9TO: Keith Lichten, Chief
WATERSHED MANAGEMENT DIVISION

FROM: Setenay Bozkurt Frucht
PLANNING and TMDL DIVISION

DATE: October 21, 2016

SUBJECT: **RESPONSE TO SANTA CLARA VALLEY WATER DISTRICT COMMENTS ON THE UPPER BERRYESSA CREEK FLOOD PROTECTION PROJECT TENTATIVE ORDER**

This memorandum includes responses to the Santa Clara Valley Water District's (District's) comments on the sedimentation analysis in the tentative order issued on August 19, 2016, and reiterates our analysis of, and the evidence for, the long-term depositional environment of Upper Berryessa Creek.

1. UPPER BERRYESSA CREEK LIES WITHIN AN ALLUVIAL FAN AND IS PRIMARILY DEPOSITIONAL

   The District states that "studies and observations by the District strongly suggest that the assumptions in the tentative order about current conditions are flawed in that current conditions are erosional, so making the system more depositional would bring the system closer to equilibrium."

   Berryessa Creek lies within an alluvial fan. An alluvial fan, by its very nature, is primarily a depositional environment. Alluvial fans are major sediment storage areas, formed where a stream rapidly loses its transporting ability because of either an abrupt reduction in slope, which decreases stream power, or a sudden change from confined to unconfined status, which leads to flow divergence (Knighton, 1998). Upper Berryessa Creek meets all three conditions that are required for optimal fan development, namely:

   a) A topographic setting where a channel becomes unconfined as it emerges from an upland drainage basin onto flatter land as evidenced by the longitudinal profile (Corps, 2014);

   b) The production of sufficient sediment for fan construction as reported by previous geomorphic studies (NHC, 1993; Corps, 2014). These studies report on the instabilities of Berryessa Creek's "canyon zone" above Old Piedmont Road where active landsliding provides "a plentiful supply of boulders, cobbles, and gravel that are transported downstream." Upper watershed site inspections reported in Corps (2014) note that the canyon reach is striking in the number of large landslides and that there are evidences of debris torrents or flows; and

   c) A climatic environment capable of generating high stream discharges and mass wasting events, which is the case for all of the Bay Area streams with their Mediterranean climate

> and active tectonic setting (the Hayward Fault Zone primarily crosses the canyon reach). The flashy hydrologic nature of such a setting dictates highly variable sediment loads and infrequent, but very large sediment pulses.

There may be episodic and temporary erosional processes acting on certain reaches (secondary processes that remobilize previously deposited sediment); however, the overall process along the Berryessa Creek fan is deposition.

That the long-term and larger geomorphic tendency of Upper Berryessa Creek is of deposition has been observed and reported on all the previous sediment studies. An analysis of geomorphology and sediment transport in the project is included in the Environmental Impact Statement (EIS), Appendix B, Part III, in which the Corps (2014, p 3-1) accurately describes the larger geomorphic context of the Project reach:

> “The Berryessa Creek Project Area […] lies within an alluvial fan. Alluvial fans are created by sediment deposition as streams carrying large sediment loads exit the steep confined channel of the uplands and meet the lower gradient unconfined valley. As a result, sediment deposition is an inevitable process on an alluvial fan and any channel improvements must recognize this behavior. On the Berryessa Creek fan, at some point between the apex of the fan and the Bay, all but the fine sediments will be deposited.”

2. LONG-TERM MAINTENANCE RECORDS CONFIRM THAT SEDIMENT DEPOSITION IS A REGULAR, PERSISTENT MANAGEMENT ISSUE

The District states “Sedimentation is a major and persistent problem on Berryessa Creek. Large quantities of sediment have been removed from the creek in an ongoing effort to maintain flow capacity in the channel.[…] Locations of historical sediment accumulation and removal are concentrated in three main areas: (1) in the sediment retention basin downstream of Piedmont Road, (2) from Sierra Creek to Cropley Road, and (3) from Interstate 680 to Calaveras Boulevard.” (NHC, 2003)

The District’s Sediment Removal Maintenance Records indicate that a total of more than 250,000 cubic yards of sediment has been removed from Berryessa Creek since 1980s (Corps, 2014, p.2-19). Of this sediment, approximately 21,400 cubic yards deposited along the project reach between I-680 and Calaveras Boulevard. Sediment deposition is an expected management problem in an alluvial fan reach and is not solely a result of localized bank erosion as the District suggests. An additional 193,227 cy were removed from Berryessa Creek downstream of the Project reach during the same period. Given the reduction in sediment transport capacity under Project conditions, we anticipate that a portion of this load will accumulate along the Project reach rather than being transported downstream.

3. TRIBUTARIES ALSO CONTRIBUTE SEDIMENT TO THE BERRYESSA CREEK

The District’s primary argument is that the sediment along the Project reach is solely from local sources via bank erosion. In addition to the upstream watershed, which produces substantial amounts of sediment via mass wasting, tributaries to Berryessa Creek also contribute significant amounts of sediment upstream of the Project reach. An overall estimate of the sediment yield for Berryessa Creek was developed by NHC and was reported in the EIS (2012, p. 2-16). This study estimated that tributaries[1] delivered a total of 5,800 tons (4,300 cubic

[1] Sweigert, Crosley, Sierra, Piedmont, and Arroyo de los Coches Creeks

yards[2]) of sediment to Berryessa Creek every year. Incorporating Berryessa Creek upstream of Old Piedmont Road, a total of 15,700 tons or 11,600 cubic yards of sediment is delivered to the system every year. This 11,600 cy of sediment is delivered to the Project reach from upstream and is not related to other local sources along the Project reach. Therefore, the District's argument that all of the sediment along the Project reach is generated locally from bank erosion is invalid. Therefore, suggesting that the Project will make the system less erosive and thus closer to equilibrium, therefore eliminating the need for maintenance, is also unfounded (it is a *non sequitur*).

4. THERE ARE EROSIONAL SITES OR SEGMENTS WITHIN THE LARGER DEPOSITIONAL ENVIRONMENT

As is the case in any stream channel, there are erosional and depositional sites within the larger geomorphic process domain (in the case of Berryessa Creek, the larger domain is the alluvial fan environment). Along the Berryessa Creek Project area, there are erosional sites where hydraulic structures cause bed or bank instabilities. Jordan, et al. (2009) states that "engineered river infrastructure elements are the primary causes of channel instability." The District provided several examples of instabilities due to or near hydraulic structures in their technical memorandum of July 20, 2016. All of these example sites point to the erosive impacts of hydraulic structures and do not provide evidence for overall trends. Indeed, Water Board staff's observations during field trips on September 4, 2015, and April 21, 2016, did not indicate a significant channel erosion tendency on a reach-scale in the proposed Project area.

The Jordan, et al. (2009) study indicated that drainage area capture and urban land use change increased water yield by 48% and sediment yield up to 61% in the Berryessa Creek watershed. The limited erosional segments along the project reach are either a direct result of in-channel structures or indicators of the hydrologic and sediment impacts of urbanization in the watershed between the 1960s and the 2000s. However, with the recognition of hydrologic impacts of development and adoption of HMP practices, as well as LID practices and constraints on new impervious surfaces, these trends will not be as significant in the future.

As articulated in the EIS (2012), sediment deposition along Berryessa Creek is an inevitable process and at some point between the apex of the fan and the Bay, all but the finest sediments will be deposited. The challenge of the proposed project is anticipate where and how much deposition will take place, develop a comprehensive and well thought-out management plan, and appropriately mitigate for the impacts.

5. DISTRICT'S INTERPRETATION OF EXISTING ANALYSES IS INCONCLUSIVE AND INCOMPATIBLE WITH THE ENVIRONMENTAL IMPACT REVIEW ASSESSMENT

The District's technical memorandum of July 20, 2016, includes a graphic showing the longitudinal profile comparison from 1967 and 2004 (see below) and interprets this graphic as evidence of incision. This graphic's spatial extent is from Old Piedmont Road to the Crosley Creek culvert, which is primarily the section of the creek known as the "Greenbelt Reach." This graphic shows the channel upstream of the Project reach and does not include the proposed Project reach.

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[2] Assuming a dry unit weight of 100 lbs/ft^3 (1.35 tons/cy).

We do not have adequate information to interpret this graphic. We do not know how many points were collected along each profile and whether the perceived differences are merely a function of line interpolation or an actual difference in elevation between surveyed points (assuming both surveys have the same datum and were performed with comparable care and quality). Without knowing anything about the quality of the surveys, one could also interpret this graphic as showing a sediment wave that passed through the upstream part of the reach with incision along the downstream part (again, assuming these lines do actually have enough data points). The upstream, downstream, and middle of the reach (around station 1,200 in Figure 1) have stable elevations. A sediment wave that deposited in the upstream of this reach in 1967 may have spread downstream by 1987. There appears to be another depositional site around station 800; however, because the 400 meter long reach downstream of it stayed at the same elevation for almost 50 years suggests that the reach does not have an incisional trend, rather that the sediment wave likely passed and spread downstream. We would expect to see large sediment pulses that temporarily deposited in this upstream reach considering the large storms of 1962, 1963, and 1967.[3] Without providing any other context and evidence for incision, this graphic is not evidence for incision upstream of the project reach.

Finally, even with all the uncertainty, if this graphic is considered as evidence of incisional trends upstream of the Project reach this would suggest that there has been a significant amount of sediment scoured from the creek bed upstream of the Project reach anddelivered to the Project reach in the last 40 years, invalidating the District's suggestion that sediment along the project reach is locally sourced.

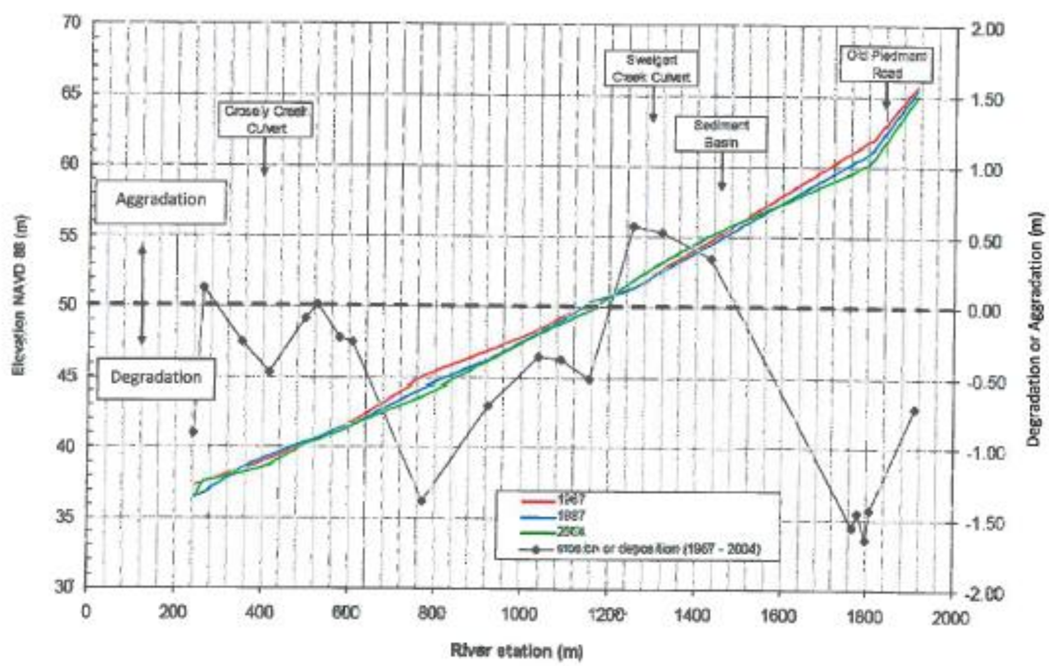

Figure 1. Longitudinal Profile Comparison of primarily the "Greenbelt Reach" (Crosley Creek Culvert to Old Piedmont Road) in 1967, 1987, and 2004.

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[3] Goodridge (1996) states that several Santa Clara Valley stations reported 20 inches of precipitation in a 3-day storm in February 1963 and nine station in Santa Clara Valley reported greatest ever 3-day rainfalls in 1960s.

The EIS (Corps, 2014) highlights the stability of the Greenbelt:

> "It contains the only section of channel that is not an excavated section constructed on an engineered alignment. The reach has only minor influences from bridges within its boundaries […] The channel capacity if more representative of a natural stream section in this reach than in other reaches" (p. 2-9)

and further emphasizes the stability of this reach and cautions against any intervention:

> "Changes to the channel in the Greenbelt Reach should be analyzed carefully and kept to a level that does not create problems with the stability of this reach. Potential problems that would have to be mitigated would be reduced stability after disturbing the vegetation on the banks and increased flow confinement if the channel was lowered."

Our field visit also pointed to the same conclusion: that the Greenbelt Reach is mostly in an equilibrium state, with a low-flow channel that formed within the larger channel and with stable and vegetated banks. The active channel ranges between 10 to 20 feet wide and approximately 4 to 6 feet deep. These active channel dimensions are what would be expected from a watershed of this size in the East Bay of approximately 15 mi^2.

6. UNANSWERED QUESTIONS ON THE SEDIMENT TRANSPORT MODELING

Tetra Tech and the Water Board engaged in a review of the HEC-RAS model in March 2016 to resolve questions on sediment transport conditions. The technical rationale for the modeling effort that would provide the basis for the selection of model inputs with respect to the upstream boundary sediment loads, bankfull flow, etc., is needed to evaluate the impacts of any project. TetraTech and the Water Board agreed to set up a meeting to resolve unanswered modeling questions. However, that meeting never happened and our questions about the sediment transport model have never been answered.[4]

A summary of our main unanswered questions is as follows:

- Discrepancy between sediment inputs to the Project reach under existing and Project conditions. The version of the sediment transport model that was provided to the Water Board shows that the upstream boundary conditions were modeled differently for existing and project conditions as detailed in our email of 3/4/2016. While baseline conditions model sediment input to the upstream boundary via a rating curve, Project conditions model boundary conditions as equilibrium load. This results in different sediment inputs to the model, which then results in different sediment inputs to the Project reach, making the comparison invalid.

- Based on the most recent sediment transport model that was made available to us, we summarized, in Table 1, below, sediment inputs to the upstream boundary and sediment erosion/deposition estimates along the project reach under baseline and project conditions. The table shows that: 1) the sediment inputs under baseline and Project conditions are different; 2) two different sediment transport equations chosen (Yang and MPM) result in

[4] The last email exchange on this subject was a series of questions from Setenay Bozkurt Frucht to Dragi Stefanovic on 3/4/2016 (with other Water Board, District, and Corps project participants cc'ed). That email was never answered, nor did any follow-up calls or meetings take place.

greatly different estimates for sediment transport capacity; iii) the Project reach will be more depositional under Project conditions (which we already established with the District and Tetra Tech).

- The District or Tetra Tech did not articulate the basis for the choice of sediment transport equations or the discrepancies between the inputs, nor did they provide a summary of their findings or explain the implications of the modeling. Water Board staff's questions on sediment modeling were never clarified. We cannot confirm that the sediment transport modeling is adequate until we are provided a technical document detailing the modeling effort and the most recent sediment transport model. We currently do not have any documentation that form the basis of the District's statement that the "sediment transport modeling and analysis on the Project design by Tetra Tech shows a system closer to equilibrium after the Project is completed." Therefore, we are not able to accept the conclusion that the Project will reduce the operation and maintenance needs below current levels. Our review of existing studies and Tetra Tech's model indicates the contrary.

Table 1. Comparison of Three Sediment Transport Models: Sediment Input and Deposition Conditions between Baseline and Project Conditions

Model	Sediment Input Boundary Condition (tons)		Erosion(-) / Deposition along Project Reach (tons)		Comments[5]	
	Baseline	Project	Baseline	Project	Baseline Conditions	Project Conditions
100-yr Yang	8,095	8,075	-1289	522	7,068 tons deposit at the most upstream cross section so only 1,027 tons are delivered downstream of Piedmont Rd.	8,075 tons are delivered downstream of Piedmont Rd.
100-yr MPM	8,085	2,046	-997	-642	5,625 tons deposit at the most upstream cross section so only 2,460 tons is delivered downstream of Piedmont Rd.	2,046 tons is delivered downstream of Piedmont Rd.
Dominant Q Yang	15,804	4,895	-2,628	870	14,660 tons deposit at the most upstream cross section so only 1,144 tons is delivered downstream of Piedmont Rd.	4,895 tons is delivered downstream of Piedmont Rd.

7. UNANSWERED QUESTIONS ON THE COMPARISON OF PREVIOUS AS-BUILT PLANS AND PROPOSED PROJECT

[5] Cross section stationing is different under the Baseline and Project Conditions models. I680 Bridge is at XS 14011 and XS 20511 under the Baseline and Project conditions models, respectively. Project reach is between I680 and Calaveras Boulevard.

The District previously sent the Water Board (per our request) the “As-Built Plans” for the Project reach. District staff later informed us that the design plans that were sent were not the actual as-built plans based on post-project surveys, and that they were proposed design drawings. Therefore, we are not including the comparison of 1973 cross sections to current conditions in this analysis as we presented in a previous technical memorandum (May 2016). However, the 1973 design drawings include baseline conditions at the time and show that the channel had a width-to-depth ratio similar to today, suggesting that the channel tends to move toward some “equilibrium” dimensions. We still would like to compare current proposed Project to the previously built project to understand channel evolution in the last 50 years and to anticipate how the system will respond to the proposed modifications. Therefore, we request the as-built surveys, or in the absence of those, 100% design plans of the previous project.

SUMMARY

In summary, all lines of geomorphic evidence, analysis, and existing studies indicate that the Project reach is aggradational in the long-term. Greenbelt Reach, which represents conditions closest to reference conditions in this system, points to the tendency that even after being disturbed due to channel widening and deepening during the construction of the previous flood control project, the channel returns to these quasi-steady equilibrium conditions. The Water Board views these trends as part of natural processes in the watershed, recognizes the stream’s tendency to move toward these equilibrium conditions, and recognizes the environmental benefits and much improved habitat conditions under these equilibrium conditions. Since the District is proposing to significantly modify the channel and will have to continuously intervene in the channel’s natural processes and tendencies, it is critical to develop a management plan based on sound geomorphic analysis and evidence-based adaptive management for the Project reach and to mitigate for the expected impacts of the Project.

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