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CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
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SCIENTIFIC PEER REVIEW COMMENTS AND STAFF RESPONSE

The following comments address the external scientific review of the Total Maximum Daily Load for Fecal Coliform for the Lower Salinas River Watershed, Monterey County, California. The external scientific reviewer was Stefan Wuertz, Ph.D. of the University of California at Davis, who submitted his review in a document (submittal) dated May 15, 2009, and received via email in the Central Coast Water Board's office on May 18, 2009.

Central Coast Water Board staff asked the reviewer to determine whether the scientific portion of the TMDLs was based upon sound scientific knowledge, methods, and practices. We requested the reviewer make this determination for several issues that constituted the scientific basis of the TMDLs. The issues are presented below, with the reviewer's comments and staff's response.

In general, the reviewer comments were broadly supportive with respect to the numeric targets, the implementation plan, the proposed monitoring plan, and the Use Attainability Analysis. The reviewer also provided recommendations and comments, summarized in Section 3 of the submittal, as transcribed below:

- "It is recommended that fecal coliform TMDLs be defined on a mass basis (e.g. number of cells per day) for fecal indicator bacteria…"

- "A substantial uncertainty as to the ability to distinguish between natural and controllable sources of fecal pollution is mentioned in the report. Microbial source tracking techniques should be employed alongside FIB measurements whenever feasible."

- "The proposed measures to reduce allocations from controllable sources are supported scientifically and may be adequate to achieve necessary load reductions and compliance with a mass-based TMDL."

Scientific Peer Review of Review of Proposed Fecal TMDL in Salinas River Watershed

Section 1: State of Scientific Knowledge about Pathogens and Microbial Indicators in Recreational Waters

1. Reviewer's comment: The Salinas River watershed is considered to be impaired on the basis of Fecal Coliforms. Microbial indicator organisms or fecal indicator bacteria (FIB) are monitored rather than pathogens because direct measurements of protozoa, bacteria, and viruses of public health significance are considered to be too slow, too difficult for routine analyses, and too expensive.

   For the microbial indicator approach to be effective at protecting public health in recreational waters there must be a well-defined relationship between the presence of FIB and incidence of illness or disease in humans. A perusal of the scientific literature suggests that FIB measured close to point source releases of fecal pollution may indicate the likelihood of illness at marine beaches and other recreational areas; however, there is very little evidence that such a relationship exists for nonpoint source pollution (see for example, Colford et al. 2007, Wong et al. 2009).

   In contrast, a wealth of scientific data exists suggesting that FIB can survive and even propagate in the environment, including on roofs, in city parks, and in the epilithon (biofilms attached to rocks in rivers and streams) and sediments of rivers and streams. Most recently, both enterococci and *E. coli* cells have been reported in great numbers along California's coastal beaches (Lee et al. 2006, Yamahara et al. 2007) and freshwater beaches (Ishii et al. 2007) suggesting sand washout as a major mechanism for loading of *E. coli* into the beach waters. Sand and sediment appear to act as temporal sources and sinks of *E. coli* and FIB in general can become "naturalized" in the environment (Ishii and Sadowsky 2008). Studies showing that FIB levels in sediments are high and can lead to unpredictable pulses of indicator concentrations in the water column due to subsurface flow on beaches or resuspension in the overlaying water complicate matters for regulatory agencies, which currently must rely on indicator measurements alone to determine the safety of recreational waters.

   Direct pathogen measurements rarely correlate with elevated FIB counts. Scientists are increasingly calling for regulations and standards that target rapid monitoring of relevant indicator organisms including disease causing agents, such as *Cryptosporidium* spp., *Giardia lamblis*, Adeno- and Enteroviruses, and a variety of bacterial pathogens (e.g., Field and Samadpour 2007, Santo Domingo et al. 2007). Improved water filtration technology and quantitative molecular detection methods are becoming available to establish standard methodology and operating procedures with the objective of cataloguing the extent of microbial pollution of recreational waters. The costs of diagnostic assays have decreased appreciably and there is no longer any reason to doubt that many pathogens can be reliably detected in the

environment. These technological advances should facilitate future regulations to establish pathogen-specific numeric targets for impaired watersheds.

Against this scientific backdrop the overarching question is how to best develop Pathogen (or Fecal/Total Coliform) TMDLs that are still based on microbial indicator standards (fecal coliforms, *E. coli*, *Enterococcus*) and yet allow for more advanced pathogen monitoring methodology and science-based decisions to be applied should classical FIB measurements prove inadequate at predicting public health risks for recreational uses. U.S. EPA is in the process of updating its recreational criteria with a focus on the protection of human health at public swimming areas in coastal waters of the United States. EPA also wants the revised/new criteria and methods to be applicable in different types of water bodies. Scientific knowledge regarding the persistence of FIB in the environment has evolved substantially in the past 5 years. It is, therefore, important to insert language into the Final TMDL Project Report that explicitly acknowledges uncertainties regarding the environmental sources of fecal indicator bacteria. For example, it is conceivable that observed exceedances of water quality objectives in targeted watersheds are in part caused by seeding of the water column from stream sediments and other specific niches that allow indicator bacteria to persist and multiply.

Staff response: Staff inserted additional narrative into the Project Report, acknowledging and outlining the scientific uncertainties which the Reviewer has noted. Staff added narrative to the Project Report noting that technological and regulatory advances may require the proposed TMDL to be modified in the future should new regulatory standards or methods be adopted with respect to pathogen monitoring.

2. Reviewer's comment: Taken in their entirety the proposed measures as outlined in the Draft TMDL Project Report for the targeted watersheds should reduce the levels of fecal microbial indicators in creeks, rivers and the estuary by improvements to storm water drainage systems as well as human and domestic animal discharges, onsite sewage disposal systems and controllable wildlife sources. As TMDLs are being implemented and monitored additional studies may be conducted by the Central Coast Regional Water Quality Control Board to analyze sources of FIB that cannot be attributed to controllable sources as component of site-specific objectives. One of the chief uncertainties is the release of "naturalized" FIB from non-fecal (or not recently fecal) sources. These sources represent natural, uncontrollable sources and cannot be subjected to implementation actions as mentioned on page 49 in the report. Unpublished studies in progress in California would suggest that these in-stream sources can be significant. Specific suggestions for the calculation of TMDLs and load allocations are included in section 2.

Staff response: Staff agreed with the Reviewer's comment. Staff added narrative to the Project Report clarifying that Responsible parties may also demonstrate that although water quality objectives are not being achieved in receiving waters, controllable sources of pathogens are not contributing to the exceedance. If this is the case, the Central Coast Water Board may re-evaluate the numeric target

and allocations. For example, the Central Coast Water Board may pursue and approve a site-specific objective. The site-specific objective would be based on evidence that natural, or background sources alone were the cause of exceedances of the Basin Plan water quality objective for pathogen indicator organisms. Additionally, narrative was added stating that should all control measures be in place, and fecal coliform concentrations remain high, and the TMDL not be met, staff may investigate or require investigations (e.g., genetic studies to isolate sources or other appropriate monitoring) to determine if the high level of fecal coliform is due to uncontrollable sources or other controllable sources not previously identified.

Section 2.1: Problem Statement

3. Reviewer's comment: The beneficial uses identified in the Central Coast Water Quality Control Plan (Basin Plan) for the (lower) Salinas River watershed that are associated with pathogen concentrations are water contact recreation (REC-1), non-contact water recreation (REC-2), and shellfish harvesting (SHELL). Current levels of fecal coliforms (FC) are not supportive of REC-1 or REC-2 beneficial uses in this watershed; in addition, it is proposed to remove SHELL as beneficial use.

   Staff response: Staff noted and agreed the Reviewer's comment.

Section 2.2: Source analysis

4. Reviewer's comment: Source analysis for fecal coliform and generic *E. coli* as indicators for the presence of pathogens was based on indicator bacteria density data, land use, genetic typing, field reconnaissance, and personal communication. Identified sources were classified in terms of source categories and source organisms. Storm drain discharges, domestic animal discharges, illegal dumping, homeless encampments, onsite waste disposal systems as well as spills and leaks from sewage collection and treatment systems and natural sources are mentioned as source categories. Humans, pets (cats and dogs), domestic animals (cattle, horses, goats, sheep, and chickens) as well as wildlife (wild pigs, skunk, opossum, birds, and deer) are specifically listed as source organisms. Reviewer finds the assessment of the relative importance of all sources listed by staff to be logical and conclusive.

   Staff response: Staff agreed with the Reviewer's comment.

5. Reviewer's comment: Wild animals are listed as natural sources and were partially identified via DNA fingerprinting analysis. Reviewer agrees that most of these natural sources are not controllable. Based on information available it is concluded that data are insufficient to state unequivocally whether natural sources alone were causing exceedances of water quality objectives (WQO) in the lower portions of the project area. These conclusions are reasonable, but as discussed in section 1 of this review, fecal coliforms in the lower portions of the watershed could be originating from a contamination event in the past, having been swept up into the water column

due to a resuspension event or by gradual erosion of microbial biofilms present in the stream bed. These latter scenarios, which also represent natural, but uncontrollable sources, are not acknowledged in the current Draft TMDL Project Report. A critical condition mentioned in the draft report that occurs during and following rain events is well justified based on presented coliform and *E. coli* data.

Staff response: Staff modified the Source Analysis section of the Project Report to empirically assess the potential load contribution of sediment-associated bacteria, and the potential load contribution of wildlife. Staff agreed with the Reviewer's comment pertaining to critical conditions.

Section 2.3: Numeric Targets

6. Reviewer's comment: The fecal coliform water quality objective of a log mean fecal coliform concentration of 200 per 100 mL, based on a minimum of not less than five samples for any 30-day period, and a limitation of not more than ten percent of total samples during any 30-day period with fecal coliform concentration above 400 per 100 mL is proposed as numeric target or the lower Salinas Watershed. These numeric targets were selected based on the assumption that shellfish harvesting beneficial use will be removed.

   In the absence of sufficient pathogen data or sufficient scientific knowledge about the public health risks associated with FIB in recreational waters impacted by NPS pollution this target is reasonable. Improvements in the controllable sources as outlined in the Draft Project Report should provide load reductions of human and domestic animal fecal pollution.

   Staff response: Staff agreed with the Reviewer's comment.

Section 2.4: TMDLs and Allocations

7. Reviewer's comment: Fecal coliform TMDL are proposed for six different waterbodies listed on the 303(d) list and four waterbodies that are not currently listed. The ability to differentiate between controllable and natural sources is stated as the chief uncertainty.

   Reviewer does not follow the rationale presented by the Water Board to set TMDLs as the same set of concentrations as the numeric targets. The EPA Protocol for Developing Pathogen TMDLs (2001) states that "… fecal indicators, however, TMDLs can be expressed in terms of organism counts (or resulting concentration)" also referring to 40 CFR 130.2(i) (First Edition, page 7-1). However, the EPA also recommends in the Draft document "Options for the Expression of Daily Loads in TMDLs" from June 2007 that "As with load-based TMDLs, if the established concentration-based TMDL is not on a daily time step, the TMDL should also include a daily expression representing the non-daily allocation." (p47). In this document an approach is presented for identifying a daily expression corresponding to the non-

daily allocations developed in concentration-based TMDLs. Reviewer considers this approach advisable in case of concentration-based TMDLs. While it is stated in the Draft Project Report that public health risks are based on organism concentration and that pathogens are not readily controlled on a mass basis, health risks emerge from variations in concentrations at the time of contact and not from long term means.

Staff response: Staff modified the Project Report to provide for mass-based daily load expressions in accordance with 2007 USEPA draft guidance. The USEPA draft guidance was explicitly produced to address the legal issues arising from the Anacostia Decision by the U.S. District of Colombia Circuit Court of Appeals (see Transmittal Letter and Executive Summary in USEPA, 2007). USEPA continues to recognize the validity of concentration based TMDLs, where appropriate, in accordance with 40 CFR 122.45(f). *Indeed, in the draft 2007 guidance, USEPA explicitly recognizes that TMDLS may be expressed as a concentration of a pollutant, but that it would be possible to supplement the TMDL with a daily load expression.:*

> *"For TMDLs that are* ***expressed as a concentration of a pollutant****, a possible approach would be to use a table and/or graph to* ***express the TMDL as daily loads for a range of possible daily stream flows****. The in-stream water quality criterion multiplied by daily stream flow and the appropriate conversion factor would translate the applicable criterion into a daily target."**
> *-- USEPA, 2007 "Options for Expressing Daily Loads in TMDLs", Office of Wetlands, Oceans and Watersheds, June 22,2007.*
>
> * emphasis added

In the modified Project Report, Staff provides interpretations of our concentration-based allocations and TMDLs as a daily load expression in MPN/per day in accordance with the draft 2007 USEPA guidance; however, we intend to implement the concentration-based TMDLs and allocations. A daily or average daily TMDL is inappropriate for the proposed allocations and TMDLs due to both (1) the temporal component embedded in the applicable water quality objective for bacteria; and (2) the episodic and highly variable nature of FIB transport and loading in streams, which make daily fecal coliform loads inappropriate for this TMDL project.

Expressing the TMDL as a concentration equal to the water quality objective ensures that the water quality objective will be met under all flow and loading conditions. The density (concentration) of fecal indicator organisms in a discharge and in the receiving waters is the technically relevant criterion for assessing the impact of discharges, the quality of the affected receiving waters, and the public-health risk. Concentration-based allocations are deemed more straightforward since they only require measuring concentrations in the waterways and do not require extensive flow monitoring and loading calculations

Therefore, staff established concentration-based TMDLs and pollutant load allocations, expressed in terms of indicator bacteria concentrations.

8. Reviewer's comment: Perhaps the reluctance to employ loads instead of cell concentrations of fecal coliforms is rooted in the belief that bacteria are emitted from a particular fecal source (like a storm drain or wild animal) and then undergo rapid decay in the environment without leaving a trace, unlike many chemical constituents for example heavy metals which are persistent. Bacterial (fecal coliform) cells can also persist in the environment and attach to particulates, either in the water column or in the benthos; they can even grow and divide given the right conditions and finally detach. Further, it seems important to design Fecal Coliform TMDLs that are flexible enough to allow for the use of real pathogen data or microbial source tracking data during the implementation and monitoring stages and that can pinpoint the predicted effects of variations in flow conditions (stormwater, drought) or effect of reductions in specific load allocations.

   The main advantage, however, of expressing Fecal Coliform TMDLs in terms of organism loadings is that the effect of various source load reductions can be estimated and allocation scenario loadings calculated. The Water Board has proposed that the load allocations for *non-natural* sources will be equal to the TMDL. This intention can also be realized by simply multiplying the flow rate associated with that load by the water quality standard and incorporating a sediment sink and source term. Reviewer believes that natural (uncontrollable) sources may contribute a sufficiently high load so that the FIB levels will remain high in the lower portions of the watershed. Fecal coliforms could be originating from a contamination event in the past, having been swept up into the water column due to a resuspension event or by gradual erosion of microbial biofilms present in the stream bed. Simulating the effect of various controllable load reductions can also help predict the outcome of improvements in wastewater collection systems and stormwater systems. The Water Board may wish to anticipate how direct pathogen measurements can be used to meet TMDL targets by allowing for alternate expression of mass loadings once quantitative pathogen data become available on a more routine basis. Thirteen years planned for achieving the TMDL is a long enough period to envision a mechanism for incorporating other pathogen indicators (such as concentrations of actual pathogens) into the calculations intended to estimate public health risk.

   EPA recommends Load Duration Curves (An Approach for Using Load Duration Curves in the Development of TMDLs, EPA 841-B-07-006, August 2007), a type of cumulative distribution function. The approach involves plotting observed flow rates against the percent of time those values have been met or exceeded. Existing and allowable loads are calculated by multiplying flow values with the measured concentration of FIB and the numerical target, respectively. The method does not lend itself easily to estimating loads from specific sources within watersheds. Mass balance methods, on the other hand, require more data but can be used in situations where a differentiation between direct (e.g. failing septic tanks, sewers, livestock)

and diffuse (runoff from land uses) nonpoint sources is not easily made or when there are there are no pronounced seasonal (flow-related) fluctuations.

Additional models developed by EPA are in-stream models that can account for spatial and temporal variation of bacterial loading. A numerical target for a TMDL may be exceeded at certain times and in many cases it is useful to refer to modeling techniques that give a reasonable estimate of the frequency distribution of projected receiving water quality. USEPA has listed continuous simulation, Monte Carlo simulation, and lognormal probability modeling as useful approaches to calculate receiving water concentrations. References are in Protocol for Developing Pathogen TMDLs (2001) and more recent information is available from the EPA TMDL website (http://www.epa.gov/owow/tmdl/techsupp.html).

The Water Board staff acknowledges in the report that certain waterbodies within the project area are influenced by urban sources of FIB while others are not. Another reason for expressing TMDLs in terms of mass loadings is that exceedances of natural (uncontrollable) sources do not automatically lead to additional required action in terms of source monitoring and TMDL modifications if at the same time controllable sources are lowered sufficiently. In other words, the receiving water quality in segments of the watershed or estuary that contains discharge from both controllable and natural sources may be qualified and controllable sources can compensate for exceedances elsewhere. As a result the watershed is still in compliance with the TMDL.

Staff response: Staff has modified the project report to empirically assess spatial variability of FIB loading with USEPA recognized methodologies. Staff has utilized Load Duration Curves and mass balance modeling, to develop mass-based daily load expressions and allocations. The TMDL and allocations will be concentration based, but for planning and implementation purposes, the aforementioned assessments are included in the Project Report.

Section 2.5: Implementation Plan

9. Reviewer's comment: The proposed prohibitions for domestic animal and human waste discharge for the Lower Salinas River watershed are reasonable. Further, the approach to target controllable sources of anthropogenic origin is feasible and supported by previous monitoring and source identification studies in the watershed.

   These comprise storm drain discharges, domestic animal waste discharges, discharges caused by homeless encampments or illegal dumping as well as spills and leaks from sewage collection and treatment systems. The proposed Implementation Plan and evaluation of implementation progress takes into account that additional measures may be necessary based on site-specific objectives.

   Staff response: Staff agreed with the Reviewer's comment.

Section 2.6: Monitoring Plan

10. Reviewer's comment: The proposed general monitoring plan is feasible and includes specific storm water runoff sampling and sampling of dry season flows for Salinas and Castroville locations. There is one remaining uncertainty for the adaptation of monitoring plans in case of continuing exceedances of WQO after controllable sources have been reduced or eliminated. The potential for re-growth of microbial indicators in the watershed is largely unknown. It is uncertain that mere monitoring of water quality using FIB could address this possibility. Such a monitoring program may involve a research component ("Feasibility of re-growth of microbial indicators *in situ*") and would benefit tremendously if real pathogen data were collected at the same time.

    Staff response: Staff agreed that a study to address potential re-growth would be valuable. The implementation plan does not require responsible parties to study potential fecal indicator bacteria re-growth. However, staff would consider results of such a study during the implementation and assessment phase of the TMDLs.

11. Reviewer's comment: It is, therefore, recommended to include measurements for pathogens in monitoring activities whenever feasible and especially when a presumptive hotspot of WQO exceedance has been identified. Such monitoring activity can use PCR-based methods for detection of pathogens as long as proper QA/QC procedures are followed. Further, the Water Board is advised that microbial source tracking (MST) methods have undergone significant developments since 2002, when the cited Morro Bay Estuary study was completed. In addition to ribotyping methods there are available library-independent approaches, which have been widely used in California and have been shown to be geographically independent in the state. Selected monitoring of watersheds with MST methods that target animal host-specific genetic fecal markers with fast decay rates in the environment can identify fecal contamination that is of recent origin. In other words, it may be more beneficial to combine fecal coliform monitoring with MST to verify that exceedances truly reflect a recent fecal contamination event. Costs for quantitative PCR assays on extracted DNA from water can be lower than 100 USD per assay, depending on sample volume filtered and method used. Generally, the individual assay rates decrease when several assays are performed on the same DNA extract. Consequently, costs for MST analysis are almost comparable to those of FIB tests for implementation and monitoring purposes.

    Staff response: Staff agrees MST and PCR methods would be useful to assist staff in determining the source of fecal contamination. As part of adaptive implementation efforts, staff will consider adding MST to the monitoring plan, if appropriate and as the technology becomes more accurate and affordable, as the reviewer has noted.

Section 2.7: Use Attainability Analysis

12. Reviewer's comment: It is proposed to remove the shellfish harvesting beneficial use from the Salinas River watershed. Central Coast Water Board (Water Board) staff questioned the validity of assigning the SHELL beneficial use to areas where it is highly unlikely that any shellfish are living. For legal reasons as the basis for amending the Basin Plan to remove the SHELL beneficial use a use attainability analysis (UAA) was performed to provide an assessment of the shellfish harvesting beneficial use for Salinas River Lagoon (North), Old Salinas River Estuary and Tembladero Slough. The UAA proposes removal of SHELL beneficial use based on a sound and reasonable rationale which comprises lack of historic use, inadequate habitat, and lack of probable use in the future**.**

Staff response: Staff agreed with the Reviewer's comment.

Section 3: Conclusions

13. Reviewer's comment:

1. It is recommended that fecal coliform TMDLs be defined on a mass basis (e.g. number of cells per day) for fecal indicator bacteria or human pathogens and that EPA approved models be employed.

2 A substantial uncertainty as to the ability to distinguish between natural and controllable sources of fecal pollution is mentioned in the report. Microbial source tracking techniques should be employed alongside FIB measurements whenever feasible.

3 The proposed measures to reduce allocations from controllable sources are supported scientifically and may be adequate to achieve necessary load reductions and compliance with a mass-based TMDL.

Staff response: Staff modified the Project Report to include Daily Load Expressions, but will implement this TMDL as a concentration-based TMDL, in accordance with USEPA guidance (2007). Staff agreed that MST methods would be potentially useful to assist staff in determining the source of fecal contamination. Staff agreed that the proposed measures to reduce loads from controllable sources may be adequate to achieve compliance with a concentration based TMDL. For reasons stated previously Staff chose not to implement the TMDLs on a mass basis.

Literature Cited

EPA 2007 Options for the Expression of Daily Loads in TMDLs, Draft June 2007, Office of Water, U.S. Environmental Protection Agency.