STATE OF CALIFORNIA
CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL COAST REGION
895 Aerovista Place Suite 101
San Luis Obispo, CA 93401-7906

SCIENTIFIC PEER REVIEW COMMENTS AND STAFF RESPONSE

The following comments address the external scientific review of the Total Maximum Daily Load for Fecal Coliforms (TMDLs) in Pajaro River Watershed waters including, Pajaro River, San Benito River, Llagas Creek, Tequisquita Slough, San Juan Creek, Carnadero/Uvas Creek, Bird Creek, Pescadero Creek, Tres Pinos Creek, Furlong (Jones) Creek, Santa Ana Creek, and Pachecho Creek. 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 July 30, 2008, and received via email in the Central Coast Water Board's office on August 10, 2008.

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.

On balance, the reviewer provided overall supportive assessments of the proposed TMDL as demonstrated in this statement, from the "General Conclusions" section of the submittal:

> "Taken in their entirety the proposed measures as outlined in the Draft TMDL Project Report for the Pajaro River Watershed should reduce the levels of fecal microbial indicators in creeks, rivers and the estuary by improvements to the wastewater collection and treatment systems and storm water drainage systems as well as domestic animal discharges and private sewer laterals" (Dr. Stefan Wuertz, page 4 of submittal)

Scientific Peer Review of TMDLs for Fecal Coliforms in the Pajaro River Watershed. All of the following comments are provided by Professor Stefan Wuertz.

Modification of the Pajaro River Watershed Prohibition

1. Reviewer's comment: Reviewer finds the modification of the Pajaro River Watershed Prohibition as planned by the Water Board scientifically sound and

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balanced with one exception. The allocation of FIB from natural sources constitutes a significant load and should be accounted for in the proposed TMDL. If it is expected to remain unchanged because the Water Board has no regulatory authority over waste discharges from wildlife, then calculations should be done showing to what extent other waste loads need to be reduced to meet the TMDL (see Section 2.2.3 for reviewer comments on the basis of TMDL calculations).

Staff response: Staff did not include calculations to show what extent other waste loads need to be reduced in order to meet the TMDLs because staff concluded that all controllable sources should be reduced or eliminated to the maximum extent practicable, or to the point that the numeric target is achieved. This approach is necessary because the precise contribution from uncontrollable sources is not known, therefore, the magnitude of reduction of the controllable sources to achieve the numeric target is not known.

Source Analysis

2. Reviewer's comment: Source analysis was partially based on the Source Identification Study for Morro Bay Estuary performed in 2002 by the Water Board in collaboration with California Polytechnic State University and Dr. Samadpour at U/Washington as well as a variety of other sources detailed in the Draft Project Report prepared by staff. Morro Bay Estuary is not part of the Pajaro River Watershed but the Source Identification Study has been carefully interpreted in light of similar land uses. Ribotyping data for fecal source identification are used mostly to make qualitative assessments of wildlife, livestock, pets and humans as sources of pollution. This is important because the 2002 Morro Bay Estuary Study utilized a ribotyping microbial source tracking (MST) method that was based on singleton analysis of water samples, meaning that only one *E. coli* isolate per sample was used to determine a ribotype indicating sources of fecal of contamination. It follows that only one fecal source could be attributed to a specific water sample.

   The Morro Bay Estuary Study provides insights into the role of sediments because up to 54% of the isolated strains could not be matched with any strain in the library maintained by Dr. Samadpour. Overall, of the 1659 strains analyzed from various sampling sites – mostly water samples - 29 sources were identified and for 424 strains (25.6%) no match with the library was found. Hence, strains isolated from sediments tend to be twice as likely to fall outside the animal host-specific classification. It is unknown how many of the *E. coli* or fecal coliform cells in a water sample come from a specific fecal source (ribotyping is not a quantitative method and here was based on one *E. coli* isolate) and it is conceivable that, in addition to ribotypes attributable to other wild animal types, sediments (a natural source) contributed "naturalized" fecal coliform cells which then lead to WQO exceedances. Similarly, when using the Morro Bay Estuary study to apportion fecal coliforms in Pajaro River Watershed one is faced with

considerable uncertainty in the assignment of fecal origins based on fecal coliform data. To conclude, 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. These latter scenarios are not acknowledged in the current Draft TMDLProject Report.

Staff response: Staff agreed with the reviewer's comment. Staff has amended the project report to include information about the potential contribution of "naturalized" fecal coliform from sediment. However, staff also noted that although it is conceivable that coliforms could be resuspended in the water column from sediment, and that some of these coliforms could be naturalized, that they are not all necessarily naturalized. In other words, fecal coliform in sediment are not all necessarily naturalized.

3. Reviewer's comment: Identified source categories and source organisms of fecal indicator bacteria that are covered by NPDES permit are storm drain discharges, controllable wildlife waste, trash receptacle leachate, and human waste discharges. In addition staff identified domestic animal discharges that are not covered by NPDES permits. Stormwater and sanitary sewer collection system leaks, blocks and spills are identified as controllable NPS pollution, an assessment that is fully justified by the available data. Additional source categories are private sewer laterals, onsite wastewater disposal system discharges, livestock, and irrigated agriculture. 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. However, please note that staff did not find irrigated agriculture or onsite wastewater disposal system discharges as sources of water quality impairment.

4. Reviewer's comment: Natural sources (bird and wildlife) are also listed in the Draft TMDL Project Report and their contribution may be significant as stated. Reviewer agrees that most of these natural sources are not controllable. It is recommended that fecal coliforms surviving in the watershed – that is, cells that were deposited in sediments and organic material at some time in the past and do not stem from a recent pollution event - be included as distinct natural source.

   Staff response: Staff agreed with reviewer's comment. In the project report, staff will indicate that in-stream reproduction of fecal coliform is a potential distinct source. Staff will add language in the project report clarifying that fecal coliforms resulting from multiplication are considered naturalized sources, even if the parent fecal coliforms were from controllable sources. Finally, staff DOES consider the parent fecal coliform from controllable sources, a "source" that must be regulated, even if that parent fecal coliform survives in the environment for an extended period of time.

Numeric Targets

5. Reviewer comment: The fecal coliform water quality objective of a log mean of 200 MPN per 100 mL, based on a minimum of not less than five samples for any 30-day period, is proposed as numeric target. In the absence of real 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 reviewers comment.

TMDL targets and allocations

6. Reviewer comment: Reviewer does not follow the rationale presented by the Water Board to set TMDLs as the same set of concentrations as the numeric targets. Such an approach would seem to ignore the mixing effects of receiving waters and different sources of influents and the overall influence of different flows on the indicator concentrations. It is also unclear how the considerable load from natural (largely uncontrollable) sources will be accounted for.

   Staff response: A concentration-based approach does not lend itself to identifying proportional contributions from the various sources in the varying surface waters. This is so because the concentration-based approach does not use flow, which can be attributed to sources. A concentration-based allocation methodology is justified for the Pajaro River watershed for reasons, as specified below:

   Staff acknowledges that for many pollutants, TMDLs are expressed on a mass-loading basis (e.g., pounds per day, organisms per day). For fecal indicators, however, mass is not an appropriate measure, and the USEPA allows pathogen TMDLs to be expressed in terms of organism counts (or resulting concentration) (USEPA, 2001):

> For most pollutants, TMDLs are expressed on a mass loading basis (e.g., pounds per day). For fecal indicators, however, TMDLs can be expressed in terms of organism counts (or resulting concentration), in accordance with 40 CFR 130.2(i): "TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measure," and NPDES regulations at 40 CFR 122.45(f): "All pollutants limited in permits shall have limitations...expressed in terms of mass except...pollutants which cannot appropriately be expressed by mass." – *from USEPA "Protocol for Developing Pathogen TMDLs", 2001*

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 (Santa Ana Water Board 1998, San Francisco Bay Water Board, 2006, Central Coast Water Board 2006). Therefore, staff established concentration-based TMDLs and pollutant load allocations, expressed in terms of indicator bacteria concentrations.

Establishment of a concentration-based, rather than a load-based TMDL has the advantage of eliminating the need to conduct a complex and potentially error-prone analysis to link loads and expected densities. A load-based TMDL would require calculation of acceptable loads based on acceptable bacterial densities and expected flows, and then back-calculation of expected densities under various load reduction scenarios. This becomes problematic because flows in Pajaro River Watershed waters, are variable and difficult to measure. There are reportedly only six active stream gages in the entire watershed (1,263 square miles), only four of which appear to have data of more than 20 years record. Gages with relatively short length of record are less desirable for statistical analysis. Additionally, few of the tributary waterbodies identified in the proposed TMDL appear to have any flow data. A flow/load duration analysis would inevitably involve a great deal of uncertainty, with no increased water quality benefit. Further, historic or current flow data may not be representative of future conditions in a complex and highly managed hydrologic system such as the Pajaro watershed. Flows within the watershed may fluctuate on a non-seasonal basis due to intensive water management practices.

In short, concentration-based loading capacity TMDLs are deemed more straightforward since they only require measuring concentrations in the waterways and do not require extensive discharge measurements and loading calculations. The TMDLs proposed are based on existing numeric water quality objectives. A concentration-based approach for these TMDLs simply allocates pollutant loads to sources based upon the pathogen water quality standard. Unlike mass-based load allocations, the concentration-based load allocations do not add up to equal the TMDLs, since the concentrations of individual pollution sources are not additive. Rather, in order to achieve the concentration-based TMDL, it is simply necessary to assure that each source meets the concentration-based overall load allocation.

Finally, the load from uncontrollable sources will be accounted for after such time that all implementation efforts have been exhausted to the maximum extent practicable, leaving the "largely uncontrollable" fraction of fecal coliform indicators.

7. Reviewer comment: 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. The same argument could be used for other constituents for whom TMDLs are being developed. 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 a chemical constituent which may undergo chemical transformation or sorb to particles. On the contrary, bacterial (fecal coliform) cells can persist in the environment and attach to particulates, either in the water column or in the benthos; they will also grow and divide given the right conditions and finally detach..

   Staff response: The reviewer's comment stems from the fact that concentration based TMDLs are being used, rather than load-based TMDLs. The reasons for using concentration-based TMDLs were noted in the previous staff response. The TMDLs proposed are based on existing numeric water quality objectives, and flow/load duration analysis would inevitably involve a great deal of uncertainty, due to lack of adequate data and watershed specific conditions.

8. Reviewer comment: Further, it seems important to design Pathogen 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 reductions in specific load allocations.

   Staff response: Staff agreed that tracking real pathogen data (not indicators of pathogens) is preferred. Staff will seize these opportunities when methods and resources needed to monitor pathogenic organisms, at the scale required to develop and implement TMDLs, become available.

9. Reviewer comment: The EPA Protocol for Developing Pathogen TMDLs (2001) states that "…TMDLs can be expressed in terms of organism counts (or resulting concentration), in accordance with 40 CFR 130.2(i) ….." (see page 7-1 in First Edition). However, given the availability of FIB data for the watershed and the many user-friendly statistical and mass balance models developed for TMDL calculations, it is advisable to use the tools available for simulation in the design of Pathogen TMDLs. 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).

Staff response: Staff agrees that modeling is useful and informative; it also typically requires more historic data than available, particularly flow data. A load-based TMDL would require calculation of acceptable loads based on acceptable bacterial densities and expected flows, and then back-calculation of expected densities under various load reduction scenarios. This becomes problematic because flow data is limited in Pajaro River Watershed waters, and for other reasons noted in staff comments above. Staff will consider using modeling approaches during the implementation phase if resources and data become available. Modeling during the implementation phase may inform the progress of achieving the TMDLs and result in a more precise distinction between uncontrollable and controllable sources.

10. Reviewer comment: The main advantage of expressing Pathogen 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 controllable sources will be equal to the TMDLs. This intention can also be realized by simply multiplying the flow rate associated with that load by the water quality standard. Reviewer thinks that natural (uncontrollable) sources may contribute a sufficiently high load so the FIB levels will remain high in the watershed. Simulating the effect of various controllable load reductions can help predict the outcome of improvements in wastewater collection systems and stormwater systems.

Staff response: Staff agreed that uncontrollable sources may be a significant contribution to the entire load of fecal indicator bacteria. Staff also acknowledges that "simulating" loads and load reductions may help predict watershed response to improvements. However, staff did not have sufficient data necessary (e.g. flow data) to simulate loads and to make predictions. Therefore, staff is proposing maximizing reduction of controllable sources of fecal indicator bacteria. Staff may consider an evaluation of the uncontrollable fraction after maximum reduction of controllable sources.

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11. Reviewer comment: 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.

    Staff response: Staff will consider alternative measurements and modeling mechanisms as data, resources, and the science to do so become available.

12. Reviewer comment: Even if simulation tools are not employed, simple calculations for TMDL allocations can be conducted that express TMDL values in terms of number of FIB per day. An example of TMDL allocation is shown on pp. 7-4 to 7-7 in Protocol for Developing Pathogen TMDLs (2001) where the TMDL was calculated based on allowable concentration at the mouth of the river.

    Staff response: The reviewer is referring to calculations to determine mass-based loading of fecal bacteria indicators, in this case, fecal coliform. The calculations require historic stream and/or discharge flow volume. Staff concluded that flow data and watershed specific conditions made the development of a mass-based TMDL problematic, for reasons noted in comments above. However, if sufficient flow volume data was available to staff during TMDL development, staff is confident that the resulting implementation would not be different than currently proposed, i.e., the same responsible parties and allocations would be identified. Staff will consider assessing loads during the implementation phase of the TMDLs if the resources and data necessary to run such a model become available.

13. Reviewer comment: It is stated that the Margin of Safety (MOS) is set implicitly by setting the TMDL equal to the WQS. If the Water Board decides to change the way the TMDL is calculated by defining it on a mass basis, it would be useful to include a separate MOS a certain percentage point lower than the WQS of a geometric mean for those allocations, which are clearly predominantly of human origin.

    Staff response: Staff chose not to define the TMDLs on a mass basis.

Implementation Plan

14. Reviewer comment: The proposed approach to first target controllable sources of anthropogenic origin is feasible and supported by previous monitoring and source identification studies in the watershed. The proposed Implementation Plan takes into account that additional measures may be necessary based on site-specific objectives.

Staff response: Staff agrees. The strategy is to first target controllable sources of fecal indicator bacteria during the implementation phase while assessing the feasibility of achieving the allocations during implementation.

Monitoring Plan

15. Reviewer comment: The proposed general monitoring plan is feasible and includes specific stormwater outfalls. 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 in Pajaro River Watershed") and would benefit tremendously if real pathogen data were collected at the same time.

    Staff response: Staff agrees 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.

16. Reviewer comment: It is therefore recommended to include measurements for pathogens (e.g. human Adenoviruses and Enteroviruses) 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 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 as low as 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 and vintage 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.

Time schedule for achieving the TMDLs

17. Reviewer comment: The proposed timeline is reasonable.

    Staff response: Staff agrees.

General conclusions

18. Reviewer comment 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.

    Staff response: Staff did not agree with reviewer's comment. Please see response to number 6 (above).

19. Reviewer comment: There is substantial uncertainty as to the ability to distinguish between natural and controllable sources of fecal pollution. Microbial source tracking techniques should be employed alongside FIB measurements whenever feasible.

    Staff response: Staff agreed with reviewer's comment. Please see response to number 16 (above).

20. Reviewer comment: 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 agreed with reviewer's comment, however, this is not a mass-based-TMDL. Staff also notes that if the proposed TMDL were a mass-based TMDL, then compliance with the TMDL would also imply compliance with a concentration-based TMDL, since the required load reductions would be based on the water quality objective, a concentration.

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