouth. Streams with "significant" contamination were Boulder Creek, Bear Creek, Zayante Creek, and the main section of the San Lorenzo River.
- Nitrate was identified as the limiting nutrient for algal growth in the San Lorenzo River. Nitrate levels were found to be increasing, and the levels of algal growth were believed to indicate potential nutrient enrichment in Boulder Creek, Ben Lomond, and to a lesser extent in some of the other developed areas.
- Records of septic system repair were interpreted to indicate system failure, and a "41% failure rate" was calculated for systems in the Watershed. This finding did not recognize that repairs might be needed due to factors such as old age, and that once repaired, most systems should no longer be considered to be "failing".
- Existing septic systems were described as a major problem and recommendations were made for improved installation standards, use of alternative systems, establishment of a septic system maintenance district, and completion of the Valleywide Sanitation Study.

James M. Montgomery Engineers, San Lorenzo Valleywide Wastewater Management Study, Phase 1 (and 2), 1981 (and 1983). Data collection for this study included 4 samples from 20 stations, windshield surveys of some communities, and summary of earlier data. Findings and conclusions were as follows:

- Based on the limited sampling, it was determined that in some streams passing through residential areas, fecal coliform counts increased by

as much as 2000 percent. Use of fecal coliform/fecal streptococcus ratios also indicated significant contamination from human sources.

- Based on records of repair, some communities were determined to have system failure rates of 25-45%, again not determining whether the repairs were successful or not.
- Based on broad mapping and interpretation of area-wide factors, the communities of Boulder Creek, Kings Creek / Wildwood, Ben Lomond, and Felton (Class I areas) were determined to be unsuitable for continued onsite disposal.
- Other communities (Class II areas) could continue to use onsite disposal if the existing systems were upgraded or converted to cluster systems. It was inferred that the remaining third of the developed areas could continue as they were.
- This report served as the primary basis for detailed engineering/design studies and pursuit of Clean Water Grant funds for construction of sewerage facilities in the Valley. This report also provided much of the justification for the imposition of prohibitions on continued septic system use after July, 1986, imposed by the Regional Board in Resolution 82-10 (see below).

H. Esmaili and Associates, San Lorenzo Valley Onsite Wastewater Disposal Management Study, 1982. This study primarily investigated the impacts of septic systems on shallow groundwater and deep groundwater. Eighty-six shallow boreholes were sampled for fecal coliform and nitrogen compounds approximately 12 times each from 1981 to 1982. These boreholes were placed at varying distances downgradient from septic systems in different types of

geologic conditions. The findings were as follows:

- It was concluded that the data indicated extensive, cumulative contamination of shallow groundwater by existing septic systems.
- Although it was confirmed that septic systems release significant quantities of nitrogen compounds to groundwater, modeling of the major aquifer in the basin (Quail Hollow) indicated that projected, average nitrate levels would not be expected to exceed drinking water standards.
- Recommendations were made for improved septic system installation and siting criteria, including a one acre minimum lot size for all existing lots, which was subsequently adopted by the County Board of Supervisors, as required by Resolution 82-10.

California Regional Water Quality Control Board, Central Coast Basin; Resolution No. 82-10, Concerning Revisions and Amendment of the Water Quality Control Plan, Central Coast Basin, (Prohibition of Individual Sewage Disposal Systems in the San Lorenzo Valley of Santa Cruz County and a Corresponding Request to Amend Clean Water Grant Project Priority List) Based on the findings and recommendations of the County's Watershed Management Plan, and the work of J.M. Montgomery Engineers and H. Esmaili and Associates, the Regional Board adopted Resolution 82-10 which directed the following:

- Additional wastewater discharges in designated Class I areas of the San Lorenzo Valley are prohibited and all existing discharges are prohibited as of July 1, 1986.
- In areas of the Valley outside Class I areas, discharges would be prohibited unless the County adopted special measures to ensure the

proper installation of new systems to protect water quality, as recommended in the H. Esmaili 208 Study.

- In designated Class II areas of the San Lorenzo Valley, discharges would be prohibited unless the County adopted special measures to provide for regular inspection, maintenance, reconstruction, and relocation of existing systems to protect water quality.

Larry Walker Associates, San Lorenzo Valley Septic Management Project, May, 1984. This report developed standards for the evaluation and repair of existing onsite systems in the Class II areas. The standards were more relaxed than new system installation standards, but they still included requirements for dual leachfields, and minimum groundwater separation of 3 feet. The report also included proposed procedures for managing and financing the onsite wastewater management program for the Class II areas. Three-quarters of the costs of upgrading to meet standards were to be paid by Clean Water Grant funds.

CH2M Hill, Class II Facilities Design, 1984 (with participation by local agencies). All parcels in the Class II areas were evaluated to determine the potential for upgrading the systems to meet repair standards proposed by Larry Walker and Associates. In Class II areas, 2% of the existing systems were found to meet the standards. It was estimated that 46% of the systems could not be upgraded to meet standards due to physical constraints on the parcels. It was recommended that many of these parcels also be sewered along with the Class I areas.

Santa Cruz County Planning Department, Staff Report on Surface Water Quality Monitoring Program in Santa Cruz County, 1976-1982. Samples were taken twice a year from approximately 20 stations. Stations with "heavy fecal coliform pollution" were San Lorenzo River at Boulder Creek, Two Bar Creek, Zayante Creek (at Zayante), and Branciforte Creek. "Moderate fecal coliform pollution" was found at Bear Creek, Boulder Creek, San Lorenzo River at Big Trees, Bean Creek, Carbonera Creek, and Love Creek. An increasing trend of nitrate levels in the River was reported, with substantial nitrate contributions from areas with highly sandy soils.

Metcalf and Eddy, Sewer Design, 1984. Building on the earlier work done by Montgomery Engineers, detailed engineering design work was done for collection of sewage from the Class I communities (and portions of the Class II communities), and conveyance to an area east of Felton for advanced secondary treatment and land disposal. As the project design progressed, more difficulties were encountered and the expenses increased. Considerable controversy developed over the project's cost, affordability, environmental impact, and justification. Because of these reasons, and a limited amount of available State funding, the project was denied funding for that year by the State Water Resources Control Board. The project was subsequently abandoned and design work was never completed.

Santa Cruz County Health Services Agency, San Lorenzo Wastewater Management Program, 1985-present. This program was voluntarily implemented by the County Board of Supervisors to address the ongoing concerns of state and local officials that improvements in wastewater disposal were needed, despite the failure of the sewer project. Nine stations are sampled weekly, 22 stations are sampled monthly, and an additional 9 locations each week are sampled as a part of special investigations. Samples are analyzed for nitrate, fecal coliform, fecal streptococcus, and in some instances, E.coli or Enterococci. The program also includes the onsite evaluation of 200-1000 septic systems per year during the wet months to identify dysfunctional systems and require needed improvements. Analysis of the large volume of data collected during this effort and a reassessment of previous studies has led to a substantial refinement of the conclusions drawn during those previous studies. This will be the subject of the body of this report.

3.3 Changing Conditions and Perceptions

A review of the findings from the above studies shows significant variations in the conditions that were found in the field, and in the way that those conditions were perceived: In one study, a stream reach was identified as being significantly polluted; in a following study, the same reach was found to be of satisfactory quality. One investigator believed that septic system repairs were indicative of widespread, ongoing failure, while another investigator believed that those repairs represented effective improvement of old systems that needed to be upgraded. A large portion of the populace at one time believed a major sewer project was needed at all costs, but later

perceived the project as unsatisfactory, too costly, and unnecessary.

These changing conditions and perceptions have led to disagreement as to what the real problems are, and what the best courses of action are for dealing with those problems. It was this type of disagreement which contributed greatly to the failure in 1984 of the effort to construct sewerage facilities for the Valley. It is hoped that the current report will help to dispel some of the past disagreement and form the groundwork for constructive action, as recommended in this report.

4 WATER QUALITY

This section will discuss the impacts on surface and groundwater quality which are related to wastewater disposal in the San Lorenzo Watershed. The discussion evaluates findings from both present and past studies. Main sections present the following topics: general water quality impacts potentially related to wastewater disposal, bacterial contamination of surface water, bacteria and nitrates in shallow groundwater, impacts of nitrate release on groundwater supplies, and impact of nitrates on surface water. This section concludes with an overall discussion of the influence of wastewater management on water quality in the San Lorenzo Watershed.

4.1 Potential Impacts from Wastewater Disposal

The disposal of wastewater can potentially affect surface or groundwater quality through the introduction of several classes of potentially harmful materials: pathogenic organisms (primarily bacteria and virus); nutrients (primarily nitrogen and phosphorous compounds); dissolved solids; organic materials; and various toxic compounds. The latter three potential impacts are not major concerns in the study area, and are discussed briefly in the following paragraphs, prior to a detailed evaluation of the major impacts.

Wastewater contains elevated levels of salts and other dissolved solids, which add to the total level of dissolved solids in ground and surface water. These impacts have been assessed in the Watershed by measurement of electroconductivity, concentrations of total dissolved solids, chloride, or

other specific constituents. Although some investigators have identified some increases in dissolved solids in surface water and shallow groundwater of the San Lorenzo Watershed, these increases are small in relation to the wide fluctuations in dissolved solids concentrations in the River which result from changes in flow regimes and contributions from different geologic areas (Sylvester and Covay, 1978; HEA, 1982). These impacts are not considered significant and will not be discussed further in this report.

Wastewater discharges contribute organic, oxygen-demanding materials to the environment and receiving waters. Under certain conditions, this organic loading can cause depletion of dissolved oxygen levels, significantly impacting aquatic life in the receiving waters. However, in the San Lorenzo Watershed, this is not a significant problem as indicated by presence of dissolved oxygen levels which are typically very close to maximum saturation levels (Sylvester and Covay, 1978). Any potential impact is limited by the absence of direct surface discharge of wastewater, the treatment of effluent by the soil, the high level of turbulence and dissolved oxygen in the streams, and the streams' capacity to process the abundant natural organic material that is present in the streams at certain times of the year. This will be further discussed briefly in the section on nitrate contribution to surface water (Section 4.6).

Another potential impact of wastewater disposal is the possible discharge of toxic materials such as solvents or hazardous chemicals to septic systems, resulting in discharge to groundwater or surface water. The current management approach is to deal with this potential threat primarily through regulation of uses which handle or generate hazardous materials. This is an

area which is outside the scope of this current report.

The two most significant potential impacts of wastewater disposal in the San Lorenzo Watershed are the release of pathogenic organisms and excessive nutrients to surface and groundwater. Untreated wastewater contains large amounts of bacteria, virus and other micro-organisms originating from fecal material, skin, kitchen wastes, and other sources. Micro-organisms which may occur in wastewater have the potential to cause diseases such as hepatitis, typhoid, salmonella, dysentery, giardiasis, and cholera. In a properly operating onsite wastewater disposal system, the effluent is treated by the soil and micro-organisms are removed. However, if the system is not functioning properly, incompletely treated effluent may rise to the surface of the ground, enter streams, or reach groundwater. Presence of pathogenic organisms from wastewater can create a significant health hazard and render water unsafe for drinking or swimming. These impacts will be discussed in detail in Sections 4.2 and 4.4.

Onsite wastewater disposal systems release nitrogen compounds into the environment. In this area, phosphorus does not present any kind of problem because the natural levels of phosphorus are so high. However, nitrogen compounds are a significant concern. There is a high potential for the nitrogen compounds to be converted to nitrate, which is highly soluble and is readily transmitted through the soil to groundwater or surface water. In groundwater, nitrate levels can become elevated to the extent that the water is unsafe to drink. When nitrate moves from groundwater into surface water, it will tend to stimulate the growth of algae, fungi and other primary organisms, if other factors are suitable. If there is excessive stimulation

of biological growth, it can disrupt the stream ecosystem, reduce dissolved oxygen necessary for fishlife, create unsightly and nuisance growths of algae, and impart nuisance tastes and odors to the water, increasing costs of treatment for water supply. The impacts of nitrate release from septic systems in the San Lorenzo Watershed will be evaluated in Sections 4.5 and 4.6.

4.2 Bacterial Contamination of Surface Water

Historically the major concerns regarding water quality degradation from septic systems has focussed on the elevated levels of fecal bacteria in streams of the San Lorenzo Valley. This issue is complicated by the presence of other sources of bacterial contamination and by the influence of a variety of independent factors which affect the observed bacterial levels. This section of the report will present a review of the historical data on bacterial contamination of surface water in the San Lorenzo Watershed, a summary of results from the last three years of intensive sampling, and a detailed evaluation of the significance of the various bacterial indicators and the factors which affect them.

4.2.1 Measurement of Bacterial Contamination

Because it is difficult to test for the disease-causing organisms themselves, water is tested for indicator organisms, usually the fecal coliform group of bacteria. Presence of this type of bacteria is used as an indicator that

fecal contamination exists, and that pathogenic organisms are potentially present. Fecal coliform bacteria also occur in the intestines of warm-blooded animals, as well as humans. Some types also persist in the open environment. Coliform levels in streams can often be quite variable over short periods of time and distance. All of these factors make interpreting results of fecal coliform sampling problematic. (The use of fecal coliform as an indicator will be discussed more extensively in a subsequent section.)

Pursuant to the standard set forth in the Water Quality Control Plan for the Central Coast Basin (the Basin Plan), water is considered unsafe for swimming or body contact if the logarithmic (or geometric) mean of at least five fecal coliform samples per 30-day period exceeds 200 organisms per 100 milliliters, or if 10% of the samples exceed 400/100ml. This is the standard generally used to evaluate whether fecal contamination is a serious problem. The higher the fecal coliform level, the more serious the problem.

Tests for other types of bacteria are also sometimes utilized to assess the degree of fecal contamination. Some investigators use a comparison of the amount of fecal coliform organisms to the amount of fecal streptococcus organisms present in a water sample to indicate the extent to which contamination comes from human versus animal sources (Geldreich, 1969). Although the ratio does seem to provide a useful indicator, results can be quite variable and its use is controversial, as will be discussed at greater length in a subsequent section.

Recently the U.S. Environmental Protection Agency has proposed the use of entirely new indicator organisms, E.coli and enterococci, to replace the fecal

coliform test. Their research in other parts of the country indicated that the level of swimming-related illness did not correlate with fecal coliform levels, but did correlate well with the other bacterial tests (EPA, 1986). Santa Cruz County has begun to utilize and evaluate these new tests. However, all the historical and more recent data uses fecal coliform, which will be the primary parameter used to evaluate the extent of fecal contamination in the San Lorenzo Watershed. Information on the other types of bacteria and other factors will be used to help evaluate the significance of the contamination.

4.2.2 Historical Bacteria Levels

A number of studies have been made to assess the degree of fecal contamination present in streams of the San Lorenzo Watershed. The broad findings of those studies were discussed earlier in Section 3.2. In order to compare the specific, quantitative findings of those studies, the results of fecal coliform and fecal strep analyses have been combined in Table 1. This table includes results for all sampling efforts with a finite duration of one month to two years, in which at least 12 samples were collected on at least a monthly basis. The samples from Montgomery (1983) are also included for comparison, even though only four samples were collected from each station. The stations selected are those which were sampled in a number of different studies. Station locations are shown in Figure 1.

Table 1: Summary of Bacteriologic Data from Past and Present Studies

Summary of Fecal Coliform Levels (/100ml) and Mean Fecal Coliform/Fecal Strep Ratios (FC/FS)

Station Number	Location	1969 SCCHD Median	1973 RWQCB Mean	1973 RWQCB FC/FS	1973-75 USGS Mean	1973-75 USGS Logmean	1975-78 SCCPD Logmean	1975-78 SCCPD FC/FS	1981 JMM Logmean	1981 JMM FC/FS	1986-DRY SCCHSA Logmean	1986-DRY SCCHSA FC/FS	1986 SCCHSA Logmean	1986 SCCHSA FC/FS	1987 SCCHSA Logmean	1987 SCCHSA FC/FS	1988 SCCHSA Logmean	1988 SCCHSA FC/FS
060	SLR @ Big Trees	145	110	0.75	100	87	210	0.75	43	3.54	142	0.41	183	0.53	123	0.38	223	0.54
070	Zayante Cr @ SLR		370	0.63	860	170			268	2.70	119	0.71	168	0.57	121	0.46	185	0.60
07109	Bean Creek				560	340	130	0.76	25	0.10	261	0.59	296	0.42	178	0.29	247	0.42
07528	Lompico Creek		200		4800	930			215	1.10	242	0.57	278	0.46	213	0.41	286	0.58
0762	Zayante Cr @ Zayante		510	0.33	1500	850	160	0.37	42	0.40	186	0.39	214	0.4	149	0.45	147	0.52
180	SLR @ Ben Lomond	125	126	0.24			153		16	0.08	99	0.72	168	0.6	78	0.37	115	0.44
245	SLR below Boulder Creek								37	2.12	410	0.86	450	0.72	119	0.74	181	0.76
249	SLR @ Boulder Creek	77	200	0.23			221				263	0.78						
250	Boulder Creek		210	0.36	90	73	172	0.65	44	1.90	77	0.32	110	0.28	57	0.17	118	0.4
271	Bear Creek		140	0.14	79	72	118	1.16	84	1.50	146	0.31	201	0.38	156	0.42	419	0.66
289	SLR @ Brimblecom Rd		120	0.50	230	120	23[illegible]	4.53			166	0.37	254	0.42	167	0.36	180	0.48
310	Kings Creek				160	86			344	1.70	210	0.21	254	0.22	192	0.41	677	0.4
349	SLR @ Waterman Gap				21	14	9	0.37			8	0.12	15	0.09	6	0.13	42	0.29
MEAN		115.67	220.67	0.40	840.00	274.20	156.11	1.23	111.80	1.51	179.15	0.49	215.92	0.42	129.92	0.38	235.00	0.51

SOURCES OF DATA

SCCHD -Santa Cruz County Health Department
August 1968 - August 1969, 40 samples from each station.

RWQCB -Regional Water Quality Control Board, 1973
Average of 23 samples from each station

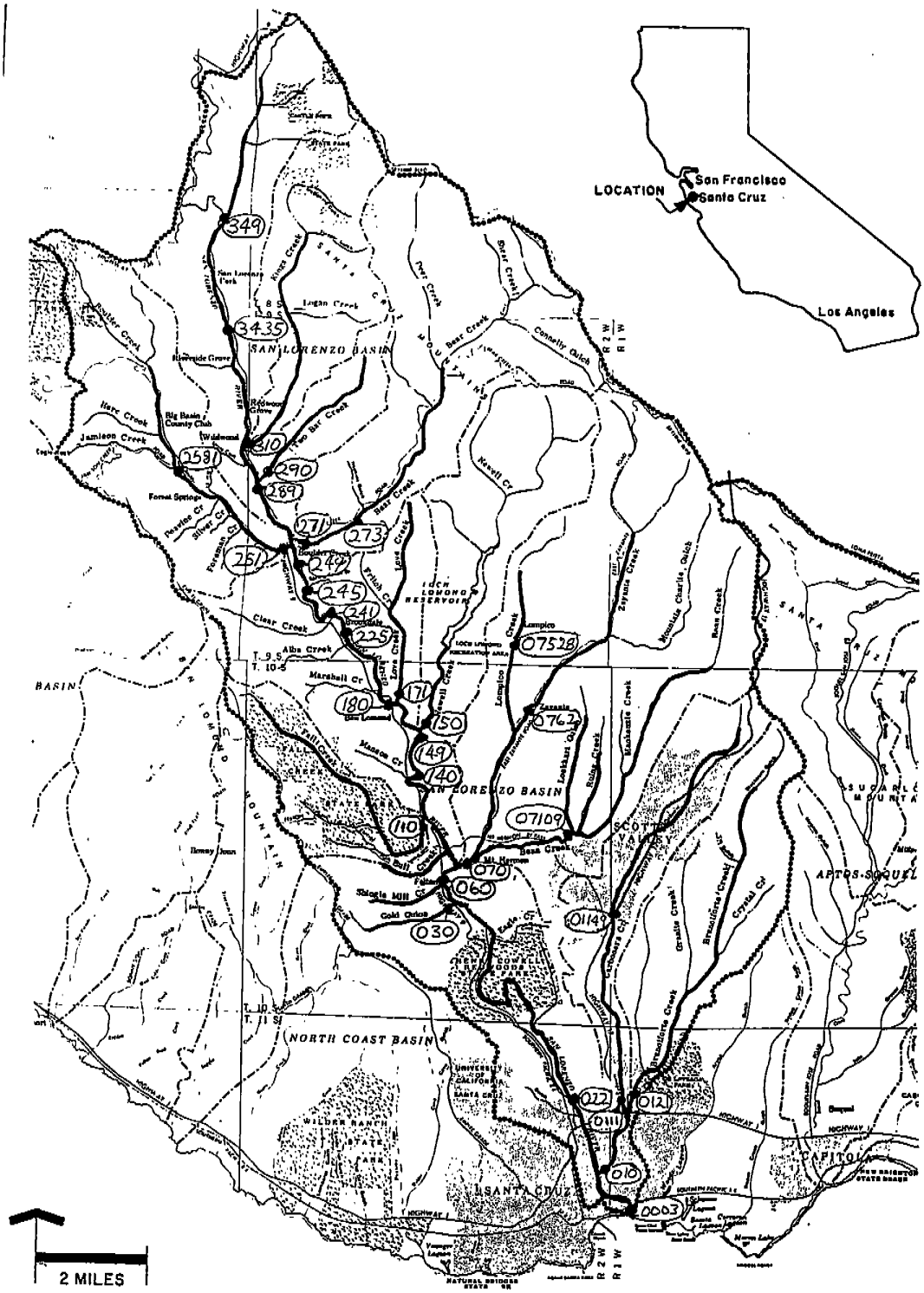
USGS -U.S. Geological Survey (Sylvester and Covay, 1978)
12 samples from 10/74 to 9/75

SCCPD -Santa Cruz County Planning Department, 1979
Monthly samples from 10/75 to 9/78

JMM -James M. Montgomery Engineers, 1983
1981, 4 samples collected from each station

SCCHSA -Santa Cruz County Health Services Agency
1986-88 Weekly or monthly samples from each station

Figure 1: San Lorenzo River Watershed Study Area and Major Water Quality Sampling Locations, 1985-89. (See Table 2 and Appendix A for description of station numbers.)



In comparing the data, it must be kept in mind that considerable variability in the reported findings can result from differences in the method of reporting the data, the time of year and weather conditions when samples are collected, the analytical procedures, the number of samples collected, and the significant variation in bacteria levels that occurs from year to year. These variations in the results of different studies and the ways in which those results are presented is evident in Table 1.

Three different statistical measurements have been used by different studies to summarize the data: the median value, the average (or arithmetic mean), and the logarithmic (or geometric) mean. The latter calculation is currently the preferred way of presenting bacteriological data. Because fecal coliform values can be so highly variable, a logmean is much more representative than an arithmetic mean, in which a single high value can have a much greater effect on the value of the summary statistic than many low values. This difference can be seen in the USGS data, where both arithmetic mean and logmean are presented.

The time of year during which the samples were collected can significantly affect the overall results of the study. Fecal coliform values, and fecal strep values tend to be much higher during periods of storm runoff. If a study includes samples obtained during runoff events, the logmean of fecal coliform will be larger. This is shown by the two sets of logmeans calculated from the Santa Cruz County Health Services Agency (SCCHSA) 1986 data. The first column, designated "DRY", does not include data from any samples taken when it had rained during the previous three days. Logmeans calculated from data which do not include rainy periods are generally 10-20% lower than the

logmeans for all data during the same time period. Sets of data which do include some storm runoff data are the USGS data, the JMM (Montgomery) data, and the SCCHSA data from 1987 and 1988.

A third source of data variability comes from possible differences in analytical techniques. Although it cannot be confirmed, both the USGS and the JMM measurements of fecal strep were much lower than RWQCB data and the SCCHSA 1986-88 data. Lower values of fecal strep yield higher fecal coliform/fecal strep ratios, as can be seen in the JMM data. Recent literature has shown that fecal strep can die off rapidly, and that if samples are not analyzed within 4 hours of collection, results may be much lower (APHA, et al., 1985).

One other variation between studies arises from differences in the sample size. The smaller the sample size, the more variability the means will show. This is apparent in the JMM data, which consisted of at most 4 sample collection days, one of which was during a period of rain and storm runoff, and one of which was four months following the first three. Not only is there a considerable range of variability of mean values from station to station, but there was also an unusual amount of variability between individual samples collected at one station. A number of stations showed values ranging from less than 2/100ml to over 1000/100ml. With such a broad range, this data is probably not statistically reliable. It is interesting to note that although the JMM data shows the lowest overall Watershed mean value of 110/100ml, this study drew the conclusion that the water quality degradation was severe enough to recommended sewering of the Valley.

With all the variation in approaches used by the different studies, it would be useful to have a body of data that was collected over the years utilizing similar procedures. The County Health Services Agency has also monitored fecal coliform levels at natural bathing areas on a weekly basis since 1970. This data has been analyzed to calculate logmeans of all samples during the 30-day period surrounding the sample. The calculated values for three stations are plotted in Figures 2a,b,c. This analysis has been taken one step further in Figure 3, which shows the percent of weeks during the summer when the body contact standard was exceeded on the San Lorenzo River at Boulder Creek, one of the primary areas of concern in the Watershed.

Figure 2: Historical Summer Fecal Coliform Levels (30-Day Logmeans) At Selected Bathing Areas

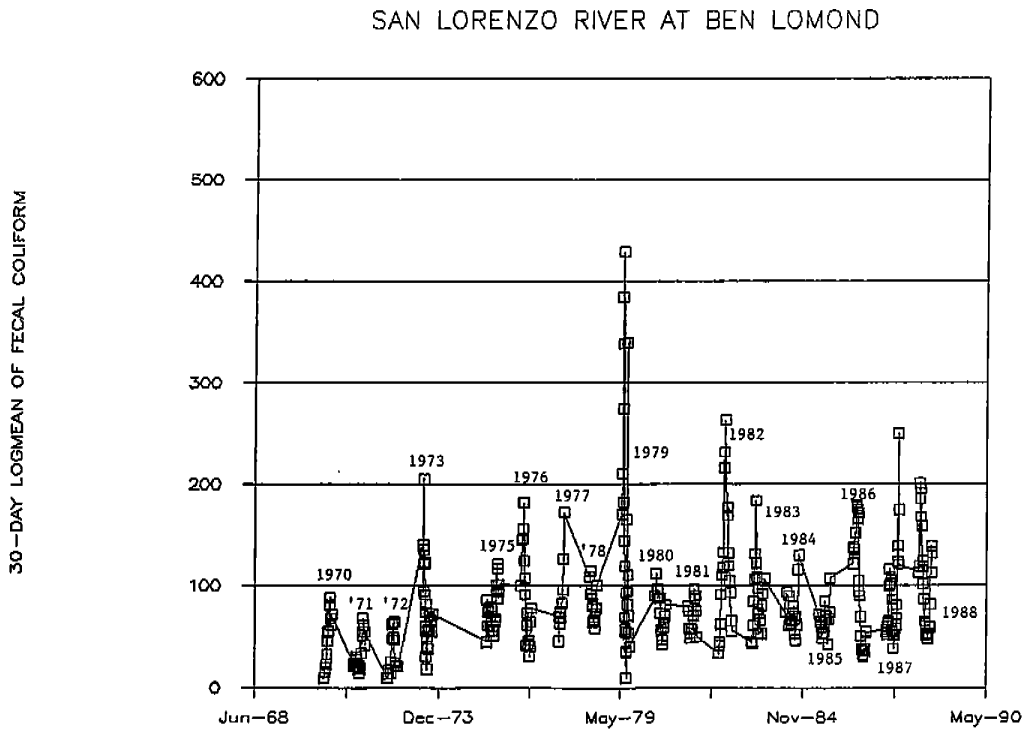
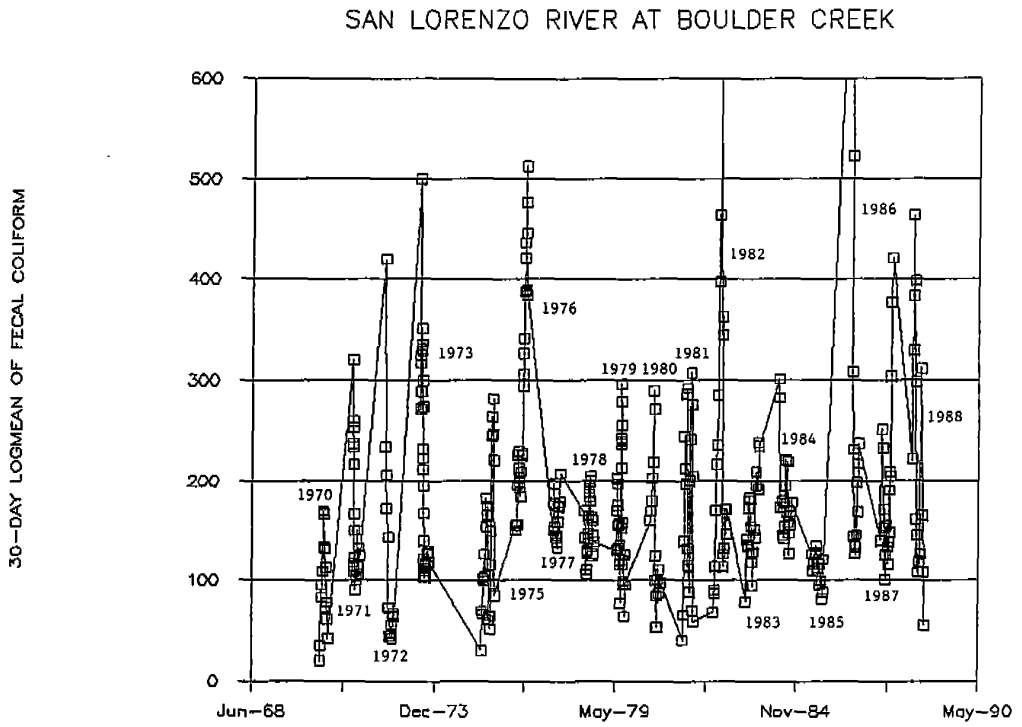


Figure 2: (Continued) Historical Summer Fecal Coliform Levels (30-Day Logmeans) At Selected Bathing Areas



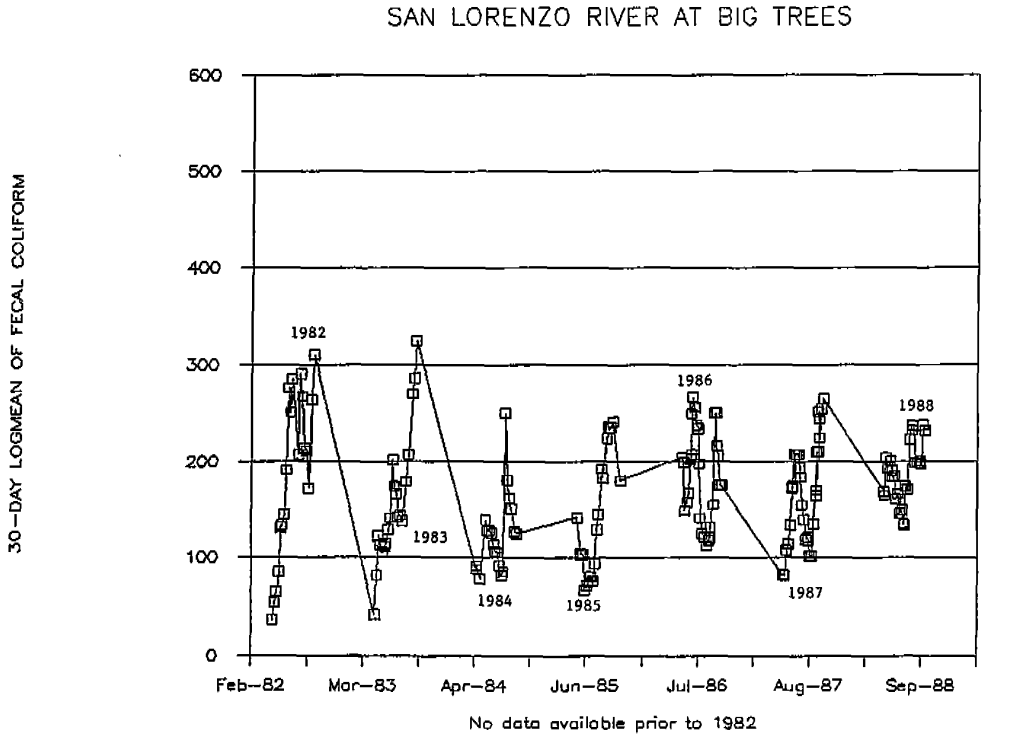
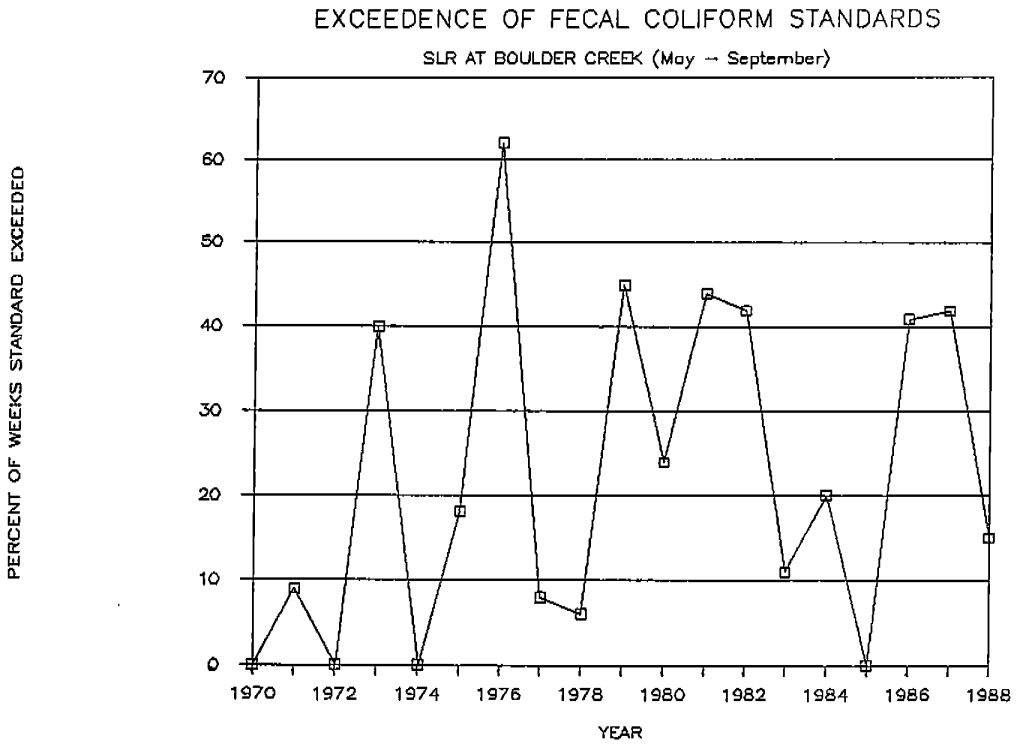


Figure 3: Historical Exceedence of Fecal Coliform Standards for Body Contact Sports During the Summer in the San Lorenzo River at Boulder Creek



The information presented in Table 1 and Figures 2 and 3 can be used to draw some conclusions regarding fecal coliform levels in the Watershed during the past 18 years. Individual stations frequently vary significantly from year to year, independent of fluctuations at other stations. Zayante Creek, Lompico Creek and Bean Creek all seemed to show unusually high fecal coliform levels in 1973 and 1973-75. Boulder Creek and the River below Boulder Creek were both unusually high in 1973 and in 1986. In 1986, the high counts were a result of a streamside septic system failure which was found and corrected that summer.

Overall fluctuations in mean fecal coliform levels throughout the Watershed can also be identified. The early years of 1969 through 1972 appear to have been generally low. Other low years were 1975, 1977, 1978, 1983, 1984, 1985, and 1987. High years were 1973, 1976, 1982, and 1986. It is not apparent what causes these basin-wide fluctuations. A comparison to the amount of summer streamflow did not show a significant relationship. Summer streamflow provides a good reflection of the amount of rainfall, the amount of groundwater recharge, and saturation of the Watershed during the previous winter and spring. The driest year, 1977, and the wettest year, 1983, had relatively low fecal coliform levels. The second driest year, 1976, and the second wettest year, 1982, showed high fecal coliform levels. In recent history, 1987, which was the fourth driest in the last 13 years, had much lower fecal coliform levels than 1986, which was the third wettest year. However, in 1988, which had lower streamflows than 1987, the overall fecal coliform levels were significantly higher. The factors which would affect fecal coliform levels in wet years and dry years will be discussed in Section 4.2.6.

In conclusion, the review of historical bacterial data does not reveal any significant pattern. A statistical regression analysis of the data did not show any statistically significant long-term trend. There do appear to be broad climatic influences which cause similar basin-wide fluctuations. However, considerable variability can occur from station to station in different years. High levels on a particular stream in a particular year may relate to an upstream septic failure, or some other type of upstream impact of limited duration. This lack of consistent behavior seems to indicate that periods of elevated fecal coliform levels result primarily from broad climatic

factors and random episodes, and there has been no worsening of bacterial contamination.

4.2.3 Current Monitoring Program Results

The current water quality monitoring program being carried out by the County is more comprehensive than previous programs in both the duration of the program and the frequency and total number of samples collected. This program has been specifically designed to assess the impacts of wastewater disposal in the San Lorenzo Watershed. The purpose of the sampling program has been to generate enough data to provide a statistically reliable picture of bacterial levels in the Watershed, to evaluate the significance of those levels, to identify problem areas, and to do follow-up investigations of potential problems.

During the period from October 1, 1985 to December 31, 1988, over 3900 fecal coliform samples have been collected from over 300 locations in the Watershed. Regular monthly sampling was done at 32 stations in 1985-86, and at 22 stations during 1987-88. Weekly sampling was done at 16 stations in 1985-86 and 9 stations during 1987-88. In addition, weekly sampling was done during the summer months at 7 natural bathing areas. A total of 2950 samples were collected from the regular stations. This program has continued into 1989, although some significant modifications may eventually be made as a result of the findings contained in this report.

Samples are generally collected from fast flowing riffle areas of the streams, and chilled for transport to the lab. Analyses for fecal coliform and fecal strep are performed within 2-3 hours of sample collection. Both bacteriological analyses utilize the membrane filter method of analysis. Standard Methods are followed, with one exception: results are reported even if the number of colonies on the plates are not within the range specified by Standard Methods (APHA, et al., 1985). An analysis of replicate samples and dilutions showed that the single dilution method was statistically reliable for the purposes of this study. This also allows considerably more samples to be analyzed.

In addition to the bacteriologic analyses, samples are also analyzed in the field for electroconductivity, temperature, dissolved oxygen, and pH; and in the lab for turbidity and nitrate. During 1985-86, stream discharge measurements were made on a monthly basis, and for the entire period, observations of staff and recording gauge height have been made at the USGS gauging stations.

Results of the analyses have been maintained in a computer database. For this report, statistical analyses have been carried out using SPSS-PC+ software to calculate mean values and evaluate possible statistical relationships among the data. Bacteriologic data from some of the regular stations are summarized in Table 2. Data from the other regular stations is contained in Appendix A.

Table 2: Summary of Water Quality Data from Selected Stations, 1985-88.

STATION NUMBER	LOCATION	Water Year (Oct-Sep)	FECAL COLIFORM LOGMEAN (/100ml)	NUMBER FECAL COLIFORM SAMPLES	MEAN FECOLI/ FECSTREP RATIO	FECAL STREP LOGMEAN (/100ml)	NUMBER FECAL STREP SAMPLES	E.COLI LOGMEAN (/100ml)	NUMBER E.COLI SAMPLES	ENTERO-COCCI LOGMEAN (/100ml)	NUMBER ENTERO COCCI SAMPLES	NITRATE-NITROGEN MEAN (mg/l-N)	NUMBER NITRATE SAMPLES
349	SLR @ Waterman Gap	1985-86	14.85	27	.09	295.14	12	.	0	.	0	.17	12
		1986-87	6.26	47	.13	90.87	47	.	0	.	0	.10	46
		1987-88	42.18	26	.29	106.74	28	.	0	105.02	4	.11	26
310	Kings Cr @ SLR	1985-86	254.44	58	.22	1466.81	12	.	0	.	0	.27	10
		1986-87	192.05	61	.41	944.43	49	.	0	.	0	.22	12
		1987-88	677.09	49	.40	2688.45	49	.	0	602.07	6	.32	10
271	Bear Cr nr SLR	1985-86	200.76	62	.38	742.28	13	.	0	.	0	.15	10
		1986-87	156.32	24	.42	740.92	12	.	0	.	0	.11	12
		1987-88	419.46	11	.66	1254.30	11	.	0	1678.09	2	.10	12
251	Boulder Cr. @ Hy 9	1985-86	110.14	61	.28	577.36	13	.	0	.	0	.42	11
		1986-87	56.62	24	.17	345.83	11	.	0	.	0	.58	12
		1987-88	118.22	11	.40	317.23	11	.	0	104.88	2	.58	12
245	SLR @ River St	1985-86	450.01	61	.72	972.02	14	.	0	.	0	.31	11
		1986-87	119.37	62	.74	290.60	50	200.61	22	.	0	.23	47
		1987-88	181.26	56	.76	237.86	57	200.58	10	102.32	10	.31	54
180	SLR @ Ben Lomond	1985-86	167.87	50	.60	315.50	12	.	0	.	0	.27	12
		1986-87	78.06	61	.37	265.45	50	.	0	.	0	.20	12
		1987-88	114.60	58	.44	246.59	56	.	0	136.13	11	.23	12
150	Newell Cr @ SLR	1985-86	80.14	37	.24	441.61	12	.	0	.	0	.80	12
		1986-87	111.15	12	.82	327.11	12	.	0	.	0	.77	12
		1987-88	127.75	11	.59	298.01	10	.	0	136.75	2	.69	11
0762	Zayante Cr @ Zayante	1985-86	213.83	60	.40	731.60	12	.	0	.	0	.22	12
		1986-87	148.77	61	.45	492.28	51	.	0	.	0	.18	12
		1987-88	146.74	56	.52	327.86	58	.	0	201.33	12	.21	10
07528	Lompico Cr bl Lomp.	1985-86	277.98	61	.46	735.35	13	.	0	.	0	.32	12
		1986-87	212.88	63	.41	644.59	51	.	0	.	0	.22	13
		1987-88	285.67	57	.58	932.25	56	.	0	749.19	12	.21	11
070	Zayante Cr @ SLR	1985-86	168.23	38	.57	728.94	12	.	0	.	0	.70	12
		1986-87	121.11	13	.46	371.09	12	.	0	.	0	.60	12
		1987-88	184.94	12	.60	371.23	12	.	0	84.85	2	.77	12
060	SLR @ Big Trees	1985-86	183.41	51	.53	561.35	12	.	0	.	0	.48	12
		1986-87	123.41	63	.38	425.90	51	217.15	24	.	0	.42	49
		1987-88	223.27	60	.54	375.24	60	276.77	10	132.77	12	.39	56
030	Gold Gulch @ SLR	1985-86	150.15	39	.38	484.45	11	.	0	.	0	.18	11
		1986-87	135.14	12	.52	275.43	12	.	0	.	0	.15	12
		1987-88	167.67	11	.59	271.68	11	.	0	185.47	2	.12	11
022	SLR @ Sycamore Grove	1985-86	89.96	29	.27	264.23	12	.	0	.	0	.32	12
		1986-87	82.01	63	.27	422.84	51	132.23	22	.	0	.27	12
		1987-88	66.51	57	.25	273.13	60	212.87	10	56.72	12	.35	14
01149	Carbonera bl Scots V	1985-86	562.63	12	.89	1691.91	12	.	0	.	0	1.03	12
		1986-87	542.22	12	.30	2318.02	12	.	0	.	0	1.08	12
010	Branciforte Cr @ SLR	1985-86	885.76	12	1.28	1322.34	12	.	0	.	0	.62	11
		1986-87	911.68	12	.96	1206.86	12	.	0	.	0	.32	12
		1987-88	1457.31	11	3.66	789.09	11	.	0	367.42	2	.29	11
003	Riversouth @ Trestle	1985-86	804.32	40	3.46	355.38	19	.	0	.	0	.45	11
		1986-87	827.79	63	2.52	463.35	56	1115.02	26	.	0	.17	11
		1987-88	484.23	55	2.21	291.44	54	1370.72	10	286.50	12	.17	11

It is clear from a review of the data that there is significant presence of bacterial contamination in surface waters of the San Lorenzo Watershed. Frequently this contamination is in excess of standards for safe body contact. The following sections will address the significance of the bacterial contamination and will discuss: the impacts of bacterial contamination on beneficial uses of Watershed streams; the significance of various types of bacteriologic indicators; the influence of physical, hydrologic and seasonal factors on bacterial levels in streams; and the sources of bacterial contamination in the San Lorenzo Watershed.

4.2.4 Influence on Beneficial Uses

The major beneficial uses of the San Lorenzo River and its tributaries are water supply, fishery habitat, passive recreation, and active body-contact recreation. Although bacterial contamination is a concern for water supply, potential pathogens are removed by normal water treatment processes of filtration and disinfection. Body contact recreation is the beneficial use that is most likely to be impacted by bacterial contamination. Concern over potential health hazards for swimmers, and the concern for general public health impacts from failing septic systems, has driven most of the prior efforts to investigate water quality and upgrade wastewater disposal practices in the Valley. The extent of the impact on safe body-contact recreation can be evaluated in two ways: the frequency that established standards for safe body-contact are exceeded, and the occurrence of water borne disease resulting from swimming in the River or its tributaries.

Historically the San Lorenzo River has served as a major recreational resource for swimming and wading during the warm summer months. Major natural bathing areas are located at San Lorenzo Woods, Bear Creek Scout Camp, Boulder Creek Junction, Boulder Creek Dam, Brookdale, Ben Lomond, Highlands Park, Henry Cowell Redwoods State Park, Paradise Park, Sycamore Grove, and the Rivermouth in Santa Cruz. The County has monitored most of these bathing areas on a weekly basis since 1970. Figures 2 and 3 show the water quality trends for some of the bathing areas over the last 18 years. Table 3 shows the frequency that standards were exceeded at all the major bathing areas during the last three years.

Table 3: Amount of Time Bathing Areas Were Unsafe Due to High Fecal Coliform Levels (Logmean Greater than 200/100ml) During Recent Summer Months (May to September)

	1986		1987		1988	
Bathing Area	Weeks	% of Time	Weeks	% of Time	Weeks	% of Time
SLR @ San Lorenzo Woods	14	82%	9	47%	8	40%
SLR @ Boulder Creek	7	41%	8	42%	3	15%
SLR @ Brookdale	17	100%	19	100%	20	100%
SLR @ Ben Lomond	0	0%	0	0%	0	0%
SLR @ Big Trees (Felton)	5	29%	7	37%	7	35%
SLR @ Sycamore Grove	0	0%	0	0%	0	0%
SLR @ Rivermouth	17	100%	19	100%	20	100%

(See Figures 2 and 3 for actual fecal coliform data, including years prior to 1986.)