

Mr. Michael Bessette
City of West Sacramento
April 12, 2011
Page 1 of 3

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April 12, 2011

Mr. Michael Bessette
Flood Protection Manager
West Sacramento Flood Control Agency
c/o MBK Engineers
1110 West Capital Ave.
West Sacramento, CA 95691

Dear Mr. Bessette:

**Subject: West Sacramento Levee Improvement Program
Robustness, Resiliency, and Redundancy of the design of
The Rivers and CHP Academy Early Implementation Projects**

The West Sacramento Flood Control Agency (WSAFCA) is nearing completion of the design for the CHP Academy and the Rivers Early Implementation Projects (EIP). The purpose of this transmittal is to provide an opinion letter regarding the Redundancy, Resiliency and Robustness of the design of the CHP Academy and Rivers projects (as defined in the US Army Corps of Engineers Engineering Circular, EC 1165-2-209), based on its review of information provided by WSAFCA on the Projects.

The West Sacramento Levee Improvement Program (WSLIP), sponsored by WSAFCA, was designed in accordance with US Army Corps of Engineers (USACE) standards and criteria, including the 200-year water surface elevation, which in of themselves incorporates redundancy, resiliency and robustness. The design also considered the California Department of Water Resources standards and criteria for the 200-year return period water surface elevation plus 3 feet. WSAFCA, through this Board of Senior Consultants (BOSC), has also performed several Safety Assurance Reviews and meetings that provided independent technical evaluations of the adequacy, conservatism and robustness of the design.

In the BOSC's judgment, the design of the CHP Academy and Rivers projects addressed redundancy, resiliency, and robustness through the use of conservative design assumptions and components. Examples of these design assumptions and features include:

For Both the Rivers and CHP Academy EIP Sites

- The design water surface elevations evaluated for both levee reaches assumes neither up- nor downstream levees breach or fail for this event, even if they were not designed for levels considered for this project. This assumption results in a conservative design water surface elevation at these sites.

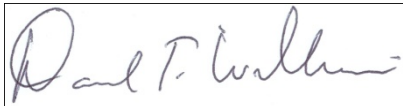
- Seepage analyses for downstream reaches of the levee at the CHP Academy site assumed the waterside blanket layer consisted of 1) a pervious sand material in the west due to disturbance by excavation on the waterside of the levee or 2) as the Sacramento River was approached on the east it was modeled as an impervious layer with head in the aquifer below the blanket set at 28 feet to match the level of the river and the 3D effects imposed by the river.
- The assumption of the disturbance/removal of the waterside blanket layer and the 3D effects of the Sacramento River is conservative in that it allows for greater hydraulic head in the underlying aquifer layer. This results in computed exit gradients at the landside of the levee that are higher than those that would exist if intact waterside blanket materials were present or the Sacramento River was not considered in the modeling.
- The seepage analyses at the CHP Academy site were performed with the existing internal drainage features within the landside stability berms assumed to be non-functional. The resulting phreatic surfaces through the levee and exit gradients are thus conservative.
- Space and site constraints at both sites resulted in seepage cutoff walls being the preferred approach for remediating underseepage deficiencies. These features result in very low residual exit gradients at the levee toe compared to a seepage berm remediation method. Over most extents of both projects, this approach reduced exit gradients well below acceptable thresholds and, accordingly, provided for a more robust design. A further benefit of this approach is the reduction of pore pressures in the landside slopes that significantly improved the stability factors of safety.
- Sensitivity analyses have been performed on the seepage models to assess the impact of the assumed permeabilities of the subsurface strata on the computed exit gradients. Sensitivity analyses, in our judgment, help provide confidence in the values selected for design and improve its robustness.
- Lower bound values of shear strengths were conservatively used to analyze the steady-state and the sudden drawdown stability for the 200-year and 200 year + 3 feet water surface elevations. Calculated factors of safety met criteria for both loading conditions. Using average values of shear strength parameters would have resulted in higher factors of safety. The conservative use of lower bound shear strength parameters in design assures robustness.
- Stability analyses were performed assuming steady-state seepage conditions and a fully developed phreatic surface within the levee embankment. Considering the relatively short duration of the high recurrence interval design floods, the assumption of a fully saturated embankment and blanket layer for purposes of stability analysis is considered conservative.
- Seepage and stability analyses were performed for all levee reaches using both the 200-year and 200-year + 3 feet water surface elevations. As shown in the attached tables, the results of these analyses provided seepage exit gradients and slope stability factors of safety that exceed the minimum requirements for all conditions analyzed.

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Page 3 of 3

- Piezometers will be installed at the levee crown and landside levee toe at four locations along the CHP Academy levee and at three locations along The Rivers levee to monitor the effectiveness of the remedial measures. These locations correspond with the seepage analysis sections analyzed in the design.
- Site-specific surveys were performed for this reach of the levee to verify differences between the NGVD 29 and NAVD 88 Datum's. This action contributes to the robustness of the design.

In summary, the design and plans and specifications of the Rivers and CHP Academy projects, in addition to having been reviewed by the BOSC, have also undergone reviews by the US Army Corps of Engineers, the California Department of Water Resources, and the Central Valley Flood Protection Board. All of these regulatory agencies have concurred the design should be adequate to provide protection for the 200-year and 200-year + 3 feet design water surface elevations used.

Respectfully submitted,



Dr. David T. Williams, P.E. CFM.



Mr. George L. Sills, P.E.



Dr. Ray E. Martin, P.E.

Attachment:

- Summary Table of Exit Gradients and Slope Stability Factors of Safety

CHP Academy Project

Summary of Exit Gradients and Stability Factors of Safety

Geotechnical Model Station	200-Yr Design WSEL for Evaluation	Exit Gradient 1/ Existing Condition	Steady-State Stability FS 2/ Existing Condition	Exit Gradient 1/ Project Condition	Steady-State Stability FS 2/ Project Condition	Sudden Drawdown Stability FS 2A/ Project Condition	200-Yr + 3 Feet Design WSEL for Evaluation	Exit Gradient 1A/ Existing Condition	Steady-State Stability FS 2A/ Existing Condition	Exit Gradient 1A/ Project Condition	Steady-State Stability FS 2A/ Project Condition	Sudden Drawdown Stability FS 2A/ Project Condition
13+00	34.2	0.31	3/	0.27 4/	1.47 4/	1.22 4/	37.2	0.35	3/	0.30 4/	1.43 4/	1.20 4/
32+00	34.8	1.04	3/	0.30 5/	1.63 5/	1.29 5/	37.8	1.18	3/	0.32 5/	1.58 5/	1.27 5/
51+50	35.5	0.78	3/	0.35 6/	1.72 6/	1.67 6/	38.5	0.98	3/	0.37 6/	1.67 6/	1.66 6/
62+00	36.5	2.73	3/	<0.10 7/	1.90 7/	1.50 7/	39.5	3.27	3/	<0.10 7/	1.80 7/	1.46 7/

1/ Allowable Gradient is <0.5; exit gradient computed at toe of levee unless otherwise indicated.

1A/ Allowable Gradient is <0.6; exit gradient computed at toe of levee unless otherwise indicated.

2/ FS = Factor of Safety. Required FS is minimum of 1.4 2A/ Required FS is minimum of 1.2

3/ FS for Existing conditions not computed

4/ Project Condition is Reconstructed Waterside Slope and Flattened Landside Slope

5/ Project Condition is Cutoff Wall to Elev. -40 (70 Feet Deep Assuming Degrade to Elev. +30); Waterside and Landside Slope Flattening

6/ Project Condition is Cutoff Wall to Elev. +5 (25 Feet Deep Assuming Degrade to Elev. +30); Waterside and Landside Slope Flattening

7/ Project Condition is Cutoff Wall to Elev. +5 (25 Feet Deep Assuming Degrade to Elev. +30); Waterside and Landside Slope Flattening

The Rivers Project

Summary of Exit Gradients and Stability Factors of Safety

Geotechnical Model Station	200-Yr Design WSEL for Evaluation	Exit Gradient 1/ Existing Condition	Steady-State Stability FS 2/ Existing Condition	Exit Gradient 1/ Project Condition	Steady-State Stability FS 2/ Project Condition	Sudden Drawdown Stability FS 2A/ Project Condition	200-Yr + 3 Feet Design WSEL for Evaluation	Exit Gradient 1A/ Existing Condition	Steady-State Stability FS 2A/ Existing Condition	Exit Gradient 1A/ Project Condition	Steady-State Stability FS 2A/ Project Condition	Sudden Drawdown Stability FS 2A/ Project Condition
71+50	36.7	0.75	3/	<0.10 4/	1.97 4/	3.61 4/	39.7	0.91	3/	<0.10 4/	1.92 4/	3.66 4/
87+50	36.7	1.13	3/	0.26 5/	1.64 5/	4.41 5/	39.7	1.36	3/	0.30 5/	1.60 5/	4.34 5/
97+50	36.7	0.66	3/	<0.10 6/	2.06 6/	1.76 6/	39.7	0.85	3/	<0.10 6/	2.01 6/	1.72 6/

1/ Allowable Gradient is <0.5; exit gradient computed at toe of levee unless otherwise indicated.

1A/ Allowable Gradient is <0.6; exit gradient computed at toe of levee unless otherwise indicated.

2/ FS = Factor of Safety. Required FS is minimum of 1.4 2A/ Required FS is minimum of 1.2

3/ FS for Existing conditions not computed.

4/ Project Condition is Cutoff Wall to Elev. -98 (128 Feet Deep Assuming Degrade to Elev. +30); 3H:1V Waterside and Landside Slopes.

5/ Project Condition is Cutoff Wall to Elev. -78 (108 Feet Deep Assuming Degrade to Elev. +30) ; 3H:1V Waterside and Landside Slopes.

6/ Project Condition is Cutoff Wall to Elev. -55 (85 Feet Deep Assuming Degrade to Elev. +30) ; 3H:1V Waterside and Landside Slopes.