CENTRAL COAST REGION CONDITIONAL WAIVER COOPERATIVE MONITORING PROGRAM

FOLLOW-UP MONITORING REPORT:

WATER QUALITY RESULTS FROM UPSTREAM MONITORING 2008

Central Coast Water Quality Preservation, Inc.
"Managing the Cooperative Monitoring Program on Behalf of Ag"

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Executive Summary

For the purposes of the Conditional Waiver of Waste Discharge Requirements for Discharges from Irrigated Lands, the Cooperative Monitoring Program (CMP) is required to conduct Follow-up monitoring to better characterize areas of concern identified by the core monitoring program. During 2008, "Upstream Monitoring" was conducted at 33 publically accessible sites, upstream of 17 core CMP sites. This monitoring was conducted concurrently with the monthly core CMP monitoring, for similar or identical suites of water quality constituents. Upstream Monitoring was generally intended to improve the understanding of source areas for constituents of concern measured at core CMP sites, and had 3 specific objectives: 1) Further characterize source areas for constituents of concern within agricultural watersheds of concern; 2) Differentiate between agricultural and urban sources for constituents of concern in agricultural areas with mixed land use upstream; and 3) Characterize water quality in areas of large watersheds not currently addressed by the CMP. Water quality sampling generally conformed to the CCAMP Conventional Water Quality Parameter Sampling Standard Operating Procedures. Data were submitted electronically to the CCRWQCB on a quarterly basis, along with results for the core CMP.

Upstream Monitoring in the Northern Monitoring Unit included San Juan Creek (San Juan Bautista), Llagas Creek (Gilroy), Quail Creek (Salinas), and Chualar Creek (Chualar), the Salinas Reclamation Canal (Salinas), the San Benito River (Hollister), and the upper Salinas watershed (Bradley, San Miguel, Paso Robles). Upstream Monitoring in the Southern Monitoring Unit included Glen Annie Creek (Goleta), the lower Santa Ynez River (Lompoc), the upper Santa Ynez River (Buellton), Orcutt-Solomon Creek and Green Valley (Santa Maria), and Oso Flaco Creek (Guadalupe/Santa Maria).

In general, results showed multiple source areas in each watershed for the constituents of concern measured at core CMP sites. In some cases, source areas differed in importance depending on the parameter of interest. Some sub-watershed areas did not appear to be important sources of surface water quality impairment. Often, the importance of a sub-watershed area as a source depended on whether concentrations or loads were of more interest. Finally, it was possible in a few watersheds to determine the relative importance of agricultural versus urban sources for certain constituents.

The source area analysis for 2008 Upstream Monitoring was facilitated by land use and hydrologic information. In watersheds lacking natural dry-season baseflows and having predominantly agricultural land use, results generally pointed to all or most sub-watershed areas as being sources for constituents of concern downstream. In mixed land use watersheds, monitoring results clearly reflected urban contributions, though the importance of these relative to contributions from agriculture differed by watershed. In watersheds with areas of high water table and/or augmented land drainage (i.e. tile drains), monitoring results showed clear contributions from the shallow groundwater and/or tile drains, however the ultimate source for constituents of concern in those waters remains unclear (i.e. current ag operations versus historic ag operations versus present day, up-gradient sources of groundwater contamination). In larger watersheds fed by major reservoirs, the diluting influence of the relatively "clean" reservoir releases on downstream water quality was clear. In general, the source area analysis showed that CMP watersheds of concern do not have "natural" stream flows. That is, flows in these water bodies are generally comprised of urban or industrial (including ag) effluents, tile drainage of sub-surface waters, and/or reservoir releases of waters which in some cases were delivered from outside the watershed.

Information from Upstream Monitoring in 2008 has been, and continues to be, used by the CMP to perform focused outreach to farmers in areas of concern, including locally relevant data about how their own operations might be contributing to water quality issues. It is anticipated that as farmers learn of water quality concerns in a way that is specifically relevant to their own operations, monitoring results from the core CMP and potential future Upstream Monitoring will demonstrate improvements in water quality related to changes made on-farm.

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1 INTRODUCTION

For the purposes of the Conditional Waiver of Waste Discharge Requirements for Discharges from Irrigated Lands, the Cooperative Monitoring Program (CMP) is required to conduct Follow-up monitoring to better characterize areas of concern identified by the core monitoring program (CCRWQCB 2004a and b). A copy of the Monitoring and Reporting Program for the Conditional Waiver is available at:

http://www.swrcb.ca.gov/centralcoast/board_decisions/adopted_orders/2004/2004_0117_mrp_conditional_ag_waiver.pdf.

Short term goals of the core CMP are to:

- Assess the status of water quality and associated beneficial uses in agricultural areas;
- Identify problems associated with agricultural activities;
- Conduct focused monitoring to further characterize problem areas and to better understand sources of impairment; and
- Provide feedback to growers in problem areas.

Results from the first four years of the core CMP are presented and discussed in the Central Coast Cooperative Monitoring Program 2005-2008 Water Quality Report (CCWQP 2009a). The intent of Follow-up monitoring is to increase understanding of the areal scope, sources, and severity of water quality issues identified by the core CMP, such that better feedback can be provided to growers related to management practice implementation (CCRWQCB 2004b). To this end, several Follow-up monitoring projects have been completed by the CMP, including:

- Monitoring of organophosphate pesticides at 25 core CMP sites, in conjunction with four aquatic toxicity monitoring events conducted for the core CMP (CCWQP 2008a);
- Continuous monitoring (15 minute intervals throughout one growing season) of streamflows at 6 core CMP sites believed to be heavily influenced by irrigation (CCWQP 2009b);
- Monitoring for aquatic toxicity in conjunction with an effort by California Department of Pesticide Regulation to monitor several pesticide classes in four CMP water bodies (CCWQP 2009c; Starner 2008);
- Monthly monitoring (for 1 year) at locations upstream of core CMP sites to identify source areas (i.e. reaches or sub-watershed areas) for constituents of concern measured at core CMP sites (this report).

The latter project, referred to hereafter as "Upstream Monitoring," was first described in the Follow-up Water Quality Monitoring Plan: Upstream Monitoring (CCWQP 2007). During 2008, Upstream Monitoring was conducted at 33 publically accessible sites, upstream of 17 core CMP sites. This monitoring was conducted concurrently with the monthly core CMP monitoring, for similar or identical suites of water quality constituents. Upstream Monitoring was generally intended to improve the understanding of source areas for constituents of concern measured at core CMP sites, and had 3 specific objectives:

1. Further characterize source areas for constituents of concern within agricultural watersheds of concern;
2. Differentiate between agricultural and urban sources for constituents of concern in agricultural areas with mixed land use upstream; and

3. Characterize water quality in areas of large watersheds not currently addressed by the CMP.

Upstream Monitoring results were reported to the Central Coast Regional Water Quality Control Board (CCRWQCB) on a quarterly basis, and are being used along with results of the core CMP to provide feedback to growers. The remainder of this report briefly describes the methods used in the program; provides important background information on Upstream Monitoring watersheds; discusses results of 2008 Upstream Monitoring; and provides an analysis of source areas for water quality issues based on these results.

2 METHODS

2.1 Sample Collection and Analysis

Water quality parameters monitored during 2008 Upstream Monitoring included the following basic chemical and physical parameters: Air Temperature (^{o}C); Water Temperature (^{o}C); Conductivity (µS/cm); Salinity (ppt); Total Dissolved Solids (mg/L); Dissolved Oxygen (mg/L and % saturation); and Turbidity (NTU). The following nutrient-related parameters were also monitored: Nitrate (mg/L as N), Orthophosphate (mg/L as P), and Total and Unionized Ammonia (mg/L as N). Finally, the following toxicity-related parameters were monitored as well: Toxicity to Invertebrates and Fish in water (% survival and % growth or reproduction); Toxicity to Algae in water (% growth); and invertebrate toxicity in sediments (% survival and % growth in sediment). Specific parameters monitored at each site are given in Tables 1 and 2. A map of the entire CMP monitoring area is provided in Figure 1. Maps of Upstream Monitoring locations are provided by watershed area, as Figures 2 through 12.

Water quality monitoring generally conformed to the CCAMP Conventional Water Quality Parameter Sampling Standard Operating Procedures (specific methods described in the CMP's Quality Assurance Project Plan, or QAPP; CCWQP 2006). Additional details on sample collection may be found in the QAPP, pages 18-29, 42-44, and Appendices A and B (CCWQP 2006).

Briefly, *in situ* parameters were measured using a Hydrolab DS4a sonde, calibrated daily. Grab samples were collected directly into laboratory-supplied containers or using a stainless steel bucket. Samples for laboratory analysis were collected in pre-cleaned or new laboratory-supplied containers appropriate to the analytes of interest. Rigorous sample custody and documentation procedures were followed, per the QAPP. A field log was maintained for each monitoring event. Laboratory analysis was also conducted per the QAPP (pages 29-32), using EPA or Standard Methods with appropriate detection limits.

2.2 Sampling Frequency and Duration

Water quality samples were collected from each site, once per month from January through December, 2008. Per the monitoring plan, exceptions to this pattern were:

- <u>Water column toxicity samples</u>: collected only during two "winter" (January and March) and two "summer" (August and September) monitoring events, concurrent with sampling for conventional constituents.
- <u>Sediment toxicity samples</u>: collected only during one "spring" (April) monitoring event, concurrent with sampling for conventional constituents.
- <u>Toxicity samples (water or sediment)</u>: were not collected in agricultural watersheds of concern if the core CMP site did not show a strong history of a certain type of toxicity. This convention was observed to enable better allocation of the limited project budget.

In addition, monitoring was not performed if there was no water present, or if unsafe conditions existed:

- Dry or ponded conditions: Samples were not collected if sites were completely dry, or if water was ponded with no apparent connectivity to downstream waters.
- Inaccessible sites: Samples were not collected if sites were inaccessible due to locked gates or high flows. In certain high flow situations, water quality samples could be collected, but in-stream flow measurements could not.

All monitoring events took place at the end of each month. The two specifically designated "winter" or "wet" events were scheduled as needed to take place within 48 hours of the first two runoff-generating storm events of the year that occurred in different months.

2.3 Data Management and Reporting

Upstream Monitoring data were submitted electronically to the CCRWQCB on a quarterly basis, along with results for the core CMP. Data were managed and stored by CCWQP and contractors as necessary to facilitate internal data review, analysis, and record-keeping. As with the core CMP, data verification and validation for Upstream Monitoring data followed the informal guidance provided by the EPA, which is described in the QAPP (CCWQP 2006). For each data submittal to CCRWQCB, data completeness, correctness, and quality were evaluated by the Program QA officer.

2.4 Quality Assurance/Quality Control

Implementation of all core CMP and of Follow-up projects is conducted according to the approved Quality Assurance Project Plan, or "QAPP" (CCWQP 2006). The QAPP was initially approved in 2005 and was revised and subsequently amended in 2006 for the expansion of the CMP. The QAPP documents the sampling and analytical methods, procedures, and requirements; data management procedures; quality assurance sample requirements and frequency; data quality objectives for the CMP; and corrective actions for quality assurance problems.

During 2008 Upstream Monitoring, quality control procedures were followed as detailed in QAPP tables B-5 and B-6 (pages 37-38). Field blank and duplicate samples were collected regularly to identify contamination and demonstrate precision of sampling procedures. Laboratory method blanks, duplicates, and matrix spikes were also analyzed to identify any contamination and demonstrate precision and accuracy of analytical procedures. Additional details regarding quality control for toxicity tests may be found in QAPP Appendix B (QAPP 2006).

The CMP's QAPP is available through the CCRWQCB at 895 Aerovista Place, Suite 101, San Luis Obispo, CA, 93401 (805-549-3147).

2.5 Data Analysis

2.5.1 Parameters of special interest

As described in section 2.1 (Sample Collection and Analysis), a large suite of water quality parameters was monitored at each Upstream Monitoring site in 2008 (Tables 1 and 2). All monitored parameters may contribute to an assessment of water quality at a given site, however certain parameters provide more direct information about agricultural discharges, in terms of both discharge contents and discharge volume. Due to the large number of sites and parameters monitored, a subset of parameters were selected for more detailed analysis and discussion in this report. Data for all parameters were subjected to the same quality assurance protocols, and all data have been reported to the CCRWQCB. The Beneficial Uses and related Water Quality Objectives used by the CCRWQCB in determining water quality impairments, as they relate to the Upstream Monitoring water bodies are provided in Tables 3 and 4. The electronic data deliverables including all parameters for 2008 Upstream Monitoring are provided in (electronic) Appendix A of this report (Electronic Data Deliverables for 2008 Upstream Monitoring), with data tables presenting results for all parameters in Appendix B (2008 Upstream Monitoring Results Tables). Parameters analyzed and discussed in detail for this report were:

- Flow: the volume of water per unit time, moving past the point of measurement. Measured *in situ* each month, instantaneously, as cubic feet per second (CFS). In agricultural watersheds without baseflows, Flow measurements can be indicative of the amount of tailwater and/or tile drain discharge, and can also be used to identify major input areas and/or non-agricultural discharges.
- Nitrate concentration: the concentration of NO_3^- as N, in mg/L (parts per million), as determined by laboratory analysis of monthly grab samples. Can indicate fertilizers, urban wastewater, or groundwater (natural or anthrophogenic) inputs to stream.
- Nitrate load: the pounds-per-hour (lbs/hr) of NO_3^- N, as calculated from grab-sampled nitrate concentration and flow measurements (extrapolated from the measurement time-scale of ‘seconds’ to a calculated time-scale of ‘hours’). This effectively flow-weights the nitrate concentrations, and converts the flow-weighted numbers to meaningful units of mass-per-time.
- Orthophosphate concentration: the concentration of PO_4^{3-} as P, in mg/L (parts per million), as determined by laboratory analysis of monthly grab samples. Can indicate fertilizers, soil amendments, or urban wastewater inputs to stream.
- Turbidity: a proxy for the concentration of suspended solids in the water, measured *in situ* as NTU’s. Can indicate eroded soil inputs to stream, and can also be used to rule out groundwater as a sole source of water to the stream because groundwater is low in turbidity.
- Flow-weighted Turbidity: as calculated from grab-sampled turbidity (i.e. sediment concentration) and flow measurements. This flow weights the turbidities in exactly the same way as a nitrate load calculation, but cannot convert to meaningful units of mass-per-time because the turbidity unit (NTU) is not a true concentration. Flow weighting of turbidity measurements facilitates comparison of sediment loading among sites.
- Invertebrate Survival in Water: the survival rate of *Ceriodaphnia dubia* (water fleas) exposed to sample water, relative to the survival rates of organisms in a non-toxic control, as determined by laboratory analysis of grab samples collected four times per year. Often indicates the presence of pesticides in water, but does not identify the specific source of toxicity.
- Invertebrate Survival in Sediment: the survival rate of *Hyalella azteca* (sand shrimp) exposed to sample sediment, relative to the survival rates of organisms in a non-toxic control, as determined by laboratory analysis of an annual grab sample. Often indicates the presence of pesticides in sediment, but does not identify the specific source of toxicity.

2.5.2 Statistical analyses – characterizing and comparing water quality among sites

Basic descriptive statistics such as median, maximum, and minimum levels for the above parameters of interest proved quite useful for analyzing spatial patterns in water quality among sites within the 2008 Upstream Monitoring watersheds. Mean values were often biased due to outlying results, especially for parameters like flow and turbidity which can be heavily impacted by storm events. Basic descriptive statistics for parameters of special interest at sites within each watershed are provided in Tables 5-19. These measures formed the basis for characterizing water quality at the 2008 Upstream Monitoring sites.

For exploratory purposes, spatial patterns in the above water quality constituents within each watershed were also examined using both parametric and non-parametric statistical methods. In general, the design of CMP monitoring is not conducive to parametric statistical analysis, due to frequent violations of certain assumptions common to parametric tests (i.e. normality and independence). Though ANOVA and post-hoc pairwise t-test results were examined for comparison, it is more appropriate to consider results from the non-parametric Friedman test and corresponding post-hoc Multiple Comparisons analyses. Specifically, results from each site within a watershed were compared with those from all other sites within the watershed, for each parameter of interest. Tests were performed with 95% confidence intervals ($\alpha = 0.05$) for the ANOVA, pairwise t-tests, and Friedman tests, and with 90% confidence intervals ($\alpha = 0.10$) for the non-parametric Multiple Comparisons tests. Parametric tests were performed using the JMP statistical software package (version 8.0, by SAS Institute, Inc.). The non-parametric Friedman tests were performed with Minitab statistical software (version 15, by Minitab, Inc.), and non-parametric Multiple Comparisons were performed with an Excel spreadsheet tool developed by CCRWQCB staff (Saiz 2009, based on Gibbons 1976).

Results of statistical analyses are given in Appendix C (Spatial Patterns in Parameters of Special Interest, Results of Statistical Analyses). A more conceptual presentation of spatial patterns within watershed areas is given via watershed- and parameter-specific "box and whisker plots," which are compiled in Appendix D (Spatial Patterns in Parameters of Special Interest, Box and Whisker Plots). Box and whisker plots were generated with JMP statistical software.

2.5.3 Source area analyses

In particular, results of statistical analyses and the box and whisker plots were used to assess source areas for constituents of concern within each watershed. First, spatial patterns in *flow* were examined to identify watershed areas which did or did not contribute to stream flows during all or part of the year. For example, if the most upstream site in a watershed was dry during all non-storm events, then it was concluded that the drainage area upstream of that site was probably not a major source of non-storm surface water quality problems in 2008. This logic overlooks some possible interactions between surface and groundwater, and between storm-deposited sediments and non-storm flows downstream. However, as a general rule of thumb for source characterization, it is helpful to differentiate between watershed areas which are typically dry, versus those which frequently contribute large portions of the downstream flow.

Next, patterns in the *concentration* of parameters of interest (section 2.5.1 above) were examined throughout each watershed. Watershed areas with concentrations for a specific parameter that were glaringly higher or lower than those at the core CMP site were identified. For example, if one branch of a watershed consistently had nitrate concentrations less than 10 mg/L as N while another branch consistently had concentrations above 50 mg/L, this spoke to the importance of the latter branch as a source of high nitrates that were observed downstream at the core CMP site. This part of the analysis served to identify several important source areas for highly concentrated inputs, and to identify watershed areas where dilution by less-concentrated inputs reduced concentrations at downstream locations.

Finally, *loading* patterns for parameters of interest were examined. This analysis drew on both flow and concentration-based monitoring data, to weight concentrations according to the size of the inputs. In some cases (i.e. nitrate), this resulted in load measurements with meaningful units (i.e. "pounds of N per hour"). In other cases (i.e. turbidity), this resulted in flow-weighted measurements useful for comparing one site to another, but not meaningful in terms of expressing a mass-based load (i.e. "NTU*CFS"). By incorporating flow data, load estimates identified areas which had glaringly high concentrations but were unexceptional in their contributions to the total amount of a constituent measured downstream. Load estimates also identified source areas which were not remarkable in terms of concentrations, but which contributed heavily to the total amount of a constituent measured downstream because of consistently high flows. The following equations were used to calculate load estimates for use in this analysis:

Equation 1: x mg N/L * y ft^3/s * K = z lbs N/hr, where *x* is the measured concentration of nitrate, in parts per million as N; and

y is the measured flow, in cubic feet per second; and

K is a conversion factor (derived in Equation 2, below) used to convert milligrams to pounds, cubic feet to liters, and seconds to hours; and

z is the calculated load estimate in pounds of N per hour.

Equation 2: $K = 0.0000022$ lbs/mg * 28.32 L/ft^3 * 3600 s/hr = 0.224 lbs/hr

Equation 3: *x* NTU * *y* ft^3/s = *z* NTU*CFS, where

x is the measured turbidity, in NTU; and

y is the measured flow, in cubic feet per second; and

z is the calculated flow-weighted turbidity in NTU*CFS.

Results of source area analyses are provided by watershed, along with the presentation of results for each 2008 Upstream Monitoring watershed in sections 3 and 4 of this report (NMU and SMU Upstream Monitoring Results, respectively). A synthesis of the flow-based and constituent-based source area analyses for all watersheds is provided in section 6 (Discussion).

3 NMU UPSTREAM MONITORING RESULTS

Upstream Monitoring in the NMU in 2008 included four small watersheds which could be described as "agricultural watersheds of concern" based on substantial agricultural land use, and on core CMP results from 2005 through mid-2007. These are: San Juan Creek (San Juan Bautista), Llagas Creek (Gilroy), Quail Creek (Salinas), and Chualar Creek (Chualar). San Juan and Llagas Creeks could also be characterized as "mixed land use" watersheds, with uncertainty as to agricultural versus urban sources for constituents of concern measured at core CMP sites. A fifth watershed – the Salinas Reclamation Canal – could also be characterized as "mixed land use," with a large urban footprint located in between two heavily agricultural areas. Finally, the San Benito and Upper Salinas watersheds form large "upper watershed areas" with core CMP sites located much further downstream, and a lack of locally-relevant core CMP data to characterize water quality therein. These two areas were monitored in 2008 to evaluate potential sources for constituents of concern to the lower watershed areas.

The seven watershed areas described above were monitored monthly during 2008, in conjunction with each core CMP monitoring event. Results were reported quarterly to the CCRWQCB, and are included in Appendices A and B of this report. Results for key parameters which can be directly related to agricultural discharges were analyzed in more detail, as discussed in section 2.5 above (Data Analysis), and presented in each watershed sub-section below. In general, both parametric and non-parametric analyses identified significant spatial differences in water quality within most of the watersheds examined. Results of statistical analyses are provided in Appendices C and D, with more basic descriptive statistics provided in a table for each watershed sub-section below. For readability, narrative discussions in this report are limited to basic descriptive statistics; please refer to Appendix C to review results of hypothesis testing regarding differences between sites.

3.1 Llagas Creek

3.1.1 Watershed description

Llagas Creek is a moderately-sized watershed, comprising just over half of the Llagas-Uvas watershed complex (104 square miles, or 66,560 acres) in southern Santa Clara County, and is a tributary to the upper Pajaro River. Two major creek systems (Little Llagas and San Ysidro) drain to Llagas Creek. Though land use adjacent to the creek channel is largely agricultural, the watershed includes the cities of Gilroy, Morgan Hill, and San Martin. There are urban, industrial, and rural residential inputs to the creek in addition to those from agriculture, and land use throughout the lower watershed is mixed. The Chesbro Reservoir, near the top of the watershed, is operated to provide supplemental flows to the creek and recharge to groundwaters during dry months. Mixed land uses and potential groundwater inputs make Llagas Creek a more complex watershed for source characterization than other CMP watersheds that have more homogeneous land use, and/or strictly surface water inputs.

Ambient monitoring data collected by the CMP in Llagas Creek at Southside Ave (305LCS) between January, 2005 and June, 2007 were assessed during development of this Follow-up project. These data indicated that levels of the following constituents do not comply with water quality objectives listed in the Basin Plan for one or more beneficial uses: Nitrate and Dissolved Oxygen. Beneficial Uses and Water Quality Objectives associated with these constituents are provided in Tables 3 and 4.

To address Follow-up monitoring requirements in the MRP, monthly monitoring was conducted at three additional sites within the Llagas Creek watershed, with the following objectives:

- To determine source areas for constituents of concern measured at site 305LCS (or entering Llagas Creek downstream of 305LCS).

- To evaluate the relative importance of each source area as a contributor to the constituents measured at 305LCS (or those entering Llagas Creek downstream of 305LCS).

To these ends, the following Upstream Monitoring sites were established in the Llagas Creek watershed for 2008 (Figure 2):

- Llagas Creek at Leavesly Ave (305HOL)
- Llagas Creek at Highway 152 (305LHB)
- Llagas Creek at Bloomfield Ave (305LLA, downstream of 305LCS)

The uppermost location, 309HOL at Leavesly Avenue, is not the most upstream access point in the watershed. However, based on prior monitoring by University of California Santa Cruz, it is the most upstream point that is typically expected to have water for sampling purposes (K. Morris, *pers comm.*).

The next most upstream location, 305LHB at the Highway 152 bridge, is the next public access point, moving downstream from 305HOL. It incorporates drainage from 305HOL when flows are present, and generally exhibits more consistent flows than the upstream site, possibly due to inputs from a nearby processing plant.

The core CMP site (305LCS at Southside Ave) incorporates drainage from 305LHB and from additional areas both east and west of the creek. It is likely that processing plant discharges contribute to field observations of a garlic odor in the water at this site. The Gilroy Wastewater Treatment Plant (South County Regional Wastewater Authority) is also located at Southside Ave, downstream of the monitoring location, and disposes of treated water in a series of ponds which allow percolation to the aquifer.

The third Follow-up site, 305LLA at Bloomfield Ave, is downstream of the core CMP site. This site is in an area that is more agricultural and less mixed in land use than the other sites, and incorporates additional inputs which join Llagas Creek and then flow to the Pajaro River.

All Upstream Monitoring points incorporate at least two unique discharges from unrelated agricultural operations or other sources (discharges entering above the site but below the next most upstream site), and most incorporate more. That is, though located to illuminate source areas within the watershed, no two Upstream Monitoring points reliably isolate discharges from a single source.

3.1.2 Results

The full suite of monitoring results for sites in the Llagas Creek watershed is provided in Appendices A and B. A site-specific summary of results for parameters of special interest is provided in Table 5 and discussed here.

Flows at the core CMP site at Southside Ave (305LCS) ranged from 0 CFS (i.e. dry) to 25 CFS, but were most typically less than 5 CFS. The upstream site 305LHB, at the Highway 152 bridge, had water with connectivity to downstream areas only in January through March, but even during these months flows were immeasurably low. Upstream site 305HOL, at Leavesly Ave, had water suitable for monitoring only in January, and this flow was also immeasurably low. Flows were also lower downstream of the core CMP site, at 305LLA (Bloomfield Ave), with a maximum of 6.9 CFS and median flow of 0.35 CFS.

Nitrate concentrations varied throughout the watershed and throughout the year. Nitrate concentrations were relatively low in the few samples collected from sites upstream of the core CMP site 305LCS (samples from 305LHB and 305HOL), except in March when 305HOL had a concentration of 17.8 mg/L. At 305LCS, nitrate levels were above 10 mg/L during four of the ten months sampled, with a maximum concentration of 22 mg/L and a median of 6.9 mg/L. Further downstream at 305LLA, nitrate concentrations were above 10 mg/L more often (during six months), with a median of 11 mg/L.

Nitrate Loads from sites upstream of 305LCS were calculated as 0 lbs N/hr during all 2008 monitoring events, due to the lack of flow. At 305LCS, loads were 0 to 46 lbs N/hr, with a median of 2.8 lbs N/hr. Loads were lower at the downstream site (305LLA), due to lower flows.

The highest **Orthophosphate** concentration measured in the Llagas watershed during 2008 occurred during January at upstream site 305LHB, with a concentration of 0.38 mg/L. The only site showing a similar level (0.34 mg/L, also in January) was 305HOL, with lower orthophosphate concentrations during other months and at the two sites further downstream. Median concentrations were less than 0.1 mg/L at 305LHB, 305LCS, and 305LLA.

Turbidity was relatively low at Llagas Creek sites compared to many other CMP watersheds. Upstream sites 305HOL and 305LHB were only sampled during winter months, and these had turbidities from 37 to 232 NTU. At the core CMP site (305LCS) and further downstream at 305LLA, turbidities were highest during storm events and during mid-summer months, with levels typically below 10 or 15 NTU during other months.

Flow-weighted Turbidity at sites upstream of 305LCS was calculated as 0 NTU*CFS during all 2008 monitoring events, due to the lack of flow. At 305LCS, the maximum flow-weighted turbidity was over 7000 NTU*CFS, which for comparison was nearly comparable to the maximum of about 8700 NTU*CFS observed in the Pajaro River at Chittenden. Median flow-weighted turbidities at 305LCS were much lower, however, at 11 NTU*CFS. Though downstream site 305LLA had a maximum flow-weighted turbidity of nearly 1000 NTU*CFS, median levels were calculated as 0 due to the number of monitoring events during which flows were 0 CFS.

Laboratory **Toxicity** analyses were not performed at Upstream Monitoring sites in the Llagas watershed due to a lack of toxicity in prior monitoring at core CMP site 305LCS. In 2008, there was no toxicity to algae, fish, or invertebrates in water or sediment at 305LCS.

Results for **other water quality parameters** of interest in the Llagas Creek watershed:

- Conductivity values averaged just over 1000 µS/cm at the lower watershed sites and under 400 µS/cm at the upper sites
- pH averaged 7.8
- Dissolved oxygen concentrations were usually near or above 7.0 mg/L, except at core site 305LCS in November and December when levels were 3.2 and 5.2 mg/L, respectively; dissolved oxygen saturation was always above 85% at the two uppermost sites (305HOL and 305LHB), but frequently fell below 85% at the lower sites (305LCS and 305LLA)
- Unionized Ammonia as N was low, with no results over 0.001 mg/L

3.1.3 Source area analysis

Based on Upstream Monitoring results from throughout the Llagas Creek watershed during 2008, several summarizing statements can be made. An 'at-a-glance' comparison of results among sites for each parameter is provided as box-and-whisker plots, in Appendix D. In summary:

- Flows in the Llagas watershed may be influenced by interactions between surface and shallow groundwaters. The most important source area for inputs to surface flows appears to have been between Highway 152 (305LHB) and Southside Ave (305LCS). Flowing water was typically not present upstream of 305LHB, and flows declined in the downstream direction from 305LCS to 305LLA (Bloomfield Ave), indicating a potential sink for surface water in that area.
- With one exception, nitrates were either low in concentration or water not present in Llagas Creek upstream of Southside Ave (305LCS). Nitrate concentrations were comparable between the two most downstream sites (305LCS and 305LLA at Bloomfield Ave), however loads often declined in the downstream direction due to flow patterns. Due to the lack of flows upstream of Highway

152 (305LHB), nitrate loading to surface waters in Llagas Creek appears to occur primarily in the area between Highway 152 and Southside Ave (305LCS).

- Turbidity levels throughout the Llagas Creek watershed tended to be similar among sites during winter storm events, generally between 200 and 300 NTU. Non-storm turbidity levels at sites with water tended to be lower, with turbidities at the most downstream site (305LLA) generally higher than those at the core CMP site, 305LCS. In terms of sediment loading, areas upstream of Highway 152 (305LHB) were not major sources due to lack of flows. The major source area for sediment loading appears to have been immediately upstream of Southside Ave (305LCS). Though turbidity levels were higher downstream at 305LLA, the apparent loss of flow in this area makes it less important in the context of loading to downstream surface waters.
- Source areas for toxicity to aquatic species were not evaluated during this study, as aquatic toxicity has historically not been a problem at the core CMP site at Southside Ave (305LCS).

At this time, the primary source area for in-stream flow, nitrate, and turbidity in the Llagas Creek watershed appears to be the reach from Southside Ave upstream to Highway 152. Land uses potentially contributing to this reach include irrigated agriculture, urban areas, and point source discharges such as processing and wastewater treatment plants. Results from this study do not support conclusions regarding the relative contributions from each of these potential sources. Further study, including field observations and sampling of specific inputs within this reach, would provide better definition.

3.2 San Juan Creek

3.2.1 Watershed description

San Juan Creek is a small to moderate-sized watershed in San Benito county (< 30 square miles, or 19,200 acres) which drains to the upper Pajaro River, just west of the confluence of the Pajaro and San Benito Rivers. The upper San Juan Creek watershed is located on the eastern slope of the Gabilan Mountains, and includes Fremont Peak State Park and substantial rangeland. Land use in the middle section of the watershed includes primarily irrigated agriculture (orchards, nurseries, vineyards, and vegetable row crops) and urban/residential uses, including the city of San Juan Bautista (Dick 2003). The lower watershed includes additional irrigated agriculture, as well as agricultural processing plants.

The upper San Juan Creek watershed is intermittently dry in summer, and water for irrigation further down the watershed is supplied by private wells and by the San Felipe Division of the Central Valley Project, via the San Justo Reservoir (known locally as “Blue Valve” water). The impetus for the San Felipe Division was an investigation of the Pajaro River Basin, which indicated groundwater overdraft in the area (Bureau of Reclamation 2009). Since heavy usage of the Blue Valve water for irrigation began, growers have relied less on pumping from wells, and groundwater levels in the area have become very high (Dick 2003).

The portion of the San Juan Creek watershed with consistent flows is forked beginning in the area just upstream of Anzar Rd. The western fork incorporates drainage primarily from the urban area of San Juan Bautista, including fairly consistent outputs from the city’s wastewater treatment plant. The more eastern fork flows through an area primarily in irrigated agricultural usage, with a large percentage of these lands using tile drain systems. Stream flows in the area are likely to be influenced by shallow groundwater due to tile drains and the high water table, and by deeper groundwater where wells are used as sources of irrigation water. It is unclear if groundwaters in parts of the San Juan Creek watershed are influenced by percolation ponds from the Hollister wastewater treatment plant.

Ambient monitoring data collected in San Juan Creek at Anzar Rd (305SJA) between January, 2005 and June, 2007 were assessed during development of this Follow-up project. These data indicated that levels of the following constituents do not comply with water quality objectives listed in the Basin Plan for one or more beneficial uses: Nitrate, and Toxicity to Invertebrates in Water and Sediment. Beneficial Uses and Water Quality Objectives associated with these constituents are provided in Tables 3 and 4.

To address Follow-up monitoring requirements in the MRP, monthly monitoring was conducted at two additional sites within the San Juan Creek watershed, with the following objectives:

- To determine source areas for constituents of concern measured at site 305SJA.
- To evaluate the relative importance of each source area as a contributor to the constituents measured at 305SJA.

To these ends, the following Upstream Monitoring sites were established in the San Juan Creek watershed (Figure 3):

- San Juan Creek at 1st Street at Christopher Ranch (305ACR)
- San Juan Creek at Mission Vineyard Road, near Highway 156 (305MVR)
- San Juan Creek at Prescott Road (305PRR)

The 1st St location, 305ACR, is on the western branch of the watershed, at the urban boundary of San Juan Bautista. It receives flows from an urban storm drain during rain events, and from wastewater treatment plant outputs on a fairly consistent basis. Upstream of the city, the channel draining the upper watershed areas appears to be dry during most of the year.

The Mission Vineyard Rd location, 305MVR, is the most upstream public access point to the main channel of the eastern fork (this is the main stem of San Juan Creek). It primarily incorporates drainage from irrigated agricultural lands southeast of the monitoring point. Rural/residential drainage can contribute in storm events, as can drainage from the upper watershed hillsides. There is also a golf course in an upstream position on this branch of the creek, however it is unclear if drainage from the golf course ever actually enters the creek.

The third Upstream Monitoring site, 305PRR, is located where Prescott Rd crosses the eastern fork of San Juan Creek, roughly mid-way between 305MVR (in the upstream direction) and the core CMP site (305SJA, in the downstream direction). Drainage to this site incorporates drainage from upstream site 305MVR, and from additional irrigated agricultural lands on either side of the creek.

The core CMP site (305SJA) incorporates drainage from 305PRR and from additional agricultural lands on either side of the creek in between the two sites. Site 305SJA also incorporates drainage from the more urbanized western fork of the watershed (site 305ACR) and from an agricultural processing facility located on San Juan Highway near Anzar Rd. Because San Juan Creek is a major tributary to the upper Pajaro River, site 305SJA can also be considered an “upstream” point for assessing sources to the Pajaro River at Chittenden (305CHI).

All Upstream Monitoring points incorporate at least two unique discharges from unrelated agricultural operations or other sources (discharges entering above the site but below the next most upstream site), and most incorporate more. That is, though located to illuminate source areas within the watershed, no two Upstream Monitoring points reliably isolate discharges from a single source.

3.2.2 Results

The full suite of monitoring results for sites in the San Juan Creek watershed is provided in Appendices A and B. A site-specific summary of results for the parameters of special interest is provided in Table 6 and discussed here.

Flows were fairly consistent in the San Juan watershed during 2008, relative to other small agricultural watersheds in the CMP, with all sites having flows conducive to sampling during all twelve monitoring events. Flows were highest (though still fairly low) at core CMP site 305SJA, with a maximum of 11.1 CFS and a median of 2.5 CFS. Median flows upstream at Prescott Rd (305PRR) were just under half the 305SJA median, and were lower at Mission Vineyard Rd (305MVR) and 1st St (305ACR).

Nitrate concentrations were very high in the San Juan Creek watershed, especially at 305SJA, 305PRR, and 305MVR. These sites had median concentrations of 29 to 66 mg/L, with a maximum concentration of 79 mg/L at Mission Vineyard Rd (305MVR). Concentrations at 1st St (305ACR) were much lower (though still elevated), with a maximum of 16.5 mg/L and median of 6.3 mg/L. Strong seasonal patterns were not immediately obvious at any San Juan Creek sites, however nitrate concentrations were below average at all sites during the January storm event.

Nitrate Loads were highest at the core CMP site 305SJA (median = 12.6 lbs N/hr), where flows were highest. Loads at 305PRR and 305MVR were generally comparable (around 7 to 8 lbs N/hr), probably due to higher nitrate concentrations at 305MVR but higher flows at 305PRR. Nitrate loads were much lower at 305ACR (1st St, western branch), with a median value of less than 1 lb N/hr.

Orthophosphate was much higher at 305ACR (1st St) than at other sites on the San Juan Creek watershed, ranging from 0.4 mg/L to 3.0 mg/L. The highest concentration at any other site was 0.5 mg/L at 305SJA, with median orthophosphate concentrations at 305SJA, 305PRR, and 305MVR ranging from 0.05 to 0.2 mg/L.

Turbidity levels were highest at the 1st St site (305ACR, median 82 NTU)), and lowest at the core CMP site (305SJA, median 13 NTU). Turbidity was intermediate at 305PRR and 305MVR. In general, turbidity throughout the San Juan Creek watershed was much lower than on many other agricultural watersheds in the CMP, with the exception of Llagas Creek. At 305PRR and 305ACR, turbidity was higher during the summer months than during winter storm events. There were also some elevated turbidities during summer months at 305SJA and 305MVR, though the difference between winter and summer was not as pronounced.

Flow-weighted Turbidity was highest at 305PRR and 305ACR, with lower, comparable values at the core CMP site (305SJA) and at 305MVR. The median flow-weighted turbidity at 305PRR of 41 NTU*CFS was about twice that at the core CMP site (305SJA), and about four times the median value on Llagas Creek at Southside Ave (305LCS). Referenced to the mainstem Pajaro River though, 41 NTU*CFS is about ten times lower than the median flow-weighted turbidity observed at Chittenden (305CHI).

Laboratory **Toxicity** analyses of water samples showed no toxicity to fish at core CMP site 305SJA, and showed toxicity to algae growth in one of four samples. Algae and fish toxicity analyses were not performed at Upstream Monitoring sites. Survival-based toxicity to invertebrates in water was observed in one of four samples each for 305ACR and 305MVR, occurring in September in both cases. Reproductive effects were not assessed in all samples due to use of alternative test species in high-salinity samples, however one sample from 305ACR showed impacts to reproduction. In sediment toxicity tests, there were significant impacts to survival at 305SJA (0% survival), and significant impacts to growth at all of the Upstream Monitoring sites.

Results for **other water quality parameters** of interest in the San Juan Creek watershed:

- Conductivity values were very high, with median values between 1900 and 3600 µS/cm
- pH averaged 8.1, with a maximum of 9.0
- Dissolved oxygen concentrations were generally well above 7.0 mg/L, except at 305ACR where they lower on several occasions; dissolved oxygen saturations were frequently below 85% at 305ACR, and above 85% except on about one occasion each at all other sites.

- Unionized Ammonia as N was generally below 0.025 mg/L, except on two occasions at 305ACR and on one occasion at 305SJA.

3.2.3 Source area analysis

Based on Upstream Monitoring results from throughout the San Juan Creek watershed during 2008, several summarizing statements can be made. An 'at-a-glance' comparison of results among sites for each parameter is provided as box-and-whisker plots, in Appendix D. In summary:

- Flows in San Juan Creek watershed were usually low but consistent in 2008. Flows came primarily, if not entirely, from the middle and lower watershed areas (i.e. not from the hillsides). The more urbanized western branch of the watershed was a consistent source of flow, but these were generally lower than flows from the western branch in January through August, 2008. Flows increased in a relatively steady pattern in the downstream direction on the east branch of the watershed, from Mission Vineyard Rd. (305MVR) to Prescott Rd (305PRR) to Anzar Rd (305SJA), indicating multiple source areas for flow.
- The most upstream site on the eastern branch (305MVR at Mission Vineyard Rd) had the highest nitrate concentrations, with substantial nitrate loads in the context of those observed at the core CMP site (305SJA). Loads generally increased from 305MVR to the eastern branch site at Prescott Rd (305PRR, indicating additional sources), with nitrate concentrations that were slightly lower (but still extremely high). The western branch of the watershed (305ACR) had much lower nitrate concentrations, and was a much less important source of nitrate loads to the core CMP site (loads at 305ACR were usually 10% or less of those at 305SJA).
- Turbidity levels were lowest, both in terms of concentration and when flow-weighted, at the core CMP site (305SJA). Since flow volumes were highest at 305SJA, there may be a sediment sink in the reach immediately upstream of Anzar Rd. Concentration-based turbidity levels were highest in the more urbanized western branch of the watershed (305ACR), but flow-weighted turbidities were highest at Prescott Rd (305PRR) on the eastern branch, indicating that the eastern branch is probably a greater source of sediment loading to the core CMP site. Among upstream sites on the eastern branch, concentration-based turbidity levels were roughly comparable between Mission Vineyard Rd (305MVR) and Prescott Rd (305PRR). Flow-weighted turbidities roughly doubled in the downstream direction however, indicating that the watershed areas drained by each site were roughly equivalent in terms of sediment loading to San Juan Creek.
- Toxicity to aquatic and/or benthic invertebrates was present at some level throughout the watershed, but not to the same extent as on other CMP watersheds. All Upstream Monitoring sites showed impacts to invertebrate growth in sediments, but only the core CMP site (305SJA) showed survival-based toxicity. The core CMP site did not show impacts to invertebrates in water in 2008. The sites 305MVR (uppermost site on the eastern branch) and 305ACR (on the western branch) showed impacts to invertebrates in water during one and two monitoring events, respectively.

At this time, the middle and lower portions of the San Juan Creek watershed appear to be the primary source areas for in-stream flow and constituents of concern. The more urbanized western branch was a consistent source of flow with occasional high nitrate and generally elevated turbidity. The San Juan Bautista WWTP is a possible source for this nitrate. The agricultural portion of the watershed appears to have been a more important source area for both nitrates and sediment, however. Sources for turbidity and aquatic toxicity appear to be agricultural land uses that are fairly immediate in space and time. The same may hold true for nitrates, however the influence of tile drains and high water table are confounding effects because both the timing and location of nitrate inputs to the shallow groundwater can be further removed than in the simpler case of surface discharges to a surface water body. That is, it is uncertain if nitrates in tile drain discharges are entirely sourced from the operation hosting the sump.

3.3 San Benito River

3.3.1 Watershed description

The San Benito River is one of five major tributaries whose confluences, over an approximately eight mile reach, form the upper Pajaro River (UCSC 2009). The San Benito River is not monitored as part of the core CMP. However, the other tributaries (Llagas, Uvas, and San Juan Creeks, and Miller's Canal) are all monitored on a monthly basis by the CMP, as is the main stem of the Pajaro River further downstream at Chittenden. Water quality issues have been identified by the CMP in the main stem of the Pajaro River at Chittenden, so it was deemed important to characterize water quality in the San Benito River as part of 2008 Upstream Monitoring efforts.

The San Benito watershed (about 340,000 acres or 530 square miles) comprises a substantial percentage of the total Pajaro River drainage area (about 832,000 acres; UCSC 2009). Flows from the upper San Benito River and several tributary creeks are captured by the Hernandez Reservoir, which is operated to promote groundwater recharge downstream. Just south of Hollister, Tres Pinos Creek enters the San Benito River and the channel then proceeds north through the city of Hollister, and ultimately to the Pajaro River between Betabel Rd and Highway 129. Hollister's sewage treatment plant has a history of poor function, which resulted in supervision and restrictions from the CCRWQCB (Dick 2005).

Ambient monitoring data collected in the Pajaro River at Chittenden (305CHI) between January, 2005 and June, 2007 were assessed during development of this Follow-up project. These data indicated that levels of the following constituents do not comply with water quality objectives listed in the Basin Plan for one or more beneficial uses: Nitrate, Dissolved Oxygen, and Toxicity to Invertebrates in Water. Beneficial Uses and Water Quality Objectives associated with these constituents are provided in Tables 3 and 4.

To address Follow-up monitoring requirements in the MRP, monthly monitoring was conducted at two additional sites within the San Benito River watershed, with the following objectives:

- To characterize water quality near the mouth of the San Benito River, which drains a large watershed and is not monitored as part of the core CMP.
- To determine if the San Benito River is a source area for constituents of concern measured in the Pajaro River at Chittenden.

To these ends, the following Upstream Monitoring sites were established in the San Benito watershed (Figure 3):

- San Benito River at Betabel Rd near sand plant (305SAN)
- San Benito River in Hollister near Hwy 156 (305SBH)

The Highway 156 location in Hollister, 305SBH, is at the urban boundary of Hollister. It is typically dry, but should receive flows from upstream areas and the city of Hollister during substantial rain events. Due to lack of public access, this monitoring site had to be located upstream of the wastewater treatment plant, and so is not a perfect representation of all potential urban inputs.

The Betabel Rd location, 305SAN, is the most downstream public access point that could be located above the San Benito River's confluence with the Pajaro. It is located downstream of the city of Hollister, the wastewater treatment plant and agricultural lands, near a gravel plant. This location exhibits stream flows even when upstream areas are dry; it is not known at what point along the river the flows begin. Flows and water quality at the Betabel Rd site should characterize the San Benito River's contributions to the core CMP site (305CHI) on the Pajaro River at Chittenden. As discussed above, the Chittenden site incorporates inputs from the San Benito River, as well as four other tributaries. Together, these tributaries account for roughly 70% of the flows observed at Chittenden, more so in drier periods without over-land storm runoff (UCSC 2009).

All Upstream Monitoring points incorporate at least two unique discharges from unrelated agricultural operations or other sources (discharges entering above the site but below the next most upstream site), and most incorporate more. That is, though located to illuminate source areas within the watershed, no two Upstream Monitoring points reliably isolate discharges from a single source.

3.3.2 Results

The full suite of monitoring results for sites in the San Benito watershed is provided in Appendices A and B. A site-specific summary of results for the parameters of special interest is provided in Table 7 and discussed here.

Flows in the San Benito River were extremely low. At Highway 156 near Hollister (305SBH), the river was dry except during the January and February storm events, for which the maximum flow was 4.2 CFS. Further downstream, the Betabel Rd. site (305SAN) consistently had water suitable for monitoring, but water velocities were immeasurably low during several months. The maximum flow at this site (305SAN) occurred during the January storm event (2.3 CFS). By comparison, the Pajaro River at Chittenden (305CHI) had flows up to 85 CFS during storm events. Median flows at Chittenden were around 10 CFS, and flows were occasionally low, at 1.3 CFS.

Nitrate concentrations were relatively low in the San Benito River, compared with other CMP watersheds. The maximum nitrate concentration at either San Benito site was 3.2 mg/L, and both sites had median nitrate levels of 0.2 mg/L or less. The Pajaro River at Chittenden (305CHI), however, had median nitrate concentrations just under 10 mg/L, and a maximum of 22 mg/L.

Nitrate Loads from the San Benito River at Betabel Rd. (305SAN) were extremely low, at 0.1 lbs N/hr on average. Loads near Hollister (305SBH) were even lower, and usually zero. Nitrate loads measured in the Pajaro River at Chittenden (305CHI) had a median value of 24 lbs N/hr in 2008.

Orthophosphate concentrations at San Benito River sites ranged from non-detectable to 0.08 mg/L at Betabel Rd. (305SAN). Concentrations near Hollister (305SBH) during storm events were between 0.02 and 0.04 mg/L. In the Pajaro River at Chittenden (305CHI), orthophosphate concentrations were typically around 0.2 mg/L.

Turbidity was highest in the San Benito River near Hollister (305SBH; around 130 NTU), but these levels were only representative of two storm events, as the site was dry the rest of the year. Turbidity at Betabel Rd. (305SAN) was generally around 30 NTU. Turbidity was slightly higher in the Pajaro River at Chittenden (305CHI), with median values around 50 NTU and a maximum of 174 NTU.

Flow-weighted Turbidity was extremely low on the San Benito River, with median values at both sites of 0 NTU*CFS. The maximum flow-weighted turbidity of 609 NTU*CFS near Hollister (305SBH; January storm event) was similar to the maximum value observed in San Juan Creek at Anzar Rd (517 NTU*CFS; in April). Flow-weighted turbidities in the Pajaro River at Chittenden (305CHI) were generally around 450 NTU*CFS, with a maximum value of 8,723.

Laboratory **Toxicity** analysis indicated no toxic effects to benthic invertebrates in the San Benito River, nor in the Pajaro at Chittenden. Analysis of water samples did not show toxicity to algae or fish in the San Benito River, but the Pajaro at Chittenden site (305CHI) showed impacts to fish growth in January, and to invertebrates in water (either survival or reproduction) during all 2008 toxicity monitoring events. The San Benito River near Hollister (305SBH) did not show toxic effects to invertebrates during either of the storm events when there was water present, but the Betabel Rd site (305SAN) showed toxicity to invertebrate survival in September, and to reproduction in August, 2008.

Results for **other water quality parameters** of interest in the San Benito River:

- Conductivity values were near 1500 µS/cm at 305CHI and 305SBH, and over 2500 µS/cm at 305SAN
- pH averages were around 7.8-8.0 at 305CHI and 305SAN, with a higher average (8.5) at 305SBH
- Dissolved oxygen concentrations were fairly high, with only one concentration below 7 mg/L; most dissolved oxygen saturation results were above 85%, however there were a few exceptions
- Unionized Ammonia as N was low, always below 0.025 mg/L except at 305SBH in January

3.3.3 Source area analysis

Based on Upstream Monitoring results from the San Benito River watershed during 2008, several summarizing statements can be made. An 'at-a-glance' comparison of results among sites for each parameter is provided as box-and-whisker plots, in Appendix D. In summary:

- Flows in the lower San Benito River were low in 2008. Flows from the more upstream site at Highway 156 near Hollister (305SBH) were absent except during storm events, and even these were low (< 5 CFS). Flows near the mouth of the river at Betabel Rd. (305SAN; source(s) unknown) were more consistently present, but still very low (< 2.5 CFS). In general, flows from the San Benito River were very low relative to those occurring in the Pajaro River at Chittenden.

- Nitrate concentrations in the San Benito River were very low (usually <0.5 mg/L) compared to those observed in the Pajaro River at Chittenden, and also much lower than in other tributaries to the upper Pajaro such as Llagas and San Juan Creeks. Though still low compared to other CMP watersheds, nitrate concentrations near Betabel Rd (305SAN) were elevated relative to the site average in rainy/winter months – January through March. Due to the low nitrate concentrations and very low flows, nitrate loads from the San Benito River to the Pajaro were extremely low during 2008 monitoring events.

- Concentration-based turbidity levels in the San Benito River were low relative to many other CMP watersheds, though levels >100 NTU were observed near Hollister (305SBH) during storm events. Turbidities measured at Betabel Rd (305SAN) indicated some level of sediments in the water, however sediment loading (based on flow-weighted turbidities) was generally very low due to low flows. Flow-weighted turbidities in the Pajaro River at Chittenden (305CHI) were an order of magnitude or so higher, indicating other substantial sources of sediment loading.

- No toxicity to fish, algae, or benthic invertebrates was detected in the San Benito River during 2008 (these are not frequently observed in the Pajaro River at Chittenden, 305CHI, either). Due to low flows and lack of invertebrate toxicity during storm events, the San Benito River near Hollister (305SBH) did not appear to be a source of toxicant loading to downstream areas. Sporadic toxic effects to invertebrates in water were observed at the Betabel Rd site (305SAN), however. That said, survival rates never dropped below 30%, and reproduction remained at 70% or greater. These figures plus the relatively low flow rates make it seem unlikely that the San Benito River is a major source of toxicants to the Pajaro River.

The San Benito River does not appear to be an important source area for constituents of concern measured in the Pajaro River at Chittenden. Some impairments were observed at the lowermost San Benito River site, but the low flows make it unlikely that these are important contributions to the Pajaro River. Sources for constituents measured at the San Benito River sites cannot be determined from results of this study.

3.4 Salinas Reclamation Canal

3.4.1 Watershed description

3.4.1.1 Background

The Salinas Reclamation Canal ("Reclamation Canal, " often referred to locally as the "Rec Ditch") drains a large watershed (157 square miles, or 100,480 acres) in northern Monterey county from the Gabilan mountains in the east, westward to the coast where it joins the main Salinas River and flows to Monterey Bay via the Old Salinas River Channel (CCoWS 2005). The Gabilan, Natividad, and Alisal Creeks sub-watershed areas, located east of Salinas, drain to a confluence in Carr Lake, within the city. The combined flows exit Carr Lake as the Reclamation Canal, which later incorporates flows from Santa Rita Creek and the Merrit Lake drainage. Espinosa, Alisal, and Tembladero Sloughs are also part of the Reclamation Ditch watershed, and are located predominantly west of the urban boundary of Salinas.

It is important to understand that much of the land area within the current urban footprint of Salinas, as well as much of the agricultural land west of the city, was historically swampy, and in some cases formed actual lake bottoms which flooded each winter (CCoWS 2005). Small independent projects were undertaken to drain various land areas for urban and agricultural uses, and in 1917 construction began on the Reclamation Canal. The Reclamation Canal would more permanently "reclaim" (via enhanced drainage) the greater watershed land areas in use today. Beyond providing augmented drainage to enhance usable land area, the Reclamation Canal is also often viewed as a flood control system. Several major flood events have occurred since the construction of the Reclamation Canal however, with subsequent efforts to develop recommendations for enhancements. Based on land use data from the past decade, approximately 40% of the Reclamation Canal watershed land area is in crop production, 30% is rangeland, and 6% is in urban/industrial use (CCoWS 2005). Though storm flows can be important during runoff-generating rain events, the vast majority of non-stormwater inputs to the small watersheds east of the Salinas urban boundary (Gabilan, Natividad, and Alisal Creeks, east of Boronda Rd.) are believed to be of irrigated agricultural origin. Groundwater is likely to impact the quality of any irrigation water drawn from wells that is then discharged to the creeks in this area. West of the Salinas urban boundary (Davis Rd. and Highway 101), land use is almost entirely irrigated agriculture. Irrigation tailwater contributes inputs to the Reclamation Canal in this area, as do discharges from tile drain systems which are a major component of the land reclamation efforts described above, speeding the slow natural drainage of the historically swampy area to allow crop production. Urban and industrial inputs contribute to the Reclamation Canal year round, and especially during storm events. These inputs generally occur within the urban footprint of Salinas, though drainage infrastructure conveys industrial inputs outside of the commonly acknowledged urban boundary (into agricultural areas) in a few cases. There is also substantial agricultural acreage within the urban boundary of Salinas, in an area known as Carr Lake.

3.4.1.2 Cooperative Monitoring

Ambient monitoring data collected in the Reclamation Canal at San Jon Rd. (309JON, west of Salinas) between January, 2005 and June, 2007 were assessed during development of this Follow-up project. Data from the tributaries Natividad, Gabilan, and Alisal Creeks (309NAD, 309GAB, and 309ALG, east of Salinas) were also evaluated. These data indicated that levels of the following constituents do not comply with water quality objectives listed in the Basin Plan for one or more beneficial uses: Nitrate, Unionized Ammonia, Dissolved Oxygen Saturation, and Toxicity to Invertebrates in Water and Sediment. Beneficial Uses and Water Quality Objectives associated with these constituents are provided in Tables 3 and 4.

Core CMP sites are currently located on Natividad, Gabilan, and Alisal Creeks to show water quality as discharges leave the eastern agricultural area and enter the city, but there are no sites to show water quality as it leaves the city and re-enters agricultural areas on the west side. The site at San Jon Rd is west of the city, but incorporates additional agricultural inputs. In addition, the site on Alisal Creek east of the city may not be entirely representative of agricultural runoff, as there are some industrial discharges upstream. Finally, urban/industrial inputs from within the city boundaries may be confounded by agricultural additions from the Carr Lake area, which are not addressed in this report. The relative influence of urban versus agricultural discharges on water quality in this area is unclear.

To address Follow-up monitoring requirements in the MRP, monthly monitoring was conducted at two additional sites within the Reclamation Canal watershed, and subsequent data analyses were performed based on results from these sites and the four existing CMP sites, with the following objectives:

- To determine the quality of water from agricultural, urban, and mixed land-use areas of the Reclamation Canal watershed
- To evaluate the relative importance of each source area as a contributor to the constituents measured at 309JON (Reclamation Canal west of Salinas at San Jon Rd)

To these ends, the following Upstream Monitoring sites were established in the Reclamation Canal watershed (Figure 4):

- Alisal Creek at Hartnell Rd (309HRT)
- Salinas Reclamation Ditch at Davis Rd (309AVR)

The Davis Rd site was originally proposed for location at Victor Rd, but was moved west following the initial site inspection, which revealed that the Victor Rd location is still within the urban boundary and may not incorporate all urban/industrial inputs. The Davis Rd location separates mixed urban and agricultural inputs from Salinas and areas east, from the predominantly agricultural inputs to the west.

Core CMP site 309JON is located in the Reclamation Canal at San Jon Rd, west of Salinas. It incorporates drainage from the city of Salinas and all areas east, as well as additional drainage from agricultural lands immediately west of the city.

The Hartnell Rd site (309HRT) is believed to reflect irrigated agricultural inputs better than the core CMP site at La Guardia St (309ALG), due to some non-agricultural industrial drains which enter immediately upstream of 309ALG. It is located where Alisal Creek makes a 90 degree turn under Hartnell Rd and then runs northwest towards the airport and La Guardia St.

Core CMP site 309ALG is located in Alisal Creek near the end of La Guardia St. The water body is a concrete-lined, engineered channel at this point, with a pump station controlling inputs from a tributary ditch slightly downstream. Drains from an industrial area west of Highway 101 run under the highway and contribute inputs just upstream of this site.

Core CMP site 309GAB is located on Gabilan Creek at Boronda Rd, near Independence Blvd. The Gabilan Creek watershed begins in the foothills of the Gabilan Mountains, and primarily drains forested area, rangeland, and irrigated agricultural lands upstream of Boronda Rd. Downstream of Boronda Rd, the creek maintains a narrow riparian area and flows through an urban neighborhood, until reaching the Carr Lake area within the city of Salinas and joining the Reclamation Canal.

Core CMP site 309NAD is located on Natividad Creek at Boronda Rd, near Constitution Blvd. The Natividad Creek watershed is adjacent and similar to the Gabilan. Downstream of Boronda Rd, watershed characteristics are also similar to the Gabilan, except that the creek empties into a small pond on the east side of Laurel Dr, which is then plumbed to the Carr Lake area and ultimately the Reclamation Canal.

All Upstream Monitoring points incorporate at least two unique discharges from unrelated agricultural operations or other sources (discharges entering above the site but below the next most upstream site), and most incorporate more. That is, though located to illuminate source areas within the watershed, no two Upstream Monitoring points reliably isolate discharges from a single source.

3.4.2 Results

The full suite of monitoring results for sites in the Reclamation Canal watershed is provided in Appendices A and B. A site-specific summary of results for the parameters of special interest is provided in Tables 8 and 9 and is discussed here.

Flows in the Reclamation Canal in the absence of rain events were low (< 3 CFS), with the highest median flows occurring at the most downstream sites – the western Salinas boundary at Davis Rd (309AVR) and the Reclamation Canal at San Jon Rd (309JON). Non-storm flows in eastern tributary creeks (Alisal, Gabilan, and Natividad) were even lower, with median rates less than or equal to 0.5 CFS. Gabilan Creek did not have measurable flows during any non-storm monitoring event. Flows during winter months influenced by rain events were higher at all sites by more than a factor of 10, with the highest flows (by a large margin) at the most downstream sites, west of Salinas (83 and 115 CFS at 309AVR and 309JON, respectively). Alisal Creek sites (309ALG and 309HRT) generally had higher flows than the other two eastern tributary sites (309GAB and 309NAD), with flows at the more upstream site at Hartnell Rd (309HRT) comparable to those at La Guardia St (309ALG).

Nitrate concentrations were frequently elevated at all Reclamation Canal area sites, and were generally higher in the tributaries east of Salinas. The highest concentrations were in Natividad Creek (309NAD), with an average of 53.4 mg/L and very high concentrations year-round. Concentrations in Alisal Creek at Hartnell Rd (309HRT) also remained elevated year-round, but concentrations in Alisal Creek at La Guardia St (309ALG) dropped to < 2 mg/L in October and November. Nitrate concentrations were lower at the downstream boundary of Salinas (309AVR, <10 ppm in 8 of 12 events), but then increased slightly further downstream at San Jon Rd (309JON).

Nitrate Loads were highest at the most downstream site, 305JON, which is the expectation for most watersheds barring major removal mechanisms. Nitrate loads from Gabilan and Natividad Creeks were very low (median < 0.1 lbs N/hr) due to low or absent flows. Loads from Alisal Creek at La Guardia St were comparable to those in the Reclamation Canal at Davis Rd on a median basis, with loads in the Reclamation Canal increasing from Davis Rd to San Jon Rd. Median nitrate loads further upstream on Alisal Creek at Hartnell (309HRT, 1.5 lbs N/hr) were roughly half those at La Guardia St (309ALG; 2.8 lbs N/hr).

Orthophosphate concentrations were somewhat elevated, and were comparable among sites grouped as being located either upstream or downstream of Salinas. Concentrations were higher at the sites on tributaries east of the city (median values ~0.5 to 0.8 mg/L), with the Reclamation Canal at La Guardia St having the highest average/median concentration, and Natividad Creek having the lowest. Median orthophosphate levels in the Reclamation Canal downstream of Salinas were around 0.3 mg/L.

Turbidity levels were generally higher in the tributaries east of Salinas with median values from 92 to 1139 NTU. Turbidity was lower in the Reclamation Canal west of Salinas (median ~45 NTU at both sites). Turbidities were noticeably lower in the summer months at all sites, with winter values typically in the 100's and 1000's of NTU's.

Flow-weighted Turbidity results provide a better indicator of sediment loading to the Reclamation Canal than concentration-based Turbidity results. Median flow-weighted turbidities were about twice as high at the most downstream site, 309JON, as they were at the Salinas city boundary (309AVR). On a monthly basis, levels were much higher at 309JON from April through October, but higher at 309AVR in other months. Flow-weighted turbidities were substantially higher in Alisal Creek at Hartnell Rd (309HRT) than at any other site, including Alisal Creek at La Guardia St (309ALG) which is immediately downstream. This suggests that sediment typically drops out of the water column between 309HRT and

309ALG. Gabilan Creek contributed very little sediment loading during 2008 compared to other sites, largely due to the lack of flows.

Laboratory **Toxicity** analysis of sediment samples showed toxicity to *Hyalella* survival in all samples, from all Reclamation Canal and tributary sites sampled (Gabilan Creek was not sampled). All sites also showed toxicity to *C. dubia* survival in water samples, however Natividad Creek (309NAD) and the two sites west of Salinas (309AVR and 309JON) only showed toxicity during two of the four water toxicity monitoring events (309ALG and 309HRT showed toxicity during all four events). Site 309JON showed toxicity to invertebrate reproduction during one of the events in which it did not have survival-based toxicity. Site 309GAB was only sampled once due to lack of flows, with 0% survival rates for *C. dubia* in water for that event. Only the core CMP sites (309JON, 309ALG, 309GAB, 309NAD) were sampled for toxicity to algae or fish, for which there were almost no toxic results (the only exception was to fish growth at 309ALG in August).

Results for **other water quality parameters** of interest in the Reclamation Canal watershed:

- Conductivity values were generally close to 1000 µS/cm east of the city, and closer to 1200 µS/cm west of the city
- pH was around 8.5 west of the city, and notably lower in the eastern tributaries
- Median dissolved oxygen concentrations were generally above 10 mg/L, though somewhat lower at 309NAD and 309HRT; median dissolved oxygen saturations were generally between 90% and 100%, somewhat lower at 309NAD and 309HRT than at the other sites
- Unionized Ammonia as N was generally below 0.025 mg/L, but there were exceedances of this at every site (except 309GAB, which was only sampled once)

3.4.3 Source area analysis

Based on Upstream Monitoring results from throughout the Reclamation Canal watershed during 2008, several summarizing statements can be made. An 'at-a-glance' comparison of results among sites for each parameter is provided as box-and-whisker plots, in Appendix D. In summary:

- Flows in the Reclamation Canal and tributaries were generally low, with higher flows during winter storm events. Flows were highest at the sites west (downstream) of the city of Salinas, increasing further from the City boundary (309AVR) west to San Jon Rd (indicating inputs from that area). The difference in flows between the tributary creeks east of Salinas and flows at 309AVR indicate (as expected) additional inputs within the city boundaries. Gabilan Creek did not contribute much to Reclamation Canal flows during this study, with measurable flows during only one monitoring event. Alisal Creek was a more important source of flows than Natividad Creek, with much of the flow measured at La Guardia St (309ALG) accounted for by flows from upstream at Hartnell Rd (309HRT).

- Nitrate concentrations were frequently above 10 mg/L as N at all Reclamation Canal area sites except Gabilan Creek. Natividad Creek was the most concentrated nitrate source area measured, however Alisal Creek was a more important source of nitrate loading due to higher flows. Much of the nitrate load in Alisal Creek at La Guardia St (309ALG) could often be accounted for by loading from the area upstream of Hartnell Rd (309HRT). In winter months, much of the nitrate load measured in the Reclamation Canal at San Jon Rd could be measured at the Salinas city boundary (309AVR). In summer months however, substantial additional loading from the area immediately downstream of the city boundary was apparent.

- The area above Hartnell Rd on Alisal Creek (309HRT) typically showed the highest concentration-based turbidity levels of all the Reclamation Canal area sites measured in 2008. Additional loading from downstream areas and within the Salinas boundary was apparent however, with much higher loads measured at the sites downstream of Salinas. Additional loading was also apparent from the area immediately west of the Salinas city boundary and upstream of San Jon Rd (309JON), with median flow-weighted turbidities nearly double at San Jon Rd. what they were at Davis Rd (309AVR). Gabilan and Natividad Creeks were comparatively small sources of sediment loading, mainly due to low flows. There may be a substantial sediment sink on Alisal Creek between Hartnell Rd and La Guardia St, as turbidity levels (both concentration-based and flow-weighted) generally declined in the downstream direction there in 2008.

- Toxicity to aquatic invertebrates was observed in both water and sediments at all Reclamation Canal area sites (except in Gabilan Creek, where sediment toxicity samples were not collected due to lack of flows). Alisal Creek appears to have been a more consistent source of toxicity to invertebrates than the other sites, with 0% survival rates at both sites (309HRT and 309ALG) during all four toxicity events. Other sites showed survival-based toxicity to invertebrates in water during only two of the four events. Also, though all sites showed toxic results for invertebrate survival rates in sediment, survival rates were higher outside of Alisal Creek (309HRT and 309ALG had 0% survival; other sites had some surviving *Hyalella*).

At this time, Alisal Creek and Natividad Creek appear to be important source areas of in-stream flow, elevated nitrate and turbidity levels, and aquatic toxicity to the Salinas Reclamation Canal. Land use in this area is overwhelmingly agricultural. The level of impairment on Alisal Creek at Hartnell Rd, which is upstream of all known non-agricultural inputs, suggests an important role for surface runoff from irrigated agriculture. Because measurable flows were so rare in Gabilan Creek, Gabilan does not appear to be an important source area for Reclamation Canal impairments at this time.

Though much of the impairment measured at the lowermost site, 309JON at San Jon Rd, can be explained by inputs from further up the watershed and measurable at Davis Rd. (309AVR), it is also clear that the area between these two sites is an important source area for additional inputs. The only known land use in this reach of the Reclamation Canal is irrigated agriculture.

Finally, all of the flow and constituents measured at Davis Rd., west of Salinas, were not fully explained by the contributions measured from Alisal and Natividad Creeks. This indicates additional source areas, which may include urban storm drains, flows from Santa Rita Creek (another eastern tributary not monitored by the CMP), and/or contributions from the Carr Lake area which is an area of agricultural land use within the otherwise urban boundary of Salinas. All of these other potential sources bear further investigation.

3.5 Quail Creek

3.5.1 Watershed description

Quail Creek is a small watershed in Monterey County which drains to the lower Salinas River. Drainages within the watershed are highly engineered, making accurate watershed delineation difficult. It is currently estimated that the watershed is about 10 square miles (or 6400 acres) in area, the majority of which is in rangeland and irrigated agricultural use.

At this time, all non-stormwater inputs to Quail Creek are believed to be of irrigated agricultural origin. During significant rain events, storm runoff is believed to come from all parts of the watershed. At this time, groundwater is not believed to contribute directly to surface water flows in Quail Creek; however it is likely to impact the quality of any water drawn from wells that is then discharged to the creek.

Ambient monitoring data collected in Quail Creek at Highway 101 (309QUI) between January, 2005 and June, 2007 were assessed during development of this Follow-up project. These data indicated that levels of the following constituents do not comply with water quality objectives listed in the Basin Plan for one or more beneficial uses: Nitrate, Unionized Ammonia, Dissolved Oxygen Saturation, and Toxicity to

Invertebrates in Water and Sediment. Beneficial Uses and Water Quality Objectives associated with these constituents are provided in Tables 3 and 4.

To address Follow-up monitoring requirements in the MRP, monthly monitoring was conducted at three additional sites within the Quail Creek watershed, with the following objectives:

- To determine source areas for constituents of concern measured at site 309QUI (or entering Quail Creek immediately downstream of 309QUI).
- To evaluate the relative importance of each source area as a contributor to the constituents measured at 309QUI (or those entering Quail Creek immediately downstream of 309QUI).

To these ends, the following Upstream Monitoring sites were established in the Quail Creek watershed (Figure 5):

- Quail Creek at Old Stage Road crossing (309UQA)
- Quail Creek at Potter Road crossing (309QUA)
- Quail Creek east of Highway 101 (309QCW, downstream of 309QUI)

The uppermost location, 309UQA, is the most upstream public access point in the watershed. It incorporates drainage from Old Stage Rd. east into the Gabilan foothills, from both the north and south sides of the creek. This site was also monitored by the CCRWQCB's Central Coast Ambient Monitoring Program (CCAMP) from February, 1999 through March, 2000 (CCRWQCB 2000).

The next most upstream location, 309QUA, is the next public access point, moving downstream from 309UQA. It incorporates drainage from 309UQA and from Old Stage Rd. east towards Highway 101, from both the north and south sides of the creek, but stopping short of 101. This site was also monitored by CCAMP from February, 1999 through March, 2000 (CCRWQCB 2000).

The core CMP site (309QUI) incorporates drainage from 309QUA and from additional areas both north and south of the creek on the east side of Highway 101. Inputs from the west side of 101 to this area of the watershed have also been observed at times, and drainage infrastructure is apparent, but it is unclear how common these inputs are in the absence of storm flows.

The third Follow-up site, 309QCW, is downstream of an important tributary ditch which enters Quail Creek downstream of the core CMP site (309QUI) and is thus not accounted for by routine CMP monitoring events. The ditch drains an area entirely north and east of Highway 101 and the Quail Creek channel.

All Upstream Monitoring points incorporate at least two unique discharges from unrelated agricultural operations or other sources (discharges entering above the site but below the next most upstream site), and most incorporate more. That is, though located to illuminate source areas within the watershed, no two Upstream Monitoring points reliably isolate discharges from a single source. It is also important to note that a substantial area near the intersection of Encinal and Old Stage Roads, though in the vicinity of Quail Creek, actually drains to the northwest, away from Quail Creek.

3.5.2 Results

The full suite of monitoring results for sites in the Quail Creek watershed is provided in Appendices A and B. A site-specific summary of results for the parameters of special interest is provided in Table 10 and discussed here.

Flows throughout the Quail Creek watershed were very low in 2008, with the highest flows for any site around 3 CFS. Flows were typically highest at the most downstream site, near the railroad tracks west of Highway 101 (309QCW). Flows were lower at the core CMP site 309QUI (just east of Highway 101).

Flows were comparable to 309QUI at the most upstream site at Old Stage Rd. (309UQA), where flows were also more consistent. At Potter Rd. (309QUA), located between 309UQA and 309QUI on the watershed, flows were lowest of all, averaging 0.14 CFS. All sites on the Quail Creek watershed averaged less than 1 CFS in 2008.

Nitrate concentrations were high at all sites on the Quail Creek watershed, with the only concentrations below 10 mg/L occurring during the January and February winter storm events. All sites averaged over 30 mg/L, with the highest average – 69 mg/L – occurring at the most upstream site (309UQA – Old Stage Rd.). Concentrations were lowest at the most downstream site, west of Highway 101 (309QCW).

Nitrate Loads on the Quail Creek watershed ranged from approximately 0.5 to 3 lbs N/hr on average, with isolated events reaching over 10 lbs N/hr at the two lowermost sites (309QUI and 309QCW). Nitrate loads around 2 lbs N/hr are comparable to loads observed in the upper Salinas River near San Miguel, which has much lower nitrate concentrations but quite a bit more flow when water is present.

Orthophosphate concentrations ranged from 0.15 to 5.9 mg/L as P. Spatial patterns in orthophosphate concentrations were very different than those for nitrates, with the lowest average concentration occurring at Old Stage Rd. (309UQA) and the highest average and median concentrations at Potter Rd. (309QUA).

Turbidity was elevated at all sites, with the highest values at the lowermost sites (core CMP site 309QUI and site 309QCW, west of Highway 101). Turbidities at these two sites averaged over 1000 NTU. The uppermost sites, at Potter Rd. and Old Stage Rd. (309QUA and 309UQA), both had maximum turbidities over 1000 NTU, but had median values below 100 NTU.

Spatial patterns in **Flow-weighted Turbidity** were predictable, given that both contributing factors (turbidity and flow) exhibited the same spatial pattern. The most downstream site, 309QCW, exhibited by far the highest flow-weighted turbidity levels. By comparison, flow-weighted turbidities at 309QCW were about 10% (on average) of those in the mainstem Salinas River at Bradley, even though average flows at Bradley were over 300 times greater.

Laboratory **Toxicity** analysis of water and sediment samples indicated toxicity to both aquatic and benthic invertebrates, at all sites on the Quail Creek watershed in 2008. Survival rates for Hyalella in sediment were 0% at all sites, as were survival rates for *C. dubia* in water during all four water toxicity sampling events. The only exception to this was at the most downstream site (309QCW) in August, when the survival rate was 100%. That sample did show toxicity to invertebrate reproduction, however. Toxicity to algae and fish were assessed only at the core CMP site (309QUI), and showed only one significant (toxic) result, which was for fish growth in August.

Results for **other water quality parameters** of interest in the Quail Creek watershed:

- Conductivity values averaged over 1100 μS/cm
- pH averaged 8.0
- Dissolved oxygen concentrations were generally between 5 and 12 mg/L; most dissolved oxygen saturations were above 85%, but these fell below 85% on at least one occasion at all sites
- Unionized Ammonia levels were above 0.025 mg/L as N on several occasions

3.5.3 Source area analysis

Based on Upstream Monitoring results from throughout the Quail Creek watershed during 2008, several summarizing statements can be made. An 'at-a-glance' comparison of results among sites for each parameter is provided as box-and-whisker plots, in Appendix D. In summary:

- Flows in Quail Creek watershed were very low. Flows from the upper watershed (Old Stage Rd., 309UQA) were small and consistent, but major source areas for flows appear to have been in the lower part of the watershed, entering below the Potter Rd. station (309QUA) and also entering below the core CMP site (309QUI). A lengthy stretch of wetted channel in the area downstream of Old Stage Rd. and upstream of Potter Rd. is densely vegetated, and has anecdotally been observed to retard flows in the channel for up to 7 hours. This likely explains the numerous occasions on which flows at Potter Rd. (309QUA) were lower than at the upstream site at Old Stage Rd. (309UQA).

- The upper area of the Quail Creek watershed (above Old Stage Rd.) appears to have been a frequent source area for highly concentrated nitrates, however this was not an exceptional source area in terms of nitrate loading. Other watershed areas were also important contributors to nitrate loads, due to higher flows.
- Turbidity levels were elevated throughout the watershed, but the major source areas for suspended sediments, both in terms of concentration and loads, tended to be in the lower half of the monitoring area (below Potter Rd. and the core CMP site).
- Toxicity to aquatic and benthic invertebrates was high throughout the watershed (all but one survival rate for *C. dubia* were 0%). On one occasion, inputs below the core CMP site (draining to 309QCW, west of Highway 101) did not appear to contribute to aquatic toxicity, as survival rates increased from 0% to 100% moving from 309QUI downstream to 309QCW and incorporating substantial additional flow volume.

At this time, the primary source of in-stream flow and constituents to all monitoring sites in the Quail Creek watershed appears to be surface runoff from irrigated agriculture. Though other sources may exist, none were identified during the course of this study.

3.6 Chualar Creek

3.6.1 Watershed description

Chualar Creek is a small watershed in Monterey County which drains to the lower Salinas River. Drainages within the watershed are highly engineered, making accurate watershed delineation difficult. The core CMP site (309CRR) is located on the north branch of Chualar Creek. A southern branch is believed to drain about 60% more watershed area, but the confluence of the two branches is downstream of 309CRR. It is currently estimated that the watershed is about 15 square miles (or about 9600 acres) in area, the majority of which is in rangeland and irrigated agricultural use.

At this time, all non-stormwater inputs to Chualar Creek are believed to be of irrigated agricultural origin. During significant rain events, storm runoff is believed to come from all parts of the watershed. At this time, groundwater is not believed to contribute directly to surface water flows in Chualar Creek; however it is likely to impact the quality of any water drawn from wells that is then discharged to the creek.

Ambient monitoring data collected in Chualar Creek at Highway 101 (309CRR) between January, 2005 and June, 2007 were assessed during development of this Follow-up project. These data indicated that levels of the following constituents do not comply with water quality objectives listed in the Basin Plan for one or more beneficial uses: Nitrate, Unionized Ammonia, Dissolved Oxygen Saturation, and Toxicity to Invertebrates in Water and Sediment. Beneficial Uses and Water Quality Objectives associated with these constituents are provided in Tables 3 and 4.

To address Follow-up monitoring requirements in the MRP, monthly monitoring was conducted at three additional sites within the Chualar Creek watershed, with the following objectives:

- To determine source areas for constituents of concern measured at site 309CRR (or entering via the south branch of Chualar Creek).

- To evaluate the relative importance of each source area as a contributor to the constituents measured at 309CRR (or those entering via the south branch of Chualar Creek).

To these ends, the following Upstream Monitoring sites were established in the Chualar Creek watershed (Figure 6):

- Chualar Creek, north branch at Old Stage Rd (309NOS)
- Chualar Creek, south branch, west side of Hwy 101 (309SBC)
- Chualar Creek, south branch at Old Stage Rd (309SOS)

The Old Stage Rd locations, 309NOS and 309SOS, are among the uppermost public access points in the watershed. These incorporate drainage from Old Stage Rd east into the Gabilan foothills. Drainage to 309SOS is not incorporated at the core CMP site (309CRR), which is located on the north branch of Chualar Creek.

The south branch location on the west side of Highway 101 (309SBC) is the only public access point on the south branch besides 309SOS. It incorporates drainage from 309SOS, and from the area from Old Stage Rd west towards Highway 101. From 309SOS, the south branch of Chualar Creek flows northwest along the railroad tracks, to a confluence with the north branch, located just northwest of the culvert which conveys the north branch under Highway 101.

The core CMP site (309CRR) incorporates drainage from 309NOS and from the area from Old Stage Rd west towards Highway 101. The northern and southern bounds of the drainages to both the north and south branches of Chualar Creek are uncertain.

All Upstream Monitoring points incorporate at least two unique discharges from unrelated agricultural operations or other sources (discharges entering above the site but below the next most upstream site), and most incorporate more. That is, though located to illuminate source areas within the watershed, no two Upstream Monitoring points reliably isolate discharges from a single source.

3.6.2 Results

The full suite of monitoring results for sites in the Chualar Creek watershed is provided in Appendices A and B. A site-specific summary of results for the parameters of special interest is provided in Table 11 and discussed here.

Flows throughout the Chualar Creek watershed were very low in 2008, with all sites averaging less than 1 CFS. A substantially higher flow (10.55 CFS) was measured at the more upstream site on the north branch of the creek (309NOS) during the February storm event. Median flows were highest at the two south branch sites (309SOS and 309SBC) however, with much more consistent flows on the south branch than on the north branch. This is an important point, as south branch flows are not captured by the core CMP site 309CRR. Site 309CRR was dry during 5 of the 12 monitoring events; 309NOS was dry during 8 events.

Nitrate concentrations were very high throughout the Chualar Creek watershed in 2008, with all sites averaging over 20 mg/L. Median nitrate concentrations were highest at the uppermost south branch site at Old Stage Rd (309SOS, median = 42.5 mg/L). Concentrations at the core CMP site 309CRR were the lowest on the watershed according to all metrics. The only concentrations observed below 10 mg/L occurred at 309CRR during winter storm events.

Spatial patterns in instantaneous **Nitrate Loads** depending on the descriptive metric used. On average, loads were comparable among sites, with the lowest occurring at 309CRR (1.5 lbs N/hr). Site-specific maximum loads were highest at site 309NOS on the north branch, and median loads were highest at the two south branch sites – 309SOS and 309SBC (and comparable to each other). It is also of note that although 309NOS had the highest maximum load, it also had the lowest median load, due to the fact that it was dry during 8 of the 12 monitoring events.

Orthophosphate concentrations were substantial at all sites, with the highest median values at the two north branch sites (309CRR and 309NOS, 1.0 and 1.1 mg/L as P respectively). In general, orthophosphate concentrations were comparable between sites within each branch of the watershed.

Turbidity was elevated at all sites on the Chualar Creek watershed in 2008. Average and median concentrations were comparable between sites within each branch of the watershed, and were somewhat higher at the north branch sites (309CRR and 309NOS, ~2300->3000 NTU) than at the south branch sites (309SBC and 309SOS, ~300-800 NTU). All sites had at least one Turbidity result that was too high for the field equipment to measure (>3000 NTU), except for the more downstream south branch site (309SOS), which had a maximum turbidity of 712 NTU.

Flow-weighted Turbidity results were generally comparable between sites within each branch of the watershed, however spatial patterns based on average values were opposite those based on median values. Average flow-weighted turbidities were higher by an order of magnitude on the north branch (309CRR and 309NOS), but median values were higher on the south branch (309SBC and 309SOS). This is probably driven by the fact that the two north branch sites, and especially 309NOS, were dry during many monitoring events, resulting in several flow-weighted turbidities of 0 NTU*CFS.

Laboratory **Toxicity** analysis of water samples showed toxicity to invertebrate survival at all sites, with 0% survival rates in all samples from 309NOS and 309SBC. There were toxic results in all samples from 309CRR and 309SOS as well, with the exception of a 125% survival rate at 309SOS and a 100% survival rate at 309CRR, both in January. The only site showing sediment toxicity in 2008was 309SOS on the south branch at Old Stage Rd. Algae and fish toxicity were assessed only at the core CMP site 309CRR, which showed toxicity to algae in one of four samples, and no toxicity to fish.

Results for **other water quality parameters** of interest in the Chualar Creek watershed:

- Conductivity values averaged about 1200 to 2500 μS/cm
- pH averaged 8.1
- Dissolved oxygen concentrations were generally high, with only two results much below 7 mg/L; dissolved oxygen saturations were generally above 85%, with a few values between 60 and 84%
- Unionized Ammonia results showed levels >0.025 mg/L as N in one or more samples at every site

3.6.3 Source area analysis

Based on Upstream Monitoring results from throughout the Chualar Creek watershed during 2008, several summarizing statements can be made. An ‘at-a-glance’ comparison of results among sites for each parameter is provided as box-and-whisker plots, in Appendix D. In summary:

- Flows throughout the Chualar Creek watershed were very low. The south branch (which does not contribute to the core CMP site) was a greater source of flow than the north branch, though the differences in flow among sites were generally not statistically significant. On several occasions, especially on the north branch, flows *declined* in the downstream direction, suggesting an in-stream sink or retention mechanism.

- Though nitrate concentrations were high at all sites in the Chualar watershed, the area draining to the south branch site at Old Stage Rd. appears to have been the most highly concentrated source of nitrate during most events. The more downstream south branch site, west of Highway 101, was somewhat more important in terms of loading though, as flows were higher there.

- Turbidity levels were elevated throughout the watershed, but the greater source areas for suspended sediments, both in terms of concentration and loads (i.e. flow-weighted), tended to be on the north branch. Turbdity was lowest at the most downstream site on the south branch; there may be a sink or retention mechanism for sediments east of Highway 101, where the channel widens before crossing under the highway.
- Toxicity to aquatic invertebrates was high throughout the watershed, with all but two samples showing toxic effects, indicating source areas for water-borne toxicants throughout the watershed. Though toxicity to benthic invertebrates (in sediment) has been observed at the core CMP site in the past, it was only apparent at the upper south branch site (309SOS) in 2008. All other sites had high survival rates in the 2008 sediment toxicity tests.

At this time, the primary source of in-stream flow and constituents to all monitoring sites in the Chualar Creek watershed appears to be surface runoff from irrigated agriculture. Though other sources may exist, none were identified during the course of this study.

3.7 Upper Salinas River

3.7.1 Watershed description

The Salinas River watershed encompasses nearly 4,600 square miles (nearly 3 million acres), and runs northwest from its headwaters near Santa Margarita Lake in San Luis Obispo County to where it empties into Monterey Bay, near Castroville in Monterey County (CCRWQCB 2000).

Discussion of the Salinas River watershed is generally facilitated by reference to a “lower Salinas watershed” (river mouth upstream to Bradley) and an “upper Salinas watershed” (Bradley upstream to the headwaters). The lower Salinas watershed and Salinas Reclamation Canal areas are heavily monitored by the CMP, with 17 core sites monitored on a monthly basis. The most upstream of these is located on the main stem of the Salinas River at Elm Rd in Greenfield, which is approximately 40 miles downstream of Bradley. Just upstream of Bradley, the San Antonio and Nacimiento Rivers join the Salinas River from the west, contributing large flow volumes throughout much of the year. The Estrella and Arroyo Grande Rivers are also considered main tributaries to the Salinas River, however surface water connectivity between these water bodies and the Salinas is less consistent than from the San Antonio and Nacimiento Rivers, which carry release flows from major reservoirs. Land use in the upper Salinas watershed includes vegetable row crops in the area between Greenfield and Bradley, as well as large acreages of vineyards and rangeland throughout the watershed. Urban areas include the cities of Greenfield, King City, San Miguel, Paso Robles, Templeton, and Atascadero. There are also two military bases (Fort Hunter Liggett and Camp Roberts), and exploitation of mineral and oil reserves around San Ardo.

Ambient monitoring data collected in the Salinas River at Greenfield (309GRN) between January, 2005 and June, 2007 were assessed during development of this Follow-up project. These data indicated that levels of the following constituents do not comply with water quality objectives listed in the Basin Plan for one or more beneficial uses: Nitrate as N, Toxicity to Invertebrates in Water and Sediment. Beneficial Uses and Water Quality Objectives associated with these constituents are provided in Tables 3 and 4.

To address Follow-up monitoring requirements in the MRP, monthly monitoring was conducted at 3 additional sites within the upper Salinas River watershed, with the following objectives:

- To characterize water quality in the upper Salinas River watershed and one major tributary, which drain a large area and are not monitored as part of the core CMP.
- To determine if the upper Salinas River is a source area for constituents of concern measured in the Salinas River at Greenfield.

To these ends, the following Upstream Monitoring sites were established in the upper Salinas watershed (Figure 7):

- Salinas River at Bradley (309USA)
- Salinas River at East Garrison exit off Highway 101 (309SUN)
- Estrella River at Estrella River Rd. (309ESE)

The Salinas River at Bradley (309USA) site is immediately downstream of the confluences with the tributary rivers San Antonio and Nacimiento. Releases from the reservoirs on each of these tributaries should contribute to flows at this site that are more consistent than is characteristic of other areas of the Salinas River.

The Salinas River at East Garrison site (309SUN) is on the main stem of the Salinas River, upstream of the San Antonio and Nacimiento confluences and downstream of the cities of San Miguel and Paso Robles. It is adjacent to the Camp Roberts military base. This site should represent inputs from the entire upper watershed, prior to major additions of reservoir release waters.

The core CMP site in the Salinas River at Greenfield (309GRN) is located at the Elm Rd crossing. Flows at this site are dominated by the reservoir releases entering the river at Bradley. However, the approximately 25 mile stretch of valley floor from Greenfield south to San Ardo (downstream of Bradley) includes substantial irrigated agriculture, which may contribute additional inputs.

The Estrella River at Estrella River Rd site (309ESE) is considered one of the major tributaries to the Salinas River. The location 309ESE is well upstream of the confluence with the Salinas, and typically has water present, whereas downstream areas do not (i.e. there is typically not surface water connectivity between this site and the Salinas River). Usually, CMP protocol is not to collect samples if waters at the monitoring site are not contiguous with downstream waters (this is to prevent attribution of water quality issues to discharge which are really the result of ponding and/or stagnation of water). Due to the lack of water quality information for this area, the temporary nature of this project, and interest expressed by area growers, samples were collected at this site, in exception of standard protocols. Results should be interpreted with caution.

3.7.2 Results

The full suite of monitoring results for sites in the Upper Salinas watershed is provided in Appendices A and B. A site-specific summary of results for the parameters of special interest is provided in Table 12 and discussed here.

Flows in the Salinas River at Greenfield (309GRN) were very high compared to other CMP sites (median 220 CFS), except during the September and October monitoring events, at which points the site was dry. Flows were somewhat higher and more consistent upstream at Bradley (309USA; median 277 CFS). Further upstream near San Miguel (309SUN), just upstream of the Nacimiento and San Antonio River confluences, flows were much lower (0 to 77 CFS) and the site was dry from May to December. Flows from on the Estrella River (309ESE) were very low (usually < 0.5 CFS), including four late summer/fall months when water was present but flows were 0 CFS due to immeasurably low water velocity.

Nitrate concentrations were generally low at 309GRN (<3.0 mg/L), except in April when the measured concentration was 12.3 mg/L as N. Nitrate concentrations were even lower at 309USA, 309SUN, and 309ESE, with all results below 2.0 mg/L and several non-detects. The average nitrate concentration was below 1.0 mg/L at all of the upstream sites, and was 2.25 mg/L at 309GRN.

Instantaneous **Nitrate Loads** generally increased in the downstream direction. Loads were highest at 309GRN (median 15.5 lbs N/hr), intermediate at 309USA (Bradley; median 7.1 lbs N/hr), and very small at 309SUN and 309ESE due to low flows.

Orthophosphate was less than 0.6 mg/L at all sites, with the highest values at 309ESE and at the core CMP site (309GRN). It is not clear if any one site in the group should be ranked above another, however, as maximum, average, and median metrics each emphasize different sites in this case.

Turbidity was elevated at all sites during the January, 2008 storm event, with values from 1097 NTU to >3000 NTU. Throughout the year, turbidity was generally lowest at 309USA (Bradley; median 18 NTU), and highest at 309GRN (median 56 NTU). Values were intermediate at 309SUN and 309ESE.

Flow-weighted Turbidity values were considerably higher at the core CMP site (309GRN) than at other sites, and generally reflected patterns in flow. The spatial Flow-weighted Turbidity pattern differed from the Nitrate Load pattern in that instantaneous Nitrate Loads were higher at 309SUN than at 309ESE, whereas Flow-weighted Turbidity was higher at 309ESE. This is probably due to the extremely low Nitrate concentrations at 309ESE.

Laboratory **Toxicity** analysis on water samples showed no impacts to algal growth or to sediment-dwelling invertebrates at the core CMP site 309GRN or any of its upstream sites, with the exception of one Estrella River sample showing toxicity to algae at 309ESE. There was toxicity to invertebrates in water at 309GRN in all of the three samples collected there, with two of these showing impacts to reproduction and the other showing low survival. Site 309USA also showed toxicity to invertebrate survival in water on one occasion, and both 309USA and 309ESE showed impacts to reproduction in at least one sample. Site 309SUN showed no invertebrate toxicity in either of the two samples collected there. Impacts to fish related to survival and/or growth rates were found in at least one sample at each site, including two low survival rates at 309GRN. Toxicity to fish is somewhat uncommon in the CMP results relative to invertebrate toxicity. That toxicity to fish was observed at all Upper Salinas sites may indicate unique sources of toxicity in this region. This could be an area for further study; data from this project do not facilitate speculation in this regard.

Results for **other water quality parameters** of interest in the Upper Salinas watershed:

- Conductivity values averaged just over 800 µS/cm
- pH averaged 8.2
- Dissolved oxygen concentrations were generally above 9 mg/L, with a few exceptions at 309ESE; all saturation results were above 85% (with a few exceptions at 309ESE)
- Unionized Ammonia as N was low, except at 309USA in September and October, when it exceeded 0.025 mg/L as N

3.7.3 Source area analysis

Based on Upstream Monitoring results from throughout the Upper Salinas watershed during 2008, several summarizing statements can be made. An 'at-a-glance' comparison of results among sites for each parameter is provided as box-and-whisker plots, in Appendix D. In summary:

- Flows in the Salinas River at Bradley (309USA) and downstream were much higher than at other CMP sites, due to releases from the San Antonio and Nacimiento Reservoirs. The Salinas River above Bradley does not appear to have been a source of surface flows to downstream areas from May through December, and the January through April flows were much lower than those from the reservoirs. The Estrella River, a tributary to the upper Salinas, generally does not have surface flow connectivity from the Upstream Monitoring site (309ESE) to its confluence with the Salinas. Flows at Greenfield (309GRN) appear to be influenced primarily by reservoir releases, with little or no additional input volume in the reach between Bradley and Greenfield (flows actually declined slightly within this reach).

- Nitrate concentrations were lower at all upper Salinas sites than at the core CMP site at Greenfield (309GRN), and much lower than in the small tributary sub-watersheds of the lower

Salinas (e.g. Quail Creek, Chualar Creek). Loads were also lower at the upper Salinas sites than at Greenfield. Loads from Bradley (309USA) accounted for about one third to one half of the loads observed downstream at Greenfield, with a very small portion coming from the Salinas above Bradley and/or upper tributaries. The reach between Bradley and Greenfield is, therefore, also an important source area for nitrates, despite the negligible contributions to flow in this reach. The substantial loading from the Bradley area is explained by high flows due to reservoir releases, as nitrate concentrations were relatively low.

- The upper Salinas and Estrella Rivers became very turbid with rain events in 2008, with lower (though not insignificant) turbidity levels during other months. These appeared to be important source areas for sediment loads (flow-weighted turbidities) observed at the core CMP site at Greenfield, however flow-weighted turbidities were lower in the upstream areas, indicating additional loading in the reach between Bradley (309USA) and Greenfield (309GRN).

Though the Salinas River at Greenfield (309GRN) ranks fairly low among Salinas watershed sites in terms of aquatic toxicity, toxic effects are observed there sporadically. In 2008, neither 309GRN nor the upper Salinas Upstream Monitoring sites showed toxicity to invertebrates in sediment, and there was only one incidence of toxicity to algae in water. Sporadic effects were observed to invertebrates in water at every site except 309SUN (Salinas above Bradley) however, with effects to fish at every site, including low survival rates occurring in February and August at both Greenfield (309GRN) and Bradley (309USA). Based on this information, the upper Salinas River should not be ruled out as a source of aquatic toxicity observed at downstream CMP sites. Toxicity to fish is somewhat uncommon in the CMP results relative to invertebrate toxicity. That toxicity to fish was observed at all Upper Salinas sites may indicate unique sources of toxicity in this region. This could be an area for further study; data from this project do not facilitate speculation in this regard.

At this time, the primary source of in-stream flow to the Upper Salinas River appears to be contributions from the San Antonio and Nacimiento Rivers. Increased nitrate concentrations and toxicity to aquatic organisms between Bradley and Greenfield, without concurrent increases in flow, suggest highly-concentrated, low-volume discharges from this area. This reach of the Salinas covers a large area encompassing multiple land uses including irrigated agriculture, urban areas, rural residences and oil fields. Though data from this study clearly identified this reach as a source of impairments, additional monitoring would be required to clearly identify sources/source areas within the reach given the diversity of land uses present.

4 SMU UPSTREAM MONITORING RESULTS

Upstream Monitoring in the SMU in 2008 included six watersheds (or sub-watershed areas), five of which could be described as “agricultural watersheds of concern” based on substantial agricultural land use, and on core CMP results from 2005 through mid-2007 showing impairment. These are: Glen Annie Creek (Goleta), lower Santa Ynez River (Lompoc), Orcutt-Solomon Creek and Green Valley (Santa Maria), and Oso Flaco Creek (Guadalupe/Santa Maria). With the exception of Oso Flaco Creek, all of these could also be characterized as “mixed land use” watersheds, with some uncertainty as to agricultural versus other sources for constituents of concern measured at core CMP sites. Finally, the upper Santa Ynez watershed is a large “upper watershed area,” with core CMP sites located much further downstream, and a lack of locally-relevant core CMP data to characterize water quality therein. This area was monitored in 2008 to evaluate potential sources for constituents of concern to the lower watershed areas.

The six watershed areas described above were monitored monthly during 2008, in conjunction with each core CMP monitoring event. Results were reported quarterly to the CCRWQCB, and are included in Appendix A of this report. Results for key parameters which can be directly related to agricultural discharges were analyzed in more detail, as discussed in section 2.5 above (Data Analysis), and presented in each watershed sub-section below. In general, both parametric and non-parametric analyses identified significant spatial differences in water quality within most of the watersheds examined. Results of statistical analyses are provided in Appendices C and D, with more basic descriptive statistics provided in a table for each watershed sub-section below. For readability, narrative discussions are limited to basic descriptive statistics; please refer to Appendix C to review results of hypothesis testing regarding differences between sites.

4.1 Glen Annie Creek

4.1.1 Watershed Description

Glen Annie Creek forms the upper portion of a small watershed (~6 square miles or 3800 acres, with the lower portion known as Tecolotito Creek) which drains into Goleta Slough, and ultimately to the Pacific Ocean. Glen Annie Creek is generally believed to be the most important agricultural stream in the ~45 square mile Goleta Slough watershed, and a major source of nutrients to the slough (SBCK 2005). Glen Annie Creek is located in the foothills of the Santa Ynez mountain range, where marine sediments in the local geology often lead to high background conductivities (total dissolved solids) in surface waters (SBCK 2005). The uppermost part of the watershed appears to reach northward into the Los Padres National Forest, however the main creek channel is located in the foothill area which is largely in agricultural land use (citrus and avocado orchards, and nurseries). Some rural-residential land use exists in the area as well. Lower in the watershed, there is a golf course and then land use becomes more urban, however these areas are downstream of the CMP site (315GAN).

Some water for agriculture in the Goleta area is derived from the underlying groundwater basin via private wells, which may affect water quality in any surface discharges from irrigation. However, irrigated agriculture is also a major user of Goleta Water District supplies, which are derived primarily from the Cachuma Project and the State Water Project, both of which store water in Cachuma Lake on the Santa Ynez River and deliver to the Goleta area via the South Coast Conduit tunnel, with subsequent storage in the Glen Annie Reservoir. This water is treated at the Corona Del Mar Water Treatment Plant, which is located at the upstream end of the Glen Annie Creek watershed.

Ambient monitoring data collected in Glen Annie Creek (315GAN) between January, 2006 and June, 2007 were assessed during development of this Follow-up project. These data indicated that levels of the following constituents do not comply with water quality objectives listed in the Basin Plan for one or more beneficial uses: Nitrate and Toxicity to Algae in Water. Beneficial Uses and Water Quality Objectives associated with these constituents are provided in Tables 3 and 4.

To address Follow-up monitoring requirements in the MRP, monthly monitoring was conducted at one additional site within the Glen Annie watershed, with the following objectives:

- To determine source areas for constituents of concern measured at site 315GAN.
- To evaluate the relative importance of each source area as a contributor to the constituents measured at 315GAN.

To these ends, the following Upstream Monitoring site was established in the Glen Annie watershed (Figure 8):

- Glen Annie Creek at Bishop Ranch Rd (315GBR)

The Bishop Ranch Rd location (315GBR) is the only point upstream of the core CMP site on Glen Annie Creek (315GAN) for which public access could be acquired, and even this was somewhat limited. This location incorporates drainage from the mountainous upper watershed area, and is upstream of the majority of agricultural acreage. That said, there is some orchard acreage upstream of this site, and a small tributary enters upstream from the northeast. The Glen Annie Reservoir, Corona Del Mar Water Treatment Plant, and a South Coast Edison power substation are also located immediately upstream of 315GBR.

The core CMP site (315GAN) incorporates drainage from 315GBR and from areas between the two sites, immediately east and west of the Glen Annie Creek channel. The creek channel runs in the general vicinity of Glen Annie Rd in this region, and the drainage area is constrained by steep, canyon-like topography to both the east and west. No major tributaries downstream of 315GBR, which may contribute to water quality at the core CMP site (315GAN), could be identified.

All Upstream Monitoring points incorporate at least two unique discharges from unrelated agricultural operations (discharges entering above the site but below the next most upstream site), and most incorporate more. That is, though located to illuminate source areas within the watershed, no two Upstream Monitoring points reliably isolate discharges from a single source.

4.1.2 Results

The full suite of monitoring results for sites in the Glen Annie watershed is provided in Appendices A and B. A site-specific summary of results for the parameters of special interest is provided in Table 13 and discussed here.

Flows at the Upstream Monitoring site at Bishop Ranch Rd (315GBR) were extremely low (except during the January storm event), and always lower than at the core CMP site (315GAN). Typical/median flows for the upstream site were 0.1 CFS, with median flows at the core CMP site of 0.4 CFS. With the exception of storm event outliers at both sites, the range of flows observed at each site was very small.

Nitrate concentrations at the Upstream Monitoring site 315GBR were very low compared to those at the core CMP site. Concentrations at 315GBR were never above 1.4 mg/L as N, and were always less than 10% of those at the core CMP site (315GAN), except during the January storm event. Nitrate concentrations at the core site were higher, with a maximum of 31 mg/L as N and a median of 17.3.

Instantaneous **Nitrate Load** patterns were predictable, given the lower flows and lower nitrate concentrations at the more upstream site at Bishop Ranch Rd (315GBR). Maximum loads at both sites occurred during the January storm event, with loads of 52 lbs N/hr at the core CMP site (315GAN) and 4.2 lbs N/hr at the upstream site (315GBR). Median loads were 1.6 and 0.01 lbs N/hr at these two sites, respectively.

Orthophosphate concentrations were usually low at both sites on the Glen Annie watershed during 2008, and were usually quite similar between the two sites. The maximum concentration observed at either site was 0.4 mg/L as P, and median concentrations were 0.07 mg/L at the core CMP site (315GAN) and 0.1 mg/L at the upstream site off Bishop Ranch Rd (315GBR).

Turbidity levels were very similar among sites on the Glen Annie watershed in 2008. Both sites had very high turbidities during the January storm event (2000 to >3000 NTU). But on a more regular basis, turbidity levels were typically < 10 NTU, both at the core CMP site (315GAN) and at the upstream site at Bishop Ranch Rd (315GBR).

Flow-weighted Turbidity values on the Glen Annie watershed in 2008 followed patterns in flow, as concentration-based turbidities were usually similar between the two sites. That is, flow-weighted turbidity (or sediment loading) increased in a roughly proportional manner from the upstream site at Bishop Ranch Rd (315GBR) to the core CMP site (315GAN). Maximum flow-weighted turbidities of about 26,000 to 29,000 NTU*CFS occurred during the January storm event, and otherwise were 3 to 6 orders of magnitude lower during other monitoring events. Neither reach of the watershed, as segmented by the core CMP site (315GAN) and the Follow-up site (315GBR), stands out as a much greater source of sediment loading than the other.

Toxicity analysis at the Upstream Monitoring site (315GBR) was limited to algal cell growth, due to the lack of history of toxicity to invertebrates or fish at the core CMP site prior to 2008. The core CMP site (315GAN) has a strong history of toxicity to algae, which is not very common among CMP sites. In 2008, toxicity to algae was observed during three of the four toxicity monitoring events at the core CMP site, with the non-toxic sample being collected during the January storm event. Toxicity to algae was observed during only one of the four monitoring events at the upstream site (Bishop Ranch Rd, 315GBR). Toxicity to fish or to invertebrates in sediment was not observed at the core CMP site in 2008, however toxicity to invertebrates in water was observed during all four events there (primarily reproductive effects).

Results for **other water quality parameters** of interest at core CMP site 315GAN:

- Conductivity values were typically around 1200 µS/cm at 315GBR and around 2100 µS/cm at 315GAN
- pH was typically 7.6 to 7.8
- Dissolved oxygen concentrations were almost entirely above 7 mg/L, however dissolved oxygen saturation was below 85% in 5 samples 315GBR and in 7 samples at 315GAN
- Unionized Ammonia as N was very low, never reaching even 0.01 mg/L at either site

4.1.3 Source area analysis

Based on Upstream Monitoring results from throughout the Glen Annie Creek watershed during 2008, several summarizing statements can be made. An 'at-a-glance' comparison of results among sites for each parameter is provided as box-and-whisker plots, in Appendix D. In summary:

- Flows throughout the Glen Annie Creek watershed were extremely low, except during the January storm event. It is clear that the upper watershed (upstream of Bishop Ranch Rd, 315GBR) is a consistent source of very low flows to downstream areas. The reach downstream of 315GBR but upstream of the core CMP site (315GAN) was a comparable, or perhaps slightly more important, source of flows in 2008.

- Nitrate concentrations were much lower at the upstream site (315GBR) than at the core CMP site (315GAN). The reach downstream of 315GBR and upstream of the core CMP site was clearly the dominant source of concentrated nitrates in this watershed area.

- Turbidity levels throughout the Glen Annie Creek watershed were extremely low, except during the January storm event. The upper watershed (upstream of Bishop Ranch Rd, 315GBR) showed comparable turbidity levels to the core CMP site (315GAN). Due to slightly higher flows, the reach downstream of 315GBR but upstream of the core CMP site (315GAN) may have been a slightly more important source of sediment loading in 2008. Neither watershed segment stands out in a dramatic way, however.
- Areas upstream of the core CMP site on Glen Annie Creek (315GAN) were sources of toxicity to algae and to invertebrates in water in 2008. The reach between the core CMP site and the more upstream site at Bishop Ranch Rd (315GBR) was probably a more important source of toxicity to algae than the upper watershed, as site 315GBR only showed toxicity to algae on one occasion. Source areas for toxicity to invertebrates in water are uncertain, as this was not evaluated upstream of the core CMP site, due to a lack of history of that kind of toxicity in the watershed.

At this time, the reach upstream of the core CMP site (315GAN) and downstream of Bishop Ranch Rd. (315GBR) appears to be the source area for all high nitrate concentrations observed during 2008, and almost all of the toxicity to algae. Surface runoff from irrigated agriculture is not visible from public access points in this watershed, however primary land uses in this reach are agricultural and rural residential. Though other sources may exist, none were identified during the course of this study. Sources for toxicity to invertebrates could not be evaluated because no samples for this constituent were collected at the upstream site due to lack of history of toxicity to invertebrates in water at the core CMP site.

4.2 Santa Ynez River

4.2.1 Watershed Description

The Santa Ynez River drains a large watershed (about 890 square miles, or 574, 885 acres) in Santa Barbara County, originating in the Los Padres National Forest and terminating west of the city of Lompoc at the Pacific Ocean (CCRWQCB 2007). The upper watershed area includes three reservoirs, the most downstream of which is the Cachuma Reservoir, which was constructed as part of the 1950's "Cachuma Project," whose purpose is to provide supplemental water for agricultural irrigation and for municipal areas of southern Santa Barbara County (USBR 2009). The Cachuma Reservoir stores and moderates the release of floodwaters of the upper Santa Ynez watershed, which would otherwise flow quickly to the ocean.

Below the Cachuma Reservoir, land use in the Santa Ynez watershed includes open space and rangeland, irrigated agriculture, and the cities of Santa Ynez, Solvang, and Buelton. Further downstream and west, the Santa Ynez River runs along the northern urban boundary of Lompoc. The river course west of Lompoc is bordered on the south by an area of more intensively farmed agricultural land, and on the north by the Vandenburg Air Force Base. The city of Lompoc's WWTP discharges to the Santa Ynez River via Miguelito Creek, and these discharges often dominate local flows in the river.

There are several major tributaries to the Santa Ynez River, both above and below the Cachuma Reservoir. During parts of the year however, flows reaching the lower end of the watershed (near Lompoc) are minimal. The reach near Lompoc around Highway 1 is frequently dry, even when small flows are measured upstream at River Park. Flows generally pick up again further downstream at Floradale Ave, where WWTP discharges conveyed by Miguelito Creek contribute to more consistent flows.

The lower Santa Ynez watershed is currently monitored by the CMP, with three core sites sampled on a monthly basis. The most upstream of these is located on the mainstem Santa Ynez River at River Park, just upstream of Lompoc and roughly 30 miles downstream of the Cachuma Reservoir. The CMP does not maintain monitoring sites in the large watershed area upstream of Lompoc, however. In 2008, Upstream Monitoring was conducted in the Santa Ynez watershed both to address the lack of data for the upper watershed area, and to characterize source areas for constituents of concern measured at core CMP sites in the lower watershed.

Ambient monitoring data collected in the Santa Ynez River at River Park (314SYL) and at Floradale Ave (314SYF) between January, 2005 and June, 2007 were assessed during development of this Follow-up project. These data indicated that levels of the following constituents do not comply with water quality objectives listed in the Basin Plan for one or more beneficial uses: Dissolved Oxygen, pH, Unionized Ammonia, and Toxicity to Algae. Beneficial Uses and Water Quality Objectives associated with these constituents are provided in Tables 3 and 4.

To address Follow-up monitoring requirements in the MRP, monthly monitoring was conducted at three additional sites within the Santa Ynez River watershed, with the following objectives:

- To characterize water quality in the upper Santa Ynez River watershed, which drains a large area and is not monitored as part of the core CMP.
- To determine if the upper Santa Ynez River is a source area for constituents of concern measured in the Santa Ynez River at River Park.
- To determine source areas for constituents of concern measured at core CMP sites 314SYF and 314SYN.
- To evaluate the relative importance of each source area as a contributor to the constituents measured at 314SYF and 314SYN.

To these ends, the following Upstream Monitoring sites were established in the Santa Ynez River watershed (Figure 9):

- Santa Ynez River at Avenue of the Flags, Buellton (314SYI)
- Miguelito Creek mouth upstream of confluence with Santa Ynez River (314MCM)
- Channel at West Central Ave. between Douglass and De Wolf Avenues (314DDE)

The site at Avenue of the Flags in Buellton (314SYI) is located roughly mid-way between the most upstream core CMP site (at River Park, 314SYL) and the Cachuma Reservoir. It is also monitored by the CCRWQCB's CCAMP (Central Coast Ambient Monitoring Program) on a five year rotation cycle. It is downstream of the cities of Santa Ynez and Solvang, but towards the upstream end of Buellton.

The core CMP site at River Park (314SYL) aggregates flows from the entire Santa Ynez watershed upstream of Lompoc, and is located within the River Park at Lompoc's eastern urban boundary. Flows are strongly affected by releases from the Cachuma Reservoir, and the site also incorporates inputs from several additional tributaries. Discharge-based inputs to the site are mixed, as upstream land uses include urban, agricultural, and open space.

The site in Miguelito Creek (314MCM) is located immediately downstream of the Lompoc WWTP, and just upstream of Miguelito Creek's confluence with the Santa Ynez River. Upstream of site 314MCM, Miguelito Creek is a concrete-lined channel which receives urban runoff from Lompoc. These inputs combine with WWTP discharges to create relatively consistent flows to the Santa Ynez River, which influence the core CMP site at Floradale Ave (314SYF).

The core CMP site at Floradale Ave (314SYF) is located just downstream of the western urban boundary of Lompoc. Minimum and medium-security U.S. Penitentiaries are located immediately downstream of Floradale Ave to the north, and the associated prison dairy operation is located just upstream of or adjacent to the monitoring site, also to the north of the river channel. Miguelito Creek enters roughly 500 meters upstream of 314SYF, from the south.

The site at West Central Ave (314DDE) is located within the intensively farmed area west of Lompoc and south of the Santa Ynez River, between Douglass and DeWolff Avenues. Inputs to this channel are believed to be exclusively of agricultural origin, with the exception of storm flows from the undeveloped hillsides to the south. Flows from this channel meet the Santa Ynez River, and can influence the core CMP site at 13th St on the Vandenburg Air Force Base (314SYN). Combined with results from Miguelito Creek (314MCM), water quality in this channel should provide a comparison of agricultural versus urban dishcarges to the Santa Ynez River in the area around Lompoc.

All Upstream Monitoring points incorporate at least two unique discharges from unrelated agricultural operations (discharges entering above the site but below the next most upstream site), and most incorporate more. That is, though located to illuminate source areas within the watershed, no two Upstream Monitoring points reliably isolate discharges from a single source.

4.2.2 Results

The full suite of monitoring results for sites in the Santa Ynez River watershed is provided in Appendices A and B. A site-specific summary of results for the parameters of special interest is provided in Tables 14 and 15, and discussed here. To facilitate discussion, results for the upper Santa Ynez watershed sites are given separately from those for the lower watershed sites near Lompoc.

Upper Santa Ynez watershed, above River Park (314SYL)

Flows at the core CMP site on the Santa Ynez River at River Park (314SYL) occurred only from January through May in 2008, with flows between approximately 50 and 200 CFS through April, and declining to about 3 CFS in May. The site further upstream at Buellton (314SYI) had flows of about 20 to 120 CFS in January through March, declining to less than 1 CFS by July. This site was dry from August through October, with flows returning in November and December.

Nitrate concentrations were below the Basin Plan objective of 10 mg/L as N throughout all of 2008, at both the core CMP site (314SYL) and the upstream site at Buellton (314SYI). Maximum concentrations were around 2 mg/L (+/- 0.1 mg.L) at both sites, with more typical concentrations less than 0.5 mg/L.

Nitrate Loads were highest in January, as both flows and nitrate concentrations were highest during this monitoring event at the core CMP site (314SYL) and at Buellton (314SYI). Maximum loads of 37.2 and 53.7 lbs N/hr (respectively) were not typical of either site though, since median loads at both sites were 0.00 lbs N/hr. For comparison, the minimum nitrate load near the mouth of Orcutt-Solomon Creek in Santa Maria (312ORC) in 2008 was 49 lbs N/hr.

Orthophosphate concentrations were similar at the core CMP site 314SYL and at Buellton (314SYI) in 2008. Maximum concentrations were 0.29 and 0.28 mg/L, respectively (occurring in January in both cases), and median concentrations were 0.06 and 0.04 mg/L.

Turbidity results were very low at both the core CMP site (314SYL) and the upstream site (314SYI), except in January and February. Turbidity was over 1000 NTU's at both sites in January, and in February was 209 NTU at River Park (314SYL) and 76 NTU at Buellton (314SYI). During other months, turbidity was < 10 NTU at both sites, and more typically < 3 NTU.

Flow-weighted Turbidity results were predictably highest in January and February at both 314SYL and 314SYI. Maximum levels were about 87,000 and 219,000 NTU*CFS. For comparison, the maximum flow-weighted turbidity in the Salinas River at Bradley (309USA) was about 153,000 NTU*CFS. Typically though, because upper Santa Ynez River flows and turbidity levels were low during most months, flow-weighted turbidities were also low, with median values of 0 and 5 NTU*CFS at 314SYL and 314SYI, respectively. For comparison, median flow-weighted turbidities in the Salinas River at Bradley (309USA) were about 11,600 NTU*CFS.

Laboratory **Toxicity** analyses on water samples from 314SYL and 314SYI showed no toxic effects to any of the test organisms (algae, fish, or invertebrates) in either water or sediment (invertebrates only).

Results for **other water quality parameters** of interest in the upper Santa Ynez watershed:

- Conductivity values were typically around 1300 µS/cm at 314SYL and around 1100 µS/cm at 314SYI, and much lower at both sites in January and February
- pH was typically 8.0 to 8.1 at both sites
- Dissolved oxygen concentrations (mg/L) were high, with median values of 10.8 at both sites; dissolved oxygen saturations (%) were also high, dropping below 85% only at 314SYI in June
- Unionized Ammonia as N was very low, with typical concentrations around 0.003 mg/L

Lower Santa Ynez watershed, below Lompoc (314SYF and 314SYN)

Flows on the Santa Ynez River at the core CMP sites at Floradale Ave (314SYF) and at 13th St (314SYN) were typically between 2 and 10 CFS, but were 52 to 137 CFS during the January – March period. Flows at the contributing sites 314MCM (tributary to 314SYF) and 314DDE (tributary to 314SYN) were lower, with maximum flows of 17 and 4 CFS, respectively. Site 314DDE was dry in November, and had flows less than 1 CFS during ten of the other eleven monitoring events. Median flows at the core CMP sites 314SYF and 314SYN, and at the Miguelito Creek mouth (314MCM) were all between 5 and 6 CFS. Median flows at 314DDE were much lower, at 0.12 CFS.

Median **Nitrate** concentrations were between about 10 and 20 mg/L as N at all of the Lompoc area sites (314SYF, 314MCM, 314SYN), except in the tributary ditch 314DDE, where the median concentration was 4.6 mg/L. As a group, these four sites had maximum concentrations of about 16 to 34 mg/L. The only site which always had nitrate concentrations above 10 mg/L was the Miguelito Creek site (314MCM), with a minimum concentration of 10.5 mg/L, and median of 21.1 mg/L.

Nitrate loads were similar between the core CMP site 314SYF and its contributing tributary 314MCM, with median values of about 21 to 23 lbs N/hr. Events during which 314SYF was receiving large volumes of water from the upper Santa Ynez River were an exception to this. Nitrate loads at 314SYN were typically a bit lower, with a median value of 15.3 lbs N/hr. Loads from the tributary ditch 314DDE were generally negligible in comparison, with a median of 0.08 lbs N/hr.

Orthophosphate concentrations were highest in Miguelito Creek (314MCM), with slightly lower values at the core CMP sites 314SYF and 314SYN. The median value at 314MCM was 4.4 mg/L, with a minimum of 1.8 mg/L. Median values at 314SYF and 314SYN were 3.5 and 1.8 mg/L, respectively. Orthophosphate was much lower at 314DDE, with a median concentration of 0.06 mg/L.

Turbidity results were lower in the Lompoc area than in many other monitoring areas, with a few important exceptions. Though median turbidity levels were below 10 NTU at 314SYF and 314SYN, turbidities during high flow events (>100 CFS) were over 1000 NTU at these sites. Turbidity at 314MCM was more consistent, with a median of 7 NTU and maximum of 36 NTU. Site 314DDE had higher typical turbidity results than the other Lompoc area sites, with a median value of 51 NTU.

Flow-weighted Turbidity results were similar for core CMP sites 314SYN and 314SYF, with both sites having median values around 25 NTU*CFS. Maximum flow-weighted turbidity at 314SYN was nearly double (329,784 NTU*CFS) that at 314SYN (156,008). Site 314MCM had the highest median flow-weighted turbidity value (38 NTU*CFS), but the lowest maximum value (628 NTU*CFS). Site 314DDE had by far the lowest typical flow-weighted turbidities, with a median value of 5 NTU*CFS.

Laboratory **Toxicity** analyses were performed only on samples from the core CMP sites 314SYF and 314SYN, except for toxicity to algae in water, which was also performed for site 314MCM. There were no impacts to fish in water, or to invertebrates in sediment at either 314SYF or 314SYN. Impacts to invertebrates in water were limited to reproduction, which occurred during the August and September monitoring events at both sites. Toxicity to algae was observed at 314SYF in August, and at contributing site 314MCM in March, August, and September. Site 314SYL (Santa Ynez River at River Park), which also contributes to 314SYF, did not show any aquatic toxicity during 2008.

Results for **other water quality parameters** of interest in the lower Santa Ynez watershed:

- Conductivity values were around 1500 μS/cm on average
- pH was near 7.0 at 314SYF and 314MCM; it was higher at 314DDE and 314SYN (8.7 and 7.7 on average, respectively)
- Dissolved oxygen concentrations were high at 314DDE (always above 7 mg/L), but were quite depressed on two occasions at 314SYN and frequently at 314SYF and 314MCM; dissolved oxygen saturation followed the same pattern, with results at 314DDE frequently much higher than 100%, and frequently much lower than 85% at the other sites
- Unionized Ammonia as N was very high at 314DDE, almost always above 0.025 mg/L; other sites had lower concentrations, but each exceeded 0.025 mg/L on at least one occasion

4.2.3 Source area analysis

Based on Upstream Monitoring results from throughout the upper and lower Santa Ynez River watersheds during 2008, several summarizing statements can be made. An 'at-a-glance' comparison of results among sites for each parameter is provided as box-and-whisker plots, in Appendix D. In summary:

- Much of the Flow in the mainstem Santa Ynez River upstream of Lompoc originates as controlled releases or spills from the Cachuma Reservoir. Tributaries downstream of Buellton appeared to contribute additional flows during March and April, however the reach between Buellton (314SYI) and Lompoc (River Park, 314SYL) more typically acted as a "losing" reach, with lower flows downstream. Flows increased from River Park (314SYL) to Floradale Ave (314SYF) during 10 of the 12 monitoring events, despite the fact that the river channel was often observed to be dry between these two sites. Contributions from the tributary Miguelito Creek (314MCM), which conveys urban drainage and effluent from the Lompoc WWTP, were sufficient to account for 85% or more of the observed flow increases during the majority of events. The most downstream site (13^{th} St, 314SYN) generally showed higher flows than Floradale Ave (314SYF) during winter months, and slightly lower flows in summer months. Contributions from the tributary channel between Douglass and De Wolff Avenues (314DDE) were extremely low, and were not high enough to account for significant portions of winter flow increases. No other specific sources of wintertime flow could be identified. In general, it appears that Miguelito Creek (314MCM) is an important source of flows to the lower Santa Ynez River; the drainage channel between Douglass and De Wolff Avenues (314DDE) is a very minor source.

- Miguelito Creek (314MCM) was clearly the most concentrated source of nitrate, with downstream stations on the mainstem Santa Ynez River (Floradale Ave, 314SYF; 13^{th} St, 314SYN) showing elevated nitrate concentrations as compared with the river upstream of Lompoc. The agricultural channel between Douglass and De Wolf Avenues (314DDE) was slightly elevated in nitrate concentration relative to the upper Santa Ynez River, but only exceeded 10 mg/L on one occasion and was not an important source of nitrate loading to the river. In addition to having higher concentrations, nitrate loads in Miguelito Creek (314MCM) were generally higher even than those in the mainstem river (314SYF). Site 314DDE was lower in nitrate, both in terms of concentration and load, than the downstream core CMP site (314SYN).

- Turbidity levels were substantially elevated at least once at all sites in the Santa Ynez watershed, especially during the January storm event. The exception to this was Miguelito Creek

(314MCM), which had comparatively low Turbidity levels even during winter storms. The agricultural channel between Douglass and De Wolf Avenues (314DDE) usually showed higher Turbidity levels than other sites, but was a small source of sediment loads due to low flows. Despite lower concentration-based turbidity levels, Miguelito Creek was a greater source of sediment loading than the agricultural tributary, due to more consistent flows. A sink for suspended sediments may exist in the river reach between River Park (314SYL) and Floradale Ave (314SYF), as sediment loads were usually lower at Floradale Ave than upstream at River Park. Relative to the downstream core CMP site 314SYF, Miguelito Creek (314MCM) showed higher concentrations and average loads of suspended sediment. Loads were only higher at 314SYF under the highest flow conditions. Though median turbidities were higher at 314DDE than at the downstream core CMP site (314SYN), flow-weighted turbidity (i.e. load) was two orders of magnitude lower, indicating that 314DDE was not the primary source of sediment loading.

- Toxicity to fish in water and to invertebrates in sediment were not observed in the Santa Ynez River during 2008, which is generally consistent with historical results. Toxicity to algae was observed in the Santa Ynez River at Floradale Ave (314SYF). The source was likely to have been Miguelito Creek (314MCM), as this tributary showed frequent toxicity to algae while the upstream site on the main stem river at River Park (314SYL) did not. Though no sites showed survival-based effects to invertebrates in water, the lowermost sites on the main stem river at Floradale Ave (314SYF) and 13th St (314SYN) showed impaired reproduction rates. Source areas for toxicants cannot be assessed, as the upstream tributaries (Miguelito Creek, 314MCM; Douglass/De Wolff Ave channel, 314DDE) were not tested for toxicity to invertebrates due to lack of a strong history of this kind of toxicity at core CMP sites in the area.

At this time, the upper Santa Ynez watershed does not appear to be a source of elevated nutrients or aquatic toxicity to the lower watershed. Suspended sediment concentrations were also generally not very elevated except under high flow conditions. This indicates that upstream land uses such as irrigated agriculture, rangeland, and urban areas are not important sources for impairment in the lower watershed.

Within the lower Santa Ynez watershed around Lompoc, Miguelito Creek was a clear source of elevated nutrients and toxicity to algae. Upstream land use on Miguelito Creek is entirely urban, including a WWTP immediately above the monitoring site. Miguelito Creek was also a source of sediment loading. The tributary draining lands in agricultural use south of the River (314DDE) had extremely low flows, making it a minor source of loading for all constituents. Nitrate and phosphate levels in this drain were the lowest in the watershed, however unionized ammonia was frequently elevated. Lands drained by 314DDE do not appear to have been sources of aquatic toxicity to the downstream CMP site (314SYN), as toxicity was not elevated at this site relative to 314SYF.

4.3 Main Street Ditch

4.3.1 Watershed Description

The Main Street Ditch is a small engineered drainage which begins underground, beneath the city of Santa Maria. The underground portion of the channel begins beneath Main St, well east of Blosser Rd. The precise drainage area is currently unknown because all inputs have not yet been identified, but it is almost certainly less than 10 square miles (6400 acres). The city of Santa Maria is currently engaged in a project to identify inputs to this underground segment of the channel, however several storm drain inputs can be easily identified via aboveground observations on the street. Some of the storm drains also introduce non-storm surface inputs such as car wash discharges, vegetable/berry cooler melt water, and rinse water from wash-down pads for industrial (including agricultural) equipment. An underground tributary to the Main St. Ditch also runs south-to-north beneath Hanson Way, which intersects Main St two blocks west of Blosser Rd. Specific inputs to the Hanson Way conveyance could not be identified, however aboveground land uses in the general vicinity include irrigated agricultural fields and produce processing facilities. The Main St Ditch daylights west of Hanson Way, where it runs west as an earthen channel along the south side of Main St. Here it receives additional inputs from agricultural fields, and can also receive inputs from a city stormwater retention basin located at A St and Battles Rd, via a drain. Just shy of Black Rd, the ditch makes a 90 degree turn, becoming a concrete-lined conveyance and proceeding straight to the Santa Maria River, which is usually dry in this area.

As should be apparent from the above description, land use in this drainage area is heavily mixed, and the Main St Ditch is an important drainage structure for both the city of Santa Maria and the local agricultural industry. With the exception of drain inputs from the A St/Battles Rd stormwater basin, inputs to the Ditch downstream of Hanson Way (aboveground portion) are likely to be entirely of agricultural origin. Currently, we are not aware of any direct groundwater inputs to the Ditch, however groundwater quality may influence surface water quality in the Main St Ditch via surface discharges of water drawn from wells.

Ambient monitoring data collected in the Main St Ditch near Black Rd (312MSD) between January, 2006 and June, 2007 were assessed during development of this Follow-up project (core monitoring at this site did not begin in 2005 due to construction work on the Ditch). These data indicated that levels of the following constituents do not comply with water quality objectives listed in the Basin Plan for one or more beneficial uses: Nitrate and Toxicity to Invertebrates in Water and Sediment. Beneficial Uses and Water Quality Objectives associated with these constituents are provided in Tables 3 and 4.

To address Follow-up monitoring requirements in the MRP, monthly monitoring was conducted at one additional site in the Main St. Ditch drainage area, with the following objectives:

- To determine source areas for constituents of concern measured at core CMP site 312MSD.
- To evaluate the relative importance of each source area as a contributor to the constituents measured at site 312MSD.

To these ends, the following Upstream Monitoring site was established in the Main St Ditch drainage area (Figure 10):

- Daylight point near Hanson Way (312MSS)

The daylight point site (312MSS) is located west of Hanson Way and east of Ray Rd, where the Main St Ditch changes from being an underground drain to an open, aboveground channel. This point incorporates all inputs to the underground drainage system, which stretches east beneath Main St and south beneath Hanson Way. These include both urban/industrial and irrigated agricultural discharges. As discussed above, inputs downstream of this site should be entirely of irrigated agricultural origin, with one possible occasional exception.

The core CMP site near Black Rd (312MSD) is located immediately downstream of the 90 degree “dogleg” in the aboveground portion of the Main St Ditch, west of Santa Maria. Contributions from the area downstream of the daylight point (312MSS) are likely to be of irrigated agricultural origin, however inputs from areas further upstream (underground portion) are from mixed urban and agricultural sources.

All Upstream Monitoring points incorporate at least two unique discharges from unrelated agricultural operations or other sources (discharges entering above the site but below the next most upstream site), and most incorporate more. That is, though located to illuminate source areas within the watershed, no two Upstream Monitoring points reliably isolate discharges from a single source.

4.3.2 Results

The full suite of monitoring results for sites in the Main St. Ditch drainage is provided in Appendices A and B. A site-specific summary of results for the parameters of special interest is provided in Table 16 and discussed below.

Flows in the Main St Ditch at the dogleg near Black Rd (312MSD) were very low (<1.5 CFS) except during the January winter storm event, when the flow was 37 CFS. Flows at the daylight point near Hanson Way (312MSS) were even lower, at 0.1 CFS or less except during the January winter storm event, when the flow was 9 CFS. Despite a few near-zero flows, there was water at both sites and connectivity to downstream areas during all twelve of the 2008 monitoring events. Downstream areas were generally dry, however.

Nitrate concentrations were well above 10 mg/L as N during all monitoring events at 312MSD, except in January, December, and July, when nitrate concentrations were 3.6, 5.0, and 10.0 mg/L respectively. Concentrations at 312MSS were more erratic, with concentrations below 10 mg/L during six months, but at other times having concentrations as high as 138 mg/L. The median concentration at 312MSS was about half that of 312MSD.

Nitrate Loads were low at both 312MSD and 312MSS, with 312MSS being the lower of the two. This is to be expected, as flows were lower at 312MSS and nitrate concentrations were not consistently higher. Except during the January winter storm event, nitrate loads from the Main St Ditch were extremely small compared with loads at most other Santa Maria area Upstream Monitoring sites.

Orthophosphate concentrations were elevated at both 312MSD and 312MSS, throughout 2008. Of particular note were the July and August concentrations at 312MSD of 15.9 and 19.6 mg/L, respectively. The upstream site, 312MSS, had concentrations < 1 mg/L during both of these events, indicating an orthophosphate source downstream of the daylight point. Turbidity was not particularly high during those high-orthophosphate events. Concentrations between 15 and 20 mg/L are several times higher than even those near the Lompoc WWTP, where downstream ambient waters typically have orthophosphate concentrations of 3 to 6 mg/L.

Turbidity results suggested that some suspended sediments were consistently present at both 312MSD and 312MSS (especially during the January winter storm event), but levels were generally much lower than for sites on Oso Flaco Creek or near the mouth of Orcutt-Solomon Creek. Turbidity levels were 100's of NTU's at both sites during certain winter months, and slightly higher at 312MSS, however both sites had median turbidities of 23 to 24 NTU.

Flow-weighted Turbidity results were extremely low at both sites (312MSD and 312MSS) except in storm events. Results of 3 and 1 NTU*CFS for 312MSD and 312MSS suggest negligible sediment loads relative to other Santa Maria area sites.

Laboratory **Toxicity** analyses on sediment samples showed toxicity to *Hyalella* in sediment at both the core CMP site (312MSD) and at 312MSS. With regard to invertebrate toxicity in water, three of four samples taken at each site showed significant reductions in survival rates, with several 0% survival results. In the samples without impacts to survival, there was reproduction-based toxicity at both sites. Toxicity to algae and fish was assessed only at the core CMP site 312MSD. Three of the four samples showed toxicity to algae, and two showed toxicity to fish (one survival-based and one growth-based).

Results for **other water quality parameters** of interest in the Main St Ditch watershed:

- Conductivity values were very high, with median values around 1600 µS/cm at 312MSD and around 2000 µS/cm at 312MSS
- pH averaged 7.8 at 312MSD and 8.1 at 312MSS

- Dissolved oxygen concentrations (mg/L) were generally high at 312MSS, but often depressed at 312MSD; saturation levels (%) were below 85% from approximately May through September
- Unionized Ammonia was high, frequently exceeding 0.025 mg/L at both sites, with especially high concentrations at 312MSS

4.3.3 Source area analysis

Based on Upstream Monitoring results from the Main St. Ditch drainage area during 2008, several summarizing statements can be made. An 'at-a-glance' comparison of results among sites for each parameter is provided as box-and-whisker plots, in Appendix D. In summary:

- Flows in the Main St Ditch were extremely low in 2008, except during the January storm event, when already-substantial flows nearly quadrupled between Hanson Way (312MSS) and the core CMP site near Black Rd (312MSD), from 9 CFS to 37 CFS. Flows at the core CMP site (312MSD) were consistently higher than those near Hanson Way at the daylight point (312MSS), predictably reflecting additional inputs. Total flows were generally much less than 1 CFS, however, suggesting relatively low-volume inputs from all sources.

- The drainage area upstream of Hanson Way (312MSS) was a source of highly concentrated nitrates on one occasion, but nitrate concentrations were usually higher downstream at the core CMP site (312MSD). On two occasions, inputs from the underground portion of the Main St Ditch had nitrate concentrations less than 1 mg/L. The daylighted area between Hanson Way (312MSS) and the core CMP site (312MSD) appears to have been much more important in terms of nitrate loading than the underground portion of the Ditch.

- Turbidity levels were almost identical between the two sites in terms of concentration, often elevated to between 10 and 50 NTU, but rarely exceeding 100 NTU. Sediment loading increased substantially between Hanson Way and the core CMP site, with increasing flows. In general, neither drainage area (upstream of Hanson Way, or between Hanson Way and Black Rd) stood out as a more important source area for sediments.

- Inputs to the Main St Ditch upstream of Hanson Way (312MSS) appear to have contributed to both sediment and water column toxicity to invertebrates in 2008. In a few cases though, test organism performance was slightly less impaired at the more upstream site, potentially indicating additional sources of aquatic toxicity in the reach between Hanson Way and Black Rd (312MSD). Toxicity to fish and algae were both observed at the core CMP site (312MSD) in 2008. These were not assessed at the upstream site (312MSS), based on a lack of toxicity in historical data from the core CMP site.

In general, both reaches of the Main St Ditch that were studied appeared to contribute flows to the Ditch and to drain source areas for constituents of concern. The mixed urban and agricultural area upstream of Hanson Way occasionally contributed extremely concentrated nitrates. However, the area between Hanson Way and Black Rd was a more important source of loading; at this time drainage to this reach is believed to be entirely agricultural except in major storm events. Both reaches contributed toxicity to invertebrates in sediment and water. It is unclear which upstream areas are more important sources of toxicity to algae and fish, as these parameters were not measured at the upstream site due to lack of history of toxicity to these species at the downstream site at the time of project scoping. Though the agricultural area downstream of Hanson Way was clearly a source of impairments, additional information regarding inputs to the underground portion of the Main St Ditch (upstream of Hanson Way) is needed to determine the relative importance of agricultural versus urban inputs in that part of the watershed. A major information gap is the lack of data for 312MSS from urban water quality monitoring programs (M. Adams *pers. comm.*).

4.4 Orcutt-Solomon Creek

4.4.1 Watershed Description

Orcutt-Solomon Creek is an important watershed in northern Santa Barbara County which drains to the Santa Maria River estuary near the Pacific Ocean. Drainages throughout much of the watershed are highly engineered, making accurate watershed delineation difficult. The Orcutt-Solomon Creek watershed begins east of the cities of Santa Maria and Orcutt, then runs west/northwest to the confluence of Orcutt-Solomon Creek and the Santa Maria River at the Guadalupe County Dunes Park, near the Pacific Ocean. The eastern end of the watershed is fairly dry with respect to surface water, and incorporates a wide mix of land uses including agriculture, rural-residential, urban residential, and oil extraction. West of Orcutt and Santa Maria, land use is almost exclusively irrigated agriculture. Exceptions to this are the Rancho Maria public golf course (just west of Orcutt), the Laguna County Sanitation District's reclamation plant (just west of Black Rd), the town of Guadalupe and its wastewater facility (located at the northwest, or lower end of the watershed), and the Santa Maria wastewater treatment plant, located in the middle of the watershed just west of Black Rd.

Though not verified on a regular basis, it has been noted on several occasions that the Orcutt-Solomon Creek channel east of Orcutt is typically dry. On these occasions, the most upstream non-storm flows to enter the creek appeared to be a fairly consistent discharge from a neighborhood well-head overflow which is marked by signage next to the E. Clark Ave on-ramp to Highway 135 South. Much of the other urban runoff from Santa Maria and Orcutt is channeled directly to the Santa Maria River via the Blosser and Bradley Channels and the Main St Ditch, however storm drains in some areas are plumbed to a series of large retention ponds at the western urban boundary near A Street. During extremely large overflows, this water could theoretically make its way westward down the watershed to the Betteravia Lakes area, via a topographical depression known as the "Mahoney Dip" (which passes under Mahoney Rd), and ultimately into Orcutt-Solomon Creek. Currently though, surface water connections between this area and the creek are only believed to exist during extremely large storm events.

During non-storm events only two tributaries are known to contribute surface flows to Orcutt-Solomon Creek. One of these is Green Valley, which drains the area running from the Bonita School Rd intersection with Main St, southwest under Simas St to join Orcutt-Solmon Creek near Highway 1. The other is a small creek of uncertain name (probably Solomon Creek), which begins near Highway 1 north of Orcutt-Solomon Creek and runs west to join it near the sand dunes, just a few hundred yards upstream of the Santa Maria River. It should be noted that the western/lower end of the watershed includes several areas with high water tables and/or heavy soils which require tile drains to maintain arable lands. Groundwater quality may influence surface water quality in Orcutt-Solomon Creek in this area via tile drains and via surface discharges of water drawn from wells.

Ambient monitoring data collected in Orcutt-Solomon Creek at the sand plant near the Dunes Park (312ORC) between January, 2005 and June, 2007 were assessed during development of this Follow-up project. Ambient monitoring data from further up the watershed – in Green Valley (312GVS) and in Orcutt-Solomon Creek at Highway 1 (312ORI) – were also assessed. These data indicated that levels of the following constituents do not comply with water quality objectives listed in the Basin Plan for one or more beneficial uses: Nitrate, Unionized Ammonia, Dissolved Oxygen Saturation, Toxicity to Invertebrates in Water and Sediment, and Toxicity to Fish in Water. Beneficial Uses and Water Quality Objectives associated with these constituents are provided in Table 2.

To address Follow-up monitoring requirements in the MRP, monthly monitoring was conducted at 5 additional sites throughout the Orcutt-Solomon and Green Valley watersheds, with the following objectives:

- To determine source areas for constituents of concern measured at sites 312ORC, 312ORI, and/or 312GVS.
- To evaluate the relative importance of each source area as a contributor to the constituents measured at 312ORC, 312ORI, and/or 312GVS.

To these ends, the following Upstream Monitoring sites were established in the Orcutt-Solomon and Green Valley watersheds (Figure 11):

- North fork tributary to Orcutt-Solomon Creek near sand plant (312ORN, upstream of 312ORC)
- Orcutt-Solomon Creek at Solomon Rd (312ORS, upstream of 312ORI)
- Orcutt-Solomon Creek at Black Rd (312ORB, upstream of 312ORI)
- Mahoney Dip at Mahoney Rd (312MHD, upstream of 312ORI)
- Main St drainage to Green Valley at Bonita School Rd (312MAB, upstream of 312GVS)

The north fork tributary site (312ORN) is located at the lower end of the Orcutt-Solomon watershed, just upstream of the core CMP site at the Sand Plant (312ORC). This tributary drains an area north of Orcutt-Solomon Creek and mostly west of Highway 1, with lands currently believed to be in entirely agricultural usage. During routine monitoring for the core CMP, contributions from this tributary are not differentiated from those entering the main Orcutt-Solomon Creek channel downstream of Highway 1.

Much further up the watershed, the site at Solomon Rd (312ORS) is fairly well located to mark the boundary between the urban land uses of Orcutt, and the primarily agricultural land uses west of the city. Streamflows at 312ORS incorporate inputs from the city of Orcutt, and from the more rural-residential and agricultural lands to the east. Flows are rarely observed in the stream channel east of Orcutt, however.

The site at Black Rd (312ORB) is located downstream of the Solomon Rd site, within the more agricultural area west of Orcutt. Contributions to streamflows at this site may come from the Solomon Rd site, or from the surrounding agricultural fields. There is also a public golf course nearby (just upstream). The Laguna County Sanitation District's reclamation plant is located approximately one kilometer downstream of this site.

The site at Mahoney Rd (312MHD) can theoretically receive storm drainage from the city of Santa Maria and convey it to the Betteravia Lakes region, which could then theoretically drain to Orcutt-Solomon Creek. Surface water connectivity along this route is generally not believed to exist however, except during very large storm events.

In addition to the core CMP site near the bottom of the Orcutt-Solomon watershed at the Sand Plant, core CMP sites are located on Orcutt-Solomon Creek at Highway 1 (312ORI) and on Green Valley at Simas St. (312GVS). The site at Highway 1 receives inputs from the Black Rd site (312ORB) and the substantial agricultural acreage in between. It also receives inputs from the Green Valley site (312GVS), which drains additional agricultural acreage, and is essentially a tributary to Orcutt-Solomon Creek. A City of Santa Maria wastewater treatment facility is located within the Green Valley drainage area.

The site at Main St and Bonita School Rd (312MAB) combines flows from ditches carrying agricultural inputs from all three arms of the intersection, which then flow southwest to the core CMP site at Simas St (312GVS). It should be noted that these waters are not contiguous with the "Main Street Ditch," which conveys mixed urban and agricultural inputs from Santa Maria westward along Main St., and then turns 90 degrees to run due north directly to the Santa Maria River.

All Upstream Monitoring points incorporate at least two unique discharges from unrelated agricultural operations (discharges entering above the site but below the next most upstream site), and most incorporate more. That is, though located to illuminate source areas within the watershed, no two Upstream Monitoring points reliably isolate discharges from a single source.

4.4.2 Results

The full suite of monitoring results for sites in the Orcutt-Solomon Creek watershed is provided in Appendices A and B. A site-specific summary of results for the parameters of special interest (discussed below) is provided in Tables 17 and 18. To facilitate discussion, results are presented separately for the sections of the watershed east (upstream) versus west (downstream) of Highway 1.

Orcutt-Solomon Creek at Sand Plant (312ORC)

Flows at core CMP site 312ORC were moderate and fairly consistent during 2008, averaging 7.9 CFS. Flows from each of the two contributing channels (Orcutt-Solomon Creek further upstream – 312ORI, and the north fork Solomon Creek – 312ORN) were lower and comparable, with each appearing to contribute about half of the flows aggregated at 312ORC, with 312ORI slightly higher. All sites in the watershed had measurable flows during all 2008 monitoring events.

Nitrate concentrations at 312ORC and in both of the contributing creek channels (312ORN and 312ORI) were consistently high throughout 2008. At 312ORC, concentrations ranged from 19.0 to 72.6 mg/L as N, with a median of 40.3 mg/L. On the basis of median values, 312ORN contributions were somewhat lower and 312ORI somewhat higher, however 312ORN had a maximum nitrate concentration of 380 mg/L.

Nitrate Loads were around 60 lbs N/hr on a median basis at 312ORC. Contributing loads from 312ORI were typically a bit higher than those from 312ORN, with some exceptions. By comparison, these loads are comparable to slightly higher than those typical of the mainstem Salinas River at Greenfield, and are about 10 times higher than average loads in the Santa Ynez River at Buellton where flows are higher, but nitrate concentrations much lower.

Orthophosphate concentrations were somewhat elevated in all samples during 2008, and quite similar between the core CMP site 312ORC and the sites on the two contributing channels, 312ORN and 312ORI.

Turbidity results were consistently high at the core CMP site 312ORC, and in Solomon Creek (312ORN), with median values between 300 and 500 NTU. The Orcutt-Solomon Creek channel (312ORI) had a much lower median turbidity (25 NTU), and had results below 10 NTU from July through November. The highest turbidities at 312ORC and 312ORI occurred during the January winter storm event, whereas the highest turbidities at 312ORN occurred in July and September.

Flow-weighted Turbidity results suggested that 312ORN was generally a greater contributor to sediment loads at 312ORC than the other channel (312ORI). Even though flows were slightly higher at 312ORI, turbidity levels were much higher at 312ORN, making it a larger source of sediment to 312ORC downstream.

Laboratory **Toxicity** analyses were performed four times in 2008 on water samples, and once for sediments. Sediment samples from 312ORC and both contributing channels (312ORI and 312ORN) showed toxicity to *Hyalella*, with 312ORC and 312ORN having 0% survival rates. Patterns in water sample toxicity to invertebrates were also similar between 312ORC and 312ORN, with 100% survival in January and 0% survival during the other three months. Site 312ORI showed survival-based toxicity only in March, and growth-based toxicity once in August. A slightly less sensitive test species was used at 312ORI due to high salinity. Toxicity to fish or algae were not sampled at 312ORN, and were not observed during 2008 at 312ORC. Low growth rates for fish were observed upstream at 312ORI during one event, however.

Results for **other water quality parameters** of interest in the Orcutt-Solomon Creek watershed west of Highway 1:

- Conductivity values were generally around 2700-2800 μS/cm
- pH median values were 7.8
- Dissolved oxygen concentrations were generally high, with saturation results typically between 85 and 110%. Some depressed saturation levels were measured at each site, however
- Unionized Ammonia concentrations were generally low, however there were two events with results over 0.025 mg/L -- in March and September, 2008

Orcutt-Solomon Creek at Highway 1 (312ORI) and Green Valley at Simas Rd. (312GVS)

Flows at the core CMP site on Orcutt-Solomon Creek at Highway 1 (312ORI) were low to moderate, and fairly consistent throughout 2008, ranging from 2.6 to 7.3 CFS. Contributions from core CMP site 312GVS on Green Valley and the upstream site 312ORB on Orcutt-Solomon Creek at Black Rd were smaller (about 1 CFS each on average), but both sites had measurable flows during all twelve 2008 monitoring events. Flows from the Main St/Bonita School Rd intersection (312MAB) made small contributions to the flows at 312GVS, but these were very low and the site was dry from October through December. Flows from Solomon Rd (312ORS) made small contributions to the flows at 312ORB (and thus 312ORI) during a few months, but there was no connection with downstream waters from this site during six of the twelve 2008 monitoring events. The Mahoney Dip area (312MHD) was dry except in January and February, at which times very low flows (1 and 0.15 CFS) were measured.

Nitrate concentrations were consistently high at the core CMP site 312ORI, and at the contributing core CMP site, 312GVS (median concentrations 47.6 and 55.8 mg/L as N, respectively), with all results exceeding the Basin Plan objective of 10 mg/L. Contributions from 312GVS were as high as 260 mg/L. Nitrate concentrations at the intermittent contributing sites 312MHD and 312ORS (which were also "urban boundary" sites) were always below 2.5 mg/L. Nitrate concentrations at 312MAB (contributing to 312GVS) and at 312ORB (contributing to 312ORI) were higher, with median values of 42.0 and 19.9 mg/L, respectively. Concentrations were generally lower during the January winter storm event throughout this watershed area. Also, nitrate concentrations were generally high throughout the dry season, except at 312ORB which had concentrations < 10 mg/L in June and July, and at 312MAB, which had an uncharacteristically "low" concentration (12.9 mg/L) in July.

Nitrate Loads in this sub-watershed area were predictably highest at the most downstream site, 312ORI (median 46.1 lbs N/hr). The contributing site with the highest measured loads was 312GVS, however median loads at 312GVS (10.3 lbs N/hr) were only 20% to 25% of those at 312ORI. Median loads at 312MAB contributing to 312GVS were less than 1 lb N/hr, and median loads at 312ORB contributing to 312ORI were about 2 lb N/hr. Nitrate loading from 312MHD and 312ORS was negligible.

Turbidity during the January winter storm event was over 1000 NTU at sites 312ORI, 312ORB, 312ORS, and 312MAB, and was over 500 NTU and 200 NTU at 312GVS and 312MHD, respectively. During the other monitoring events, however, sites in this sub-watershed area typically had turbidities much lower than other sites in the Santa Maria area (e.g. 312ORC on Orcutt-Solomon Creek at the sand plant; 312OFC on Oso Flaco Creek). Median turbidities were below 50 NTU for all sites in the 312ORI/312GVS sub-watershed area (except for 312MHD, but there were only two monitoring events at this site, one of which was the January storm event).

Flow-weighted Turbidity was fairly low at all sites in this sub-watershed area compared with results further downstream at 312ORC and 312ORN. Results (which can be used as a rough indicator of relative sediment loading) were negligible at 312MAB, 312MHD, and 312ORS due to the very small flows there.

Results were predictably highest at the most downstream site, 312ORI, and were comparable between the contributing sites 312GVS and 312ORB. This is to be expected, as flows and most turbidity results were also comparable between these two sites. Interestingly though, on a median basis, the summed flow-weighted turbidities (i.e. sediment loads) from 312GVS and 312ORB did not account for even 30% of the load at 312ORI, suggesting additional inputs from the land areas in between.

Laboratory **Toxicity** analyses of water and sediment samples from the core CMP site 312ORI showed survival-based toxicity to invertebrates in sediments, but not in water. One of the four samples from 312ORI did show impacts to invertebrate reproduction in water, however, as did three samples from its contributing site 312ORB. The two sites on the Green Valley contributing branch (312MAB and 312GVS) both had survival-based toxicity to invertebrates in sediment and water, but there were no impacts to sediment-dwelling invertebrates at the Orcutt-Solomon branch upstream sites except for a low growth rate at 312ORS. Toxicity to algae was present in one sample each from core CMP site 312ORI and contributing core CMP site 312GVS, but was not assessed at any of the other sites in this sub-watershed area. Toxicity to fish was assessed at 312ORI, and at the Green Valley branch sites (312GVS and 312MAB), but no toxic effects were detected except for a low growth rate in one sample from 312ORI.

Results for **other water quality parameters** of interest in the Orcutt-Solomon Creek watershed east of Highway 101:

- Conductivity values were generally over 2690 µS/cm, except at 312ORS
- pH averaged 7.4 – 7.8, except at 312MAB where it was 8.5
- Dissolved oxygen concentrations were generally high, as was dissolved oxygen saturation, with a few depressed values at 312GVS towards the end of the year and sporadically at 312ORB and 312ORS. Though 312ORI did not show depressed values, there were occasionally some extremely high values (e.g. 183% in September)
- Unionized Ammonia as N was occasionally over 0.025 mg/L at most sites, but predominantly fell well below that level

4.4.3 Source area analysis

Based on Upstream Monitoring results from throughout the Orcutt-Solomon Creek and Green Valley watersheds during 2008, several summarizing statements can be made. An 'at-a-glance' comparison of results among sites for each parameter is provided as box-and-whisker plots, in Appendix D. In summary:

- Flows in the Orcutt-Solomon Creek watershed were much higher in the area near Highway 1 and west than in the rest of the watershed. Flows from the western urban boundary of Orcutt (Solomon Rd, 312ORS) were generally small or non-existent, with slightly more consistent (but still very low) flows further downstream at Black Rd (312ORB). Contributions to Orcutt-Solomon Creek from Green Valley (312GVS) were consistent but very low (generally <1 CFS), and inputs to Green Valley from the Main St/Bonita School Rd area (312MAB) were very small – usually less than 10% of the small flows observed at 312GVS (except during one storm event). Flows at Highway 1 (312ORI) and from the north fork tributary (312ORN) were substantial and roughly equivalent, combining to create consistent bottom-of-watershed flows near the mouth of Orcutt-Solomon Creek (312ORC). In summary, the most important source areas in terms of flow volume were west of Black Rd, and in particular west of Highway 1.

- Nitrate concentrations were consistently elevated throughout the Orcutt-Solomon watershed in 2008, except at the urban boundary sites at Solomon Rd (312ORS) and the Mahoney Dip (312MHD), where concentrations were always low. Nitrate concentrations were occasionally below 10 mg/L at Black Rd (312ORB) as well, but were consistently very high throughout the rest of the watershed. Nitrate loading from the eastern portion of the watershed was low due to the low flows and low nitrate concentrations. Loading patterns in the rest of the watershed followed flow patterns, with roughly comparable loading at the bottom (312ORC) coming from the mainstem creek at Highway 1 (312ORI) and the north fork tributary (312ORN).

- Turbidity levels were elevated at least occasionally at all sites in the Orcutt-Solomon watershed, especially during the January storm event, when even the lower-turbidity, low-flow sites were important sources of sediment loading. Turbidity was highest in the north fork tributary (312ORN), which contributed to turbidity levels at the bottom of the watershed (312ORC) that were noticeably higher than levels further upstream in the main creek channel at Highway 1 (312ORI). Flow-weighted turbidities were also highest at 312ORN and 312ORC. The north fork tributary (312ORN) was generally a much more important source of sediment loading to the core CMP site 312ORC than the main creek channel at Highway 1 (312ORI), except in winter. Substantial additional sediment loading also appears to have occurred in the main creek channel west (downstream) of Highway 1 but upstream of the confluence with the north fork tributary.
- Toxicity to invertebrates in water was present to some degree at all sites in the Orcutt-Solomon and Green Valley watersheds, with lethal effects most frequent at the more downstream sites (Orcutt-Solomon near the mouth, 312ORC; North fork tributary, 312ORN). Orcutt-Solomon Creek at Highway 1 (312ORI) and at Black Rd (312ORB) did not show lethal effects, however a slightly less sensitive test species was used at 312ORI due to high salinity. Toxicity to invertebrates in sediment was present at all sites except the more upstream sites at Solomon (312ORS) and Black (312ORB) Roads. Source areas for toxicity to algae were not assessed, however core CMP sites 312ORI and 312GVS each showed reduced algae growth on one occasion. Source areas for toxicity to fish were assessed only on Green Valley, with neither site (312GVS, 312MAB) showing toxicity in 2008. Core CMP sites 312ORI and 312ORC generally did not show toxicity to fish either, except for one low growth rate at 312ORI in the fall.

At this time the lower portion of the Orcutt-Solomon Creek watershed (west of Black Rd. and especially west of Highway 1) appears to be the primary source area for in-stream flow and much of the water quality impairment observed at the mouth (312ORC), especially on a loading basis. Land use in this portion of the watershed is primarily agricultural. The eastern (more upstream) reach of the creek, which runs through the urbanized portion of the watershed, was generally dry in 2008, indicating that urban areas were less important sources of direct surface water impairment during most months.

High turbidity levels in the lower, agricultural portion of the watershed indicate direct surface runoff. This runoff may also be a source of high nitrates. Results from this study are inconclusive as to whether wastewater treatment facilities are sources of nitrate, especially when potential interactions between the stream channel, areas of groundwater upwelling, and tile drains are considered. Sources for turbidity and aquatic toxicity appear to be agricultural land uses that are fairly immediate in space and time. The same may hold true for nitrates, however the influence of tile drains and high water table are confounding effects because both the timing and location of nitrate inputs to the shallow groundwater can be further removed than in the simpler case of surface discharges to a surface water body.

4.5 Oso Flaco Creek

4.5.1 Watershed Description

The Oso Flaco Creek watershed is a small watershed (~16.2 square miles, or 10,370 acres) located just north of Guadalupe and the Santa Maria River estuary, in southern San Luis Obispo County (CRDC 2004). Drainage in the watershed is generally east-to-west, through a wedge-shaped area which is bordered on the north by the Nipomo mesa and by the Santa Maria River bed to the south. Land use in the Oso Flaco watershed is almost entirely in irrigated agriculture.

Oso Flaco Creek is joined by a small tributary from the east (Little Oso Flaco Creek, also monitored by the core CMP), about a mile and a half upstream of the creek's terminus at Oso Flaco Lake in the Guadalupe Nipomo Dunes Complex. Oso Flaco Lake is home to many species of plants, birds and other wildlife, and has been the subject of multiple conservation efforts. From the downstream end of the lake, the Oso Flaco Creek channel runs another ¼ mile through active sand dunes to the Pacific Ocean. The extent of outflow from Oso Flaco Lake depends on flow conditions from Oso Flaco Creek. Another important tributary (also from the east) is a drainage ditch which runs east to west along Oso Flaco Lake Rd, conveying inputs from most of the watershed north and east of the main creek channel.

The Oso Flaco Creek channel is dredged periodically due to high sediment deposition and flooding at the lower end of the watershed (CRCD 2004). At this time, all non-stormwater inputs to Oso Flaco Creek are believed to be of irrigated agricultural origin. During significant rain events, storm runoff is believed to come primarily from agricultural lands throughout the watershed. Storm inputs from residential developments on the mesa to the north are uncertain. Groundwater is likely to impact the quality of any water drawn from wells that is then discharged to Oso Flaco Creek. Shallow groundwater may also impact water quality in the creek via outputs from tile drains, which are used as in the Salinas Reclamation Ditch watershed, to speed the slow natural drainage of historically swampy areas (i.e. high water table and/or heavy soils) to allow crop production.

Ambient monitoring data collected in Oso Flaco Creek at Oso Flaco Lake Rd (312OFC) between January, 2005 and June, 2007 were assessed during development of this Follow-up project. These data indicated that levels of the following constituents do not comply with water quality objectives listed in the Basin Plan for one or more beneficial uses: Nitrate and Toxicity to Invertebrates in Water and Sediment. Beneficial Uses and Water Quality Objectives associated with these constituents are provided in Tables 3 and 4.

To address Follow-up monitoring requirements in the MRP, monthly monitoring was conducted at four additional sites within the Oso Flaco Creek watershed, with the following objectives:

- To determine source areas for constituents of concern measured at site 312OFC.
- To evaluate the relative importance of each source area as a contributor to the constituents measured at 312OFC.

To these ends, the following Upstream Monitoring sites were established in the Oso Flaco Creek watershed (Figure 12):

- Eastern tributary drainage at Bonita School Rd and Division St (312BSR, on south side of Division St)
- Oso Flaco Creek at Highway 1 (312OSR)
- Tributary drainage at Oso Flaco Lake Rd and Highway 1 (312OLR, northern ditch)
- Tributary drainage just upstream of confluence with main creek channel, at Oso Flaco Lake Rd (312USC)

The Bonita School Rd and Division St location (312BSR) is among the uppermost public access points in the watershed. It incorporates drainage from the eastern tip of the wedge-shaped watershed, mostly from areas east of Bonita School Rd and south of Division St.

The Oso Flaco Creek location at Highway 1 (312OSR) is the most upstream public access point to the main creek channel, and the only access point besides the core CMP site at Oso Flaco Lake Rd.

(312OFC). It incorporates drainage from an area which is generally east of Highway 1 and south of Oso Flaco Lake Rd.

The tributary drainage at Oso Flaco Lake Rd and Highway 1 (312OLR) is near the confluence of the eastern drainage monitored at 312BSR, and another drainage which runs roughly south to north along Highway 1. The monitoring site (312OLR), which is located at the northeast corner of the intersection, does not capture flows from this southern drainage, which enter immediately downstream.

The tributary drainage monitored at 312OLR continues west along Oso Flaco Lake Rd, eventually reaching the main Oso Flaco Creek channel. Site 312USC is located in this main tributary drainage, on the south side of Oso Flaco Lake Rd just upstream of the confluence with Oso Flaco Creek. Oso Flaco Creek runs under Oso Flaco Lake Rd via twin culverts at this point. Inputs to 312USC come from a) the site at 312OLR, b) the south-north drainage along Highway 1 not captured by 312OLR, and c) additional inputs west of Highway 1 and south of Oso Flaco Lake Rd.

The core CMP site on Oso Flaco Creek at Oso Flaco Lake Rd (312OFC) is located on the north side of Oso Flaco Lake Rd, immediately downstream of the twin culverts which convey creek flows beneath the road. Downstream of this point, additional inputs enter the creek from Little Oso Flaco Creek, and from lands to the north and west, prior to the creek's terminus in Oso Flaco Lake.

All Upstream Monitoring points incorporate at least two unique discharges from unrelated agricultural operations (discharges entering above the site but below the next most upstream site), and most incorporate more. That is, though located to illuminate source areas within the watershed, no two Upstream Monitoring points reliably isolate discharges from a single source.

4.5.2 Results

The full suite of monitoring results for sites in the Oso Flaco Creek watershed is provided in Appendices A and B. A site-specific summary of results for the parameters of special interest is provided in Table 19 and discussed here.

Flows were present at measurable levels at all Oso Flaco watershed sites during at least ten of the twelve 2008 monitoring events. Flows were highest at the core CMP site (312OFC), with a median value of 2.14 CFS. Flows were lowest at the Bonita School Rd/Division St intersection (312BSR) and where Oso Flaco Creek crosses Highway 1 (312OSR), with median values of 0.19 and 0.33 CFS respectively.

Nitrate concentrations were very high throughout the Oso Flaco watershed, with average values near or above 30 mg/L as N at all sites. Concentrations were lower during the January winter storm event, with values below 10 mg/L at all sites except for the core CMP site (312OFC), which had a concentration of 11.5 mg/L. The highest concentrations on the watershed in 2008 were at the more upstream sites, 312OSR and 312BSR, which had maximum concentrations of 95.6 and 125.0 mg/L, respectively.

Nitrate Loads were highest at the core CMP site (312OFC), following patterns in flow. Median loads at the upstream monitoring sites were roughly three to six times lower, at 2.5 to 5.2 lbs N/hr.

Orthophosphate concentrations were elevated at all Oso Flaco watershed sites during the January storm event in 2008, with concentrations that were roughly comparable among sites. Median values for the year were between 0.12 and 0.23 mg/L. The highest orthophosphate concentrations were at site 312USC, on the tributary ditch east of the core CMP site on Oso Flaco Lake Rd.

Turbidity measurements were very high throughout the Oso Flaco watershed in 2008, with average and median values for all sites over 100 NTU. Turbidities at all sites were above the range measurable by the field equipment (>3000 NTU) during the January winter storm event, but were also above 1000 NTU during at least one other event at all sites except 312OSR (Oso Flaco Creek at the railroad tressle). Turbidity levels at the core CMP site (312OFC) were intermediate, with the highest turbidities at sites 312OLR and 312USC.

Flow-weighted Turbidity was an order of magnitude higher at the core CMP site (312OFC), 312USC, and 312OLR than it was at 312OSR and 312BSR, which also had lower flows. Though raw Turbidity results were highest at 312OLR, Flow-weighted Turbidity was considerably higher at 312USC.

Laboratory **Toxicity** analyses performed on sediment samples showed toxicity to *Hyalella* survival at all sites on the Oso Flaco watershed in 2008. Tests for toxicity to *C. dubia* in water showed the most frequent toxicity at the Bonita School Rd/Division St intersection (312BSR) and in Oso Flaco Creek upstream at the railroad tressle (312OSR). However, all sites showed 0% survival rates for invertebrates in water on at least one occasion, and many samples without survival-based toxicity showed impacts to reproduction. Toxicity to algae and fish was assessed only at the core CMP site (312OFC), with no toxic results in 2008.

Results for **other water quality parameters** of interest in the Oso Flaco Creek watershed:

- Conductivity values averaged between 1300 and 1750 µS/cm
- pH was generally around 8.2, except at 312OFC where the median value was 7.7
- Dissolved oxygen concentrations were always above 7 mg/L at all sites; dissolved oxygen saturation were generally near 100%, with a few results over 130% at 312BSR in mid-summer
- Unionized Ammonia as N was generally low, but exceeded 0.025 mg/L at least once at every site, in some cases by two orders of magnitude

4.5.3 Source area analysis

Based on Upstream Monitoring results from throughout the Oso Flaco Creek watershed during 2008, several summarizing statements can be made. An 'at-a-glance' comparison of results among sites for each parameter is provided as box-and-whisker plots, in Appendix D. In summary:

- Flows in the Oso Flaco Creek watershed were generally low but consistent. Most, if not all, parts of the watershed appear to be source areas for flows measured at the core CMP site on Oso Flaco Lake Rd (312OFC). The drainage ditch which runs east to west along Oso Flaco Lake Rd is an important source of flows, contributing 30% or more of the flows measured at the core CMP site (312OFC) during eight of the monitoring events (as measured at site 312USC, just upstream of the tributary's confluence with the main creek channel).

- Upstream areas of the Oso Flaco Creek watershed appear to have been frequent source areas for highly concentrated nitrates (312BSR at Division St and Bonita School Rd; 312OSR in Oso Flaco Creek at Highway 1), however these were not exceptional source areas in terms of nitrate loading. Other watershed areas were also important contributors to nitrate loads, due to higher flows. Inputs to the drainage ditch between 312BSR (at Bonita School Rd) and 312OLR (at Highway 1) appear to have had a diluting effect on nitrate concentrations in the ditch, especially from June through October.

- Turbidity levels were elevated throughout the watershed, but the major source areas for suspended sediments, both in terms of concentration and loads, tended to be in the western half of the monitoring area (i.e. lower end of the watershed). Loading and concentration-based turbidity throughout the watershed were highest during the January storm event. However, most sites showed very high turbidity (>1000 NTU) and sediment loads during at least one or two spring and/or summer events as well.

- Toxicity to invertebrates in sediment was present throughout the Oso Flaco watershed in 2008 (all sites had low survival rates for *Hyalella*). Toxicity to invertebrates in water was also present at all sites, with low survival rates for *C. dubia* in at least one sample at each. Samples without reduced survival rates typically showed toxic effects to invertebrate reproduction. Some dilution of toxicants appears to have occurred in the western portion of the watershed, as the more eastern (i.e. most upstream) sites (312BSR and 312OSR) showed low invertebrate survival rates more frequently. Toxicity to fish and algae were not observed at the core CMP site (312OFC), and were not assessed at upstream sites.

At this time, the primary source of in-stream flow and constituents (including high nitrates, turbidity, and toxicity to invertebrates) to all monitoring sites in the Oso Flaco Creek watershed appears to be surface runoff and tile drain discharges from irrigated agriculture. Though other sources may exist, none were identified during the course of this study. High turbidity levels indicate that surface runoff is an important component of the inputs (as opposed to purely tile drain discharges), however it is possible that some dry season turbidity is due to resuspension of sediments deposited in channels by storm runoff.

5 DISCUSSION

The monitoring effort described in this report can generally be referenced to the "follow-up investigative monitoring" prescribed by the Central Coast Ag Waiver's Monitoring and Reporting Program, or "MRP" (CCRWQCB 2004b). Follow-up monitoring is described in the MRP, which states that: "Follow-up monitoring in problem areas should be conducted in a way to improve understanding of the nature and source of the problem. The intent of follow-up monitoring during the first cycle of the waiver program is to increase understanding of the areal scope, sources, and severity of the problem such that better feedback can be provided to growers related to management practice implementation" (CCRWQCB 2004b). All follow-up projects performed by the CMP share the objective of improving understanding of water quality issues in agricultural watersheds of the Central Coast. The specific goal of the Upstream Monitoring project detailed in this report is best described as "spatial source characterization," to identify sub-watershed areas which are important sources of constituents of concern measured at core CMP sites during routine monitoring.

All CMP watersheds incorporate multiple contributing discharges. Most also incorporate multiple land uses, and all have hydrologies which are manipulated to support these uses. Hydrologic modification is key to understanding water quality impairments in CMP watersheds, and in many cases the admonition "It's the hydrology, stupid" (Wilcox 2000) appears relevant. Central Coast water bodies are not the classic flowing streams of the eastern United States. Many CMP water bodies have no baseflow, and many are "losing streams" which would be entirely dry most of the year if not for municipal and industrial (including agricultural) discharges. In these cases, effluent discharges mix with other effluent discharges when they enter water bodies, rather than with diluting baseflows. Several CMP water bodies are controlled by large reservoirs in the upper watersheds, which are operated to release water throughout the year so as to maintain stream flows and groundwater levels for agricultural, municipal, and residential withdrawals (and to prevent seawater intrusion) in the lower watersheds. In some cases, these reservoirs are fed by the Bureau of Reclamation's Central Valley Project, effectively placing the Central Coast in the same watershed as the Central Valley, despite the lack of any natural hydrologic linkage.

It is also evident that CMP water bodies are currently perceived and/or used in a wide variety of ways by different sectors of society. The CCRWQCB Beneficial Use designations for CMP water bodies are provided in Table 4 of this report. Many CMP water bodies have Beneficial Uses which prescribe water quality to support the waters' being "drinkable, fishable, and swimmable." Wildlife protection agencies such as the CA Department of Fish and Game seek to conserve stream-related habitat for fish and other wildlife. At the same time, Caltrans, counties, and municipalities maintain some of these water bodies to convey storm drainage and prevent flooding of roadways and other public areas. A few CMP watersheds are historically swampy regions, in which new drainages were engineered decades ago to "reclaim" land for agricultural and municipal uses. In these areas, arable lands depend on the engineered drainages, as do the related cities. Most, if not all CMP water bodies have also served for decades as conduits for agricultural runoff related to irrigation and storms. It is helpful to assess water quality in CMP water bodies in light of these uses, which often control the hydrology and water quality, and thus the water bodies' current ability to support prescribed Beneficial Uses and water/habitat quality objectives.

5.1 Hydrologic Source Area Summary

Source area analysis for 2008 Upstream Monitoring included a very basic assessment of spatial patterns in stream flow for each of the water bodies. The hydrology of nearly all CMP water bodies is highly modified, with stream flows strongly tied to discharges, so this was an important first step in understanding source areas for water quality impairments. Careful placement of Upstream Monitoring sites plus reconnaissance of publically accessible areas of each watershed provided important perspectives on watershed areas which were either more or less important sources of the water sampled at CMP sites in 2008. Results can be synthesized as follows:

1) In Llagas Creek, flows were rarely present at sites upstream of Southside Ave (305LCS). Due to a more complex hydrology, upstream areas may contribute to groundwater, which is believed to interact with surface water quality lower in the watershed. The important inputs to Llagas Creek surface flows appear to begin somewhere downstream of the Highway 152 crossing (305LHB). Whether those inputs are primarily surfacing groundwaters (which could incorporate many inputs), or are true surface discharges (which could incorporate a limited number of point source inputs), is uncertain.

2) In San Juan Creek, there were consistently flows on both branches of the watershed, but not in upper watershed areas (i.e. hillsides). This indicates that both the urbanized and agricultural areas of the lower watershed are important sources of water to the core CMP site, and that surface flows most typically originate in the lower watershed. Hydrology on the eastern branch of San Juan Creek is dominated by tile drain systems; it is currently believed that the tile drainage is necessary to maintain arable lands.

3) In the San Benito River, flows were always low, with non-storm flows (of unknown origin) observed only at Y Rd, near the confluence with the Pajaro River. This indicates that without storm flows, only surface inputs from the lowermost portion of the watershed immediately affect the Pajaro River, and these are very low in volume.

4) In Quail Creek, there were consistently flows at Old Stage Rd, but areas much further upstream were generally dry. No non-agricultural sources of water were identified, and the stream does not appear to have any baseflow. This indicates that irrigated agriculture is probably the sole source of water sampled at the core CMP site, and also suggests that the creek might be dry most of the time in the absence of agricultural flows. A tributary ditch contributing just downstream of the core CMP site is a source of flows to the Salinas River not sampled by the core CMP in Quail Creek.

5) In Chualar Creek, there were consistently flows at Old Stage Rd, but upper watershed areas (i.e. in the Gabilan foothills) are believed to be dry without storm conditions. No non-agricultural sources of water were identified, and the stream does not appear to have any baseflow. This indicates that agriculture is probably the sole source of water sampled at the core CMP site, and also suggests that the creek might be dry most of the time in the absence of agricultural flows. Flow patterns also identified the southern portion of the Chualar watershed as a more important source of flows to the Salinas River than the northern branch of Chualar Creek monitored by the core CMP.

6) In the Salinas Reclamation Canal, Alisal Creek appears to be the dominant source area for surface flows east of Salinas, with important inputs from Natividad Creek, and very little input from Gabilan Creek. At least one additional creek not monitored by the CMP likely contributes from the north. Within Alisal Creek, the dominant source of flows appears to be the irrigated agricultural area west of the Gabilan foothills and upstream of Hartnell Rd. Areas within the urban boundary of Salinas contribute important additional flows (year round, but more so during storms), as does the agricultural area west of Salinas.

7) Flows in the mainstem Salinas River originate primarily in the San Antonio and Nacimiento Rivers. Tributaries upstream of San Miguel can contribute smaller flows, but many are dry arroyos. (The upper Estrella River often has water, but runs dry long before reaching the Salinas.) San Antonio and Nacimiento River flows are the main factor influencing flows at Greenfield and areas downstream.

8) In Glen Annie Creek, the watershed area upstream of Bishop Ranch Rd is a consistent source of flows measured at the core CMP site, though the origin of these remains unclear. The reach between the core CMP site and Bishop Ranch Rd is a source of slightly more flow volume than the reach above Bishop Ranch Rd.

9) The Santa Ynez River around Lompoc appears to sometimes incorporate flows from the upper watershed area influenced by Cachuma Reservoir releases, but is often dry immediately downstream of River Park. Flows resume again at Floradale Ave due to substantial contributions from the urban Miguelito Creek. Further downstream, an agricultural drainage ditch between Douglass and De Wolff Avenues is a much smaller, though fairly consistent, source of flow.

10) The Main St Ditch in Santa Maria appears to receive consistent inputs to its underground portion, and consistent additional inputs to the aboveground portion downstream of Hanson Way. All inputs are believed to be of anthropogenic origin, though the mix of urban versus agricultural inputs upstream of Hanson Way is uncertain. Inputs downstream of Hanson Way appear to be primarily, if not entirely, agricultural.

11) Orcutt-Solomon Creek is typically dry east of the city of Orcutt. Flows appear to begin with a residential/municipal well-head overflow near Highway 135, and to increase substantially once the creek channel enters the agricultural area west of the urban boundary. Flows are much higher at the lower, western end of the watershed, indicating that this is the major source area for surface flows. The extent to which these surface flows originate as simple surface "runoff," versus augmented land drainage (i.e. "tile drains"), is uncertain. Green Valley, which originates near the Main St/Bonita School Rd intersection, is a source of low but consistent flows to Orcutt-Solomon Creek just upstream of Highway 1. It remains uncertain to what (if any) extent groundwaters containing inputs from urban and upstream areas contribute to surface water flow volumes and water quality in the lower Orcutt-Solomon watershed.

12) A large portion of the northern Oso Flaco Creek watershed is drained by an engineered ditch network, which often contributed about one third of the flows observed at the core CMP site during this study. The southern portion of the watershed, and typically about two thirds of the flow measured at the core CMP site, drains to the main Oso Flaco Creek channel. More of these flows appear to originate west of Highway 1 than from east of it. Tile drains are known to contribute to surface flows downstream of the core CMP site, however they are not believed to contribute to the engineered ditch network. The extent to which tile drains contribute to the main creek channel upstream of the CMP site is uncertain.

5.2 Constituent-Based Source Area Summary

The above synthesis should clearly indicate which watershed areas did or did not contribute inputs to stream flows at CMP sites in 2008 (except in some cases by affecting groundwaters which may surface downstream). It should also indicate a few cases in which questions remain. Next, results were reviewed for specific constituents of concern measured at CMP sites. These concentration-based data were reviewed in light of flow data, to differentiate between sources of high-concentration but low-volume discharges, versus major sources of loading to downstream areas. Results can be synthesized as follows:

1) In Llagas Creek, source areas for nitrates and suspended sediments, both in terms of concentration and loading, were the reaches up- and downstream of the core CMP site at Southside Ave (305LCS). That is, the area from 305LCS upstream to the Highway 152 crossing (305LHB) and the area from 305LCS downstream to Bloomfield Ave (305LLA). Source areas for aquatic toxicity were not assessed due to a lack of history of toxicity at the core CMP site.

   Land uses potentially contributing to this reach include irrigated agriculture, urban areas, and point source discharges such as processing and wastewater treatment plants. Results from this study do not support conclusions regarding the relative contributions from each of these potential sources. Further study, including field observations and sampling of specific inputs within this reach, would provide better definition.

2) In San Juan Creek, the western (agricultural) branch of the watershed was a much more important source of nitrates than the eastern (urbanized) branch, both in terms of concentration and loading. Consistent loading did come from the eastern branch however (the San Juan Bautista WWTP is a possible source for this nitrate), and no reach on the western branch stood out as a much more significant source of nitrate loading than another. The most important source area for suspended sediment loads was the western (agricultural) branch upstream of Prescott Rd, with a possible sediment sink further downstream. The eastern (urban) branch had higher concentration-based turbidities, but lower flows. All watershed areas showed at least sub-lethal effects to invertebrates in sediment, and there were sporadic effects to invertebrates in water on both branches as well.

   Sources for turbidity and aquatic toxicity appear to be agricultural land uses that are fairly immediate in space and time. The same may hold true for nitrates, however the influence of tile drains and high water table are confounding effects because both the timing and location of nitrate inputs to the shallow groundwater can be further removed than in the simpler case of surface discharges to a surface water body. That is, it is uncertain if nitrates in the tile drain discharges are entirely sourced from the operation hosting the sump.

3) In the San Benito River, nitrate concentrations were always low compared to core CMP watersheds, and turbidities were also on the low side except during storm events. Other tributaries to the Pajaro were much more important sources for nitrate in 2008. Storm-derived sediment loads came more from the Hollister area than the downstream area around Y Rd, and the river channel downstream of Hollister may be a sink for some of these sediments.

   The San Benito River does not appear to be an important source area for constituents of concern measured in the Pajaro River at Chittenden. Some impairments were observed at the lowermost San Benito River site, but the low flows make it unlikely that these are important contributions to the Pajaro River. Sources for constituents measured at the San Benito River sites cannot be determined from results of this study.

4) In Quail Creek, the area upstream of Old Stage Rd was a source of consistent, low-volume flows which were very high in nitrates. The other watershed areas (all of them) were more important in terms of nitrate loading however, due to higher flows containing elevated nitrate concentrations. Watershed areas downstream of Potter Rd were more important sources of suspended sediments. Toxicity to invertebrates in water and sediments were ubiquitous, and it was not possible to distinguish any single source area. At least on occasion however, the ditch contributing downstream of the core CMP site contained substantially fewer toxicants. During one monitoring event, flows from this ditch appeared to dilute waters in Quail Creek enough to allow 100% survival rates for *C. dubia*, despite 0% survival rates upstream.

   At this time, the primary source of in-stream flow and constituents to all monitoring sites in the Quail Creek watershed appears to be surface runoff from irrigated agriculture. Though other sources may exist, none were identified during the course of this study.

5) In Chualar Creek, all watershed areas were sources of high nitrates in 2008, however the north branch sites were frequently dry, reducing the northern watershed's importance as a nitrate loading area relative to the south branch. The same can generally be said of suspended sediments, however a possible sediment sink in the south branch reach just upstream of Highway 101 may reduce sediment loads there compared to what they would be without the sink. Source areas for toxicity to fish and algae were not assessed, however the core CMP site on the north

branch did show toxicity to algae on one occasion. The only source area for sediment toxicity to invertebrates in 2008 appears to have been the south branch reach upstream of Old Stage Rd. This is not consistent with 2006-2007 results, which showed sediment toxicity at the core CMP site on the north branch at Highway 101. In general, all watershed areas were sources of toxicity to invertebrates in water.

At this time, the primary source of in-stream flow and constituents to all monitoring sites in the Chualar Creek watershed appears to be surface runoff from irrigated agriculture. Though other sources may exist, none were identified during the course of this study.

6) In the Salinas Reclamation Canal watershed, Natividad Creek was the source of the highest nitrate concentrations, however Alisal Creek was a more important source of nitrate loading due to higher flows. The reach of Alisal Creek upstream of Hartnell Rd was an important source area for both nitrates and suspended sediments. Alisal Creek in general was the most important source area for suspended sediment loads to the Reclamation Canal. Gabilan Creek was rarely a source area for any constituents due to lack of flows. Source areas within the urban boundary of Salinas were important during winter months, in terms of both nitrate and sediment loading. Inputs from these areas were generally lower in concentration, however, and did not contribute much to loading during the rest of the year. The area immediately downstream (west) of the Salinas urban boundary was an important source area for nitrates and suspended sediments. With regard to aquatic toxicity (in sediments and water), Alisal Creek had the highest frequency of toxicity and lowest survival rates for test organisms, as did its upstream reach sampled at Hartnell Rd. All other sites also showed toxicity to invertebrates in water and sediment. Additional source areas (contributing to these other sites) are likely, since downstream inputs without toxicants might have diluted the Alisal Creek inputs to less toxic levels. Hydrology in the lower Reclamation Canal watershed is dominated by augmented land drainage; it is currently believed that the augmented drainage is necessary to maintain arable and urban lands.

   Land use in the area east of Salinas is overwhelmingly agricultural. The level of impairment on Alisal Creek at Hartnell Rd, which is upstream of all known non-agricultural inputs, suggests an important role for surface runoff from irrigated agriculture. Though much of the impairment measured at the lowermost site west of Salinas, 309JON at San Jon Rd, can be explained by inputs from further up the watershed and measurable at Davis Rd. (309AVR), it is also clear that the area between these two sites is an important source area for additional inputs. The only known land use in this reach of the Reclamation Canal is irrigated agriculture.

   All of the flow and constituents measured at Davis Rd., west of Salinas, were not fully explained by the contributions measured from Alisal and Natividad Creeks. This indicates additional source areas, which may include urban storm drains, flows from Santa Rita Creek (another eastern tributary not monitored by the CMP), and/or contributions from the Carr Lake area which is an area of agricultural land use within the otherwise urban boundary of Salinas. All of these other potential sources bear further investigation.

7) The upper Salinas River was clearly not a source area for highly concentrated nitrates in 2008, but nitrate loading from this area was substantial due to high flows. The same can be said for suspended sediments, though high concentration-based turbidities were occasionally observed in the upper Salinas watershed during storm events. The upper Salinas did not appear to be a source area for toxicity to algae, nor for toxicity to invertebrates in sediment. It was, however, a sporadic source of toxicity to fish and invertebrates in water. More specific source areas were not identified.

   At this time, the primary source of in-stream flow to the Upper Salinas River appears to be contributions from the San Antonio and Nacimiento Rivers. Increased nitrate concentrations and toxicity to aquatic organisms between Bradley and Greenfield, without concurrent increases in flow, suggest highly-concentrated, low-volume discharges from this area. This reach of the Salinas covers a large area encompassing multiple land uses including irrigated agriculture, urban areas, rural residences and oil fields. Though data from this study clearly identified this reach as a source of impairments, additional monitoring would be required to clearly identify sources/source areas within the reach given the diversity of land uses present.

8) The reach of Glen Annie Creek upstream of the core CMP site and downstream of Bishop Ranch Rd was clearly the most important source of nitrates measured at 315GAN, both in terms of concentration and loading. No watershed area stood out as a more important source of suspended sediments, and levels were generally low to begin with. The reach between Bishop Ranch Rd and the core CMP site also appeared to be a more important source area for toxicity to algae, but the area upstream of Bishop Ranch Rd cannot be ruled out completely, as toxicity was observed there on one occasion. Toxicity to fish and to invertebrates in sediment were not found in 2008, and have not historically been issues in Glen Annie Creek. However, toxicity to invertebrates in water was consistently present at the core CMP site in 2008; source areas were not assessed due to a lack of prior toxicity of this type. Surface runoff from irrigated agriculture is not visible from public access points in this watershed, however primary land uses in the reach contributing most of the impairments are agricultural and rural residential. Though other sources may exist, none were identified during the course of this study.

9) The upper Santa Ynez River does not appear to be a source area for nitrates or suspended sediments beyond the loads which are naturally associated with moderate flows of low concentration for both constituents, except in major storms. The upper Santa Ynez River also does not appear to be a source of any aquatic toxicity. This indicates that upstream land uses such as irrigated agriculture, rangeland, and urban areas are not important sources for impairment in the lower watershed.

   In the Lompoc area, Miguelito Creek was by far the most important source of nitrates, with high concentrations and consistent flows to generate loads. Miguelito Creek was also the most important source of sediment loading, despite slightly higher concentrations (turbidity) in the agricultural channel between Douglass and De Wolff Avenues. Miguelito Creek was also the likely source of toxicity to algae observed at Floradale Ave, as these were the only two sites showing this type of toxicity in 2008. Upstream land use on Miguelito Creek is entirely urban, including a WWTP immediately above the monitoring site. Toxicity to fish and invertebrates in sediment did not occur at any site in 2008, nor did survival-based toxicity to invertebrates in water. Sub-lethal effects to invertebrates in water were observed at Floradale Ave and downstream at 13th St, but source areas were not assessed due to limited toxicity of this type in the past.

   The tributary draining lands in agricultural use south of the River (314DDE) had extremely low flows, making it a minor source of loading for all constituents. Nitrate and phosphate levels in this drain were the lowest in the watershed, however unionized ammonia was frequently elevated. Lands drained by 314DDE do not appear to have been sources of aquatic toxicity to the downstream CMP site (314SYN), as toxicity was not elevated at this site relative to 314SYF.

10) In the Main St Ditch in Santa Maria, the daylighted reach downstream of Hanson Way and upstream of Black Rd was the most important source area for nitrate loading. Inputs in this reach were generally of agricultural origin. There was one instance of very high nitrate concentrations from the area upstream of Hanson Way, but both concentrations and loads were usually lower there. Inputs in this reach were of mixed agricultural and urban origin. The area upstream of Hanson Way was clearly a source for toxicity to invertebrates in both sediment and water. However, test organism performance was even more impaired in the more downstream area,

indicating that inputs between Hanson Way and Black Rd probably contribute additional toxicants. Though the agricultural area downstream of Hanson Way was clearly a source of impairments, additional information regarding inputs to the underground portion of the Main St Ditch (upstream of Hanson Way) is needed to determine the relative importance of agricultural versus urban inputs in that part of the watershed.

11) In Orcutt-Solomon Creek, urbanized areas of Santa Maria and Orcutt and areas east of the cities were not sources of highly concentrated nitrates or major flows in 2008. The area contributing to the creek west of Orcutt, between Solomon and Black Roads, was sometimes a source. In general, the important source areas for nitrates (concentrations and loading) were downstream of Black Rd and also west of Highway 1. The area draining to the Main St/Bonita School Rd intersection (Green Valley) was also a source, as was the reach between that intersection and Simas Rd, though these were relatively low in volume. The most important source area for sediment loading in the Orcutt-Solomon watershed was clearly the north-fork tributary, west of Highway 1. Urban areas and the reach between Solomon and Black Roads were not important source areas for sediment, and contributions from Green Valley and the area between Black Rd and Highway 1 were minor. By calculation, the reaches from Black Rd. to Highway 1, and from Highway 1 west to the sand plant appear to have been important source areas for suspended sediments.

    Source areas for toxicity to invertebrates in sediment included reaches downstream of Black Rd, as well as Green Valley (at Main St and downstream). Areas upstream of Black Rd were generally not sources of aquatic toxicity in 2008. Sporadic toxicity to fish and algae occurred at Highway 1 and in Green Valley, but these were not assessed at upstream sites. Consequently, the only area shown *not* to be a source area for fish or algae toxicity in 2008 is the area west of Highway 1, as these types of toxicity were not observed at the sand plant (312ORC). Conversely, the area west of Highway 1 appears to have been an important source area for toxicity to invertebrates in water, as the north-fork tributary and core CMP site at the sand plant showed fairly consistent lethal effects. Green Valley was also a fairly consistent source area for lethal effects to invertebrates in water, with some lethal effects also observed upstream at the Main St/Bonita School intersection. Areas draining to Orcutt-Solomon Creek upstream of Black Rd and perhaps even upstream of Solomon Rd appear to have contributed more sporadically, with more sub-lethal than lethal effects.

    At this time the lower portion of the Orcutt-Solomon Creek watershed (west of Black Rd. and especially west of Highway 1) appears to be the primary source area for in-stream flow and much of the water quality impairment observed at the mouth (312ORC), especially on a loading basis. Land use in this portion of the watershed is primarily agricultural. The eastern (more upstream) reach of the creek, which runs through the urbanized portion of the watershed, was generally dry in 2008, indicating that urban areas were less important sources of direct surface water impairment during most months. High turbidity levels in the lower, agricultural portion of the watershed indicate direct surface runoff. This runoff may also be a source of high nitrates. Results from this study are inconclusive as to whether wastewater treatment facilities are sources of nitrate, especially when potential interactions between the stream channel, areas of groundwater upwelling, and tile drains are considered.

12) All areas of the Oso Flaco Creek watershed contributed nitrate loads with high concentrations. Inputs to the engineered tributary ditch along Division St between Bonita School Rd and Highway 1 appear to have had a slight diluting effect on nitrate concentrations in the ditch, especially from June through October. Winter storms were important for sediment loading throughout the watershed, but more important source areas for loading during the rest of the year were in the western half of the watershed, west of Highway 1. Areas east of Highway 1 were

probably more frequent sources of higher-concentration toxicants in 2008, as survival-based toxicity to invertebrates in water was observed more frequently at the Bonita School/Division St site and in the mainstem creek at Highway 1 than at the core CMP site. Frequency of survival-based toxicity to invertebrates in water declined moving west through the watershed, however all sites exhibited this to some extent, and samples without lethal effects generally had sub-lethal effects. No watershed area can be ruled out as a source of toxicity to invertebrates in sediment, as all sites showed lethal effects. A slightly higher percentage of invertebrates survived in sediments from sites in more western areas of the watershed, however.

At this time, the primary source of in-stream flow and constituents (including high nitrates, turbidity, and toxicity to invertebrates) to all monitoring sites in the Oso Flaco Creek watershed appears to be surface runoff and tile drain discharges from irrigated agriculture. Though other sources may exist, none were identified during the course of this study. High turbidity levels indicate that surface runoff is an important component of the inputs (as opposed to purely tile drain discharges), however it is possible that some dry season turbidity is due to resuspension of sediments deposited in channels by storm runoff.

5.3 Conclusion

The Upstream Monitoring project in 2008 was designed to identify source areas for water quality impairments, and as such has provided important insights into the areal scope of water quality issues at core CMP sites. Results generally showed that this scope extends throughout multiple sub-watershed areas within each CMP watershed, indicating that the water quality issues stem from multiple sources. Specific sub-watershed source areas are identified throughout this report. Some more general conclusions about sources for water quality impairment (and for water in general) can also be drawn.

Several of the 2008 Upstream Monitoring water bodies do not have a “baseflow.” In some of these cases, land drainage in areas with high water tables essentially creates something akin to a baseflow, however the drainage often carries constituents of concern from current or historic land use. Though some points of discharge for this drainage can be identified, it is more difficult to identify the exact source (in space or time) for the constituents it contains because the drainage consists of sub-surface waters. Water bodies from 2008 Upstream Monitoring for which this may be the case include the east branch of San Juan Creek, parts of Llagas Creek, the Salinas Reclamation Canal west of Salinas, parts of Oso Flaco Creek, parts of Orcutt-Solomon Creek, and parts of Green Valley.

In other water bodies without natural baseflow, the only water present is either storm runoff (occasional, due to infrequent large rain events) or composed entirely of anthropogenic discharges. In these cases, it is generally possible to identify each contributing discharge, and water quality in the stream is usually determined by the mix of discharges, or by the dominant one. These water bodies would likely be dry in the absence of the discharges. In some water bodies from 2008 Upstream Monitoring, the dominant discharges were agricultural. These included Quail and Chualar Creeks, Reclamation Canal tributaries from the east side of Salinas, the West Central Ave canal in Lompoc, parts of Oso Flaco Creek, parts of Orcutt-Solomon Creek, parts of Green Valley, the Main St Ditch below Hanson Way, and at least one reach of Glen Annie Creek. In other water bodies, the dominant discharges were clearly of urban origin, including the west branch of San Juan Creek, part of the Main St Ditch in Santa Maria, and Miguelito Creek in Lompoc.

A few 2008 Upstream Monitoring water bodies have flows from more “natural” water sources (i.e. non-effluent flows), but these are generally controlled by reservoirs which are operated to achieve various water supply objectives in the lower watershed areas. The upper Salinas River is an example of this. In some cases (e.g. the Santa Ynez River upstream of Lompoc), the source of some or all of this water is from outside the watershed. In San Juan Creek, water sourced from outside the watershed is delivered to the area, which contributes to high water table levels, which requires land drainage and generates stream flows in the east branch of the creek. Stream flows directly derived from reservoirs typically do not show the same level of impairment as those dominated by anthropogenic discharges. This makes sense, as the reservoir release flows heavily dilute any agricultural or urban discharges to the water body.

Upstream Monitoring in 2008 greatly improved knowledge of surface water quantity and quality in many of the key CMP watersheds, and also identified source areas for water quality impairments identified by the core CMP. This information has been, and continues to be, used by the CMP to perform focused outreach to farmers in areas of concern, including locally relevant data about how their own operations might be contributing. This information has also informed prioritization of CMP watersheds for focused advertising of a confidential, on-farm sampling service, which many farmers have taken advantage of to learn exactly how their own discharges relate to bottom-of-the-watershed water quality concerns. It is anticipated that as farmers learn of water quality concerns in a way that is specifically relevant to their own operations, monitoring results from the core CMP and potential future Upstream Monitoring will demonstrate improvements in water quality related to changes made on-farm.

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