April 8, 2018 Via email

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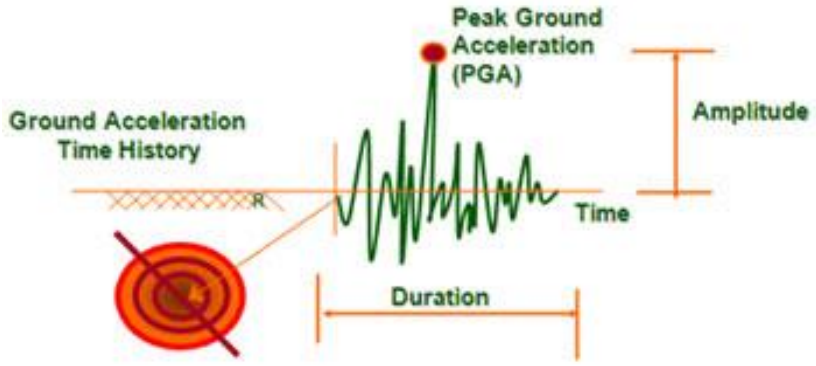
Dear Mr. Gibson, Ms. Nemeth, Mr. Kightlinger, and Dr. Sunding:

We are writing to you about the Department of Water Resources' cost-benefit analysis for the WaterFix project. The February 2018 WaterFix cost-benefit analysis by David Sunding discusses the risks and potential economic costs of export curtailment due to multiple levee failures from a Maximum Considered Earthquake (MCE) on the Hayward-Rogers Creek fault.[1] Sunding's cost-benefit analysis implies that construction of the Waterfix tunnels would result in no reduction in State Water Project and Central Valley Project exports in the event of such an earthquake. This is severely misleading and inaccurate.

The simple fact is that the WaterFix tunnels are *not* currently being designed to withstand a Maximum Considered Earthquake on nearby faults, as defined by the American Society of Civil Engineers' ASCE-7 standard. This is explained in further detail below. The Department of Water Resources and Metropolitan Water District *must* analyze the performance of the Delta tunnels for all seismic hazards in the Delta, including the ASCE-7 Maximum Considered Earthquake. DWR and MWD must also disclose the potential seismic performance of the Delta tunnels to the retail water agencies for the complete range of seismic hazards in the Delta.

The American Society of Civil Engineers ASCE-7 standards define a Maximum Considered Earthquake (MCE) as a 2% in 50 year event (1 in 2,475 years.) Critical structures are required to be designed to withstand ground motions in the Maximum Considered Earthquake.[2] The ASCE-7 standards have been adopted in the California Building Code, and apply to buildings and other above ground structures.



1Peak ground acceleration – one measure of maximum ground motion

[1] Dr. David Sunding, Economic Analysis of Stage I of the California WaterFix: Costs and Benefits to Urban and Agricultural Participants, February 12, 2018. Available at https://www.californiawaterfix.com/wp-content/uploads/2018/02/WaterFixEconomicAnalysis_Final.pdf

[2] American Society of Civil Engineers, *ASCE Minimum Design Loads and Associated Criteria for Buildings and Other Structures,* 2016. Available at https://www.asce.org/structural-engineering/asce-7-and-sei-standards/.

Although the Department of Water Resources has indicated that the Delta tunnels will be designated critical structures, the WaterFix Final Conceptual Engineering Report only includes probabilistic seismic ground motions for a 5% in 50 year event (1 in 1,000 years), and a 10% in 50 year event (1 in 500 years) (p. 46, Table 3-1.) These are significantly weaker ground motions than a 2% in 50 year event (1 in 2,475 years.)[3] The Conceptual Engineering Report further weakens the ground motions by assuming 50% attenuation at the depth of the tunnels (p. 46.)

DWR's 2010 internal, unpublished seismic analysis of the tunnel lining also showed that the tunnel lining joints could leak in a 5% in 50 year event (1 in 1,000 years.)[4] DWR and MWD engineers then began assuming that peak ground acceleration (a measure of maximum ground motion) would attenuate by 50% at the proposed tunnel depth. This is documented in the published Conceptual Engineering Report (p. 49.)[5] The assumption of 50% attenuation was not based on any seismic data, and is contradicted by an analysis in a peer-reviewed journal article, which found that, for earthquakes above magnitude 6.0, peak ground acceleration fell off by about 30% at 120-160 foot depth.[6] The analysis was based in part on downhole data from the La Cienega site in Southern California, which has soft ground conditions similar to the Delta.

DWR's 2010 internal, unpublished seismic analysis of the tunnel lining also showed that that there could be substantial, continuous liquefaction down to 100 feet.[7] This is an issue for the tunnel shafts, and for the North Delta tunnels. DWR and MWD engineers have weakened the seismic source assumptions for the liquefaction analysis in the conceptual design to a 10% in 50 year event, as documented in the published Conceptual Engineering Report (p. 49.) The Conceptual Engineering Report states that

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[3] The longer the return period, the larger the earthquakes that are likely to occur. The probabilistic hazard curve for Clifton Court Forebay from the Delta Risk Management Strategy is shown at the end of this letter.

[4] California Department of Water Resources, *2010 Draft Report of the Initial Analysis & Optimization of the Pipeline/Tunnel Option*. Available at http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/california_waterfix/exhibits/docs/dd_jardins/DDJ-141%20Initial.pdf

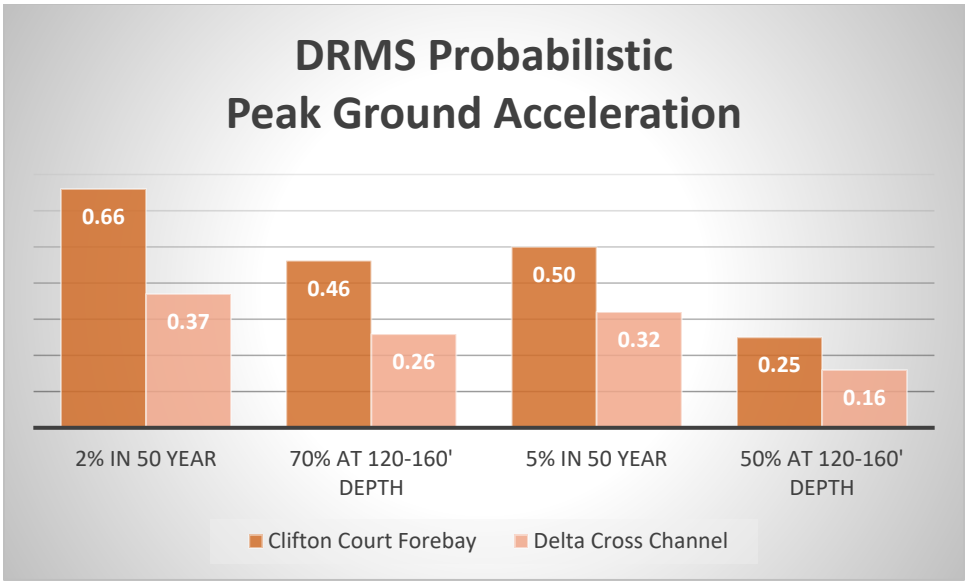
[5] California Department of Water Resources, 2015, *Final Draft Agreement Regarding Construction of Conveyance Project between the Department of Water Resources and the Conveyance Project Coordination Agency,* Available at http://cms.capitoltechsolutions.com/ClientData/CaliforniaWaterFix/uploads/Draft_Final_DCE_Agreement_Combined.pdf

[6] Hu Jin-jun & Xie Li-li, *Variation of earthquake ground motion with depth*, 2005, Section 3.1.2, Soil site, p. 77. Acta Seimol. Sin. (2005) 18: 72. doi:10.1007/s11589-005-0008-x. Available at http://link.springer.com/article/10.1007/s11589-005-0008-x

[7] California Department of Water Resources, 2010 *Draft Report of the Initial Analysis & Optimization of the Pipeline/Tunnel Option,* p. 38.

liquefaction is only expected to go down to 40-60 feet and is not expected to be an issue for the main tunnels (p. 49.)

California Water Research estimated the following probabilistic Peak Ground Accelerations for 2% based on the seismic hazard assessment in the Delta Risk Management Strategy report,[8] and assumed depth of 120-160 feet below ground, and compared the estimates with the probabilistic 5% in 50 years pga in Table 3-1 of the WaterFix Final Conceptual Engineering Report, and the CER assumed attenuation of 50% at a depth of 120-160' below ground. The 10% in 50 years pga used for the liquefaction analysis is also included. The estimates show that the WaterFix conceptual tunnel lining design used substantially weaker ground motions than would be generated by an ASCE-7 Maximum Considered Earthquake, a 2% in 50 year event.

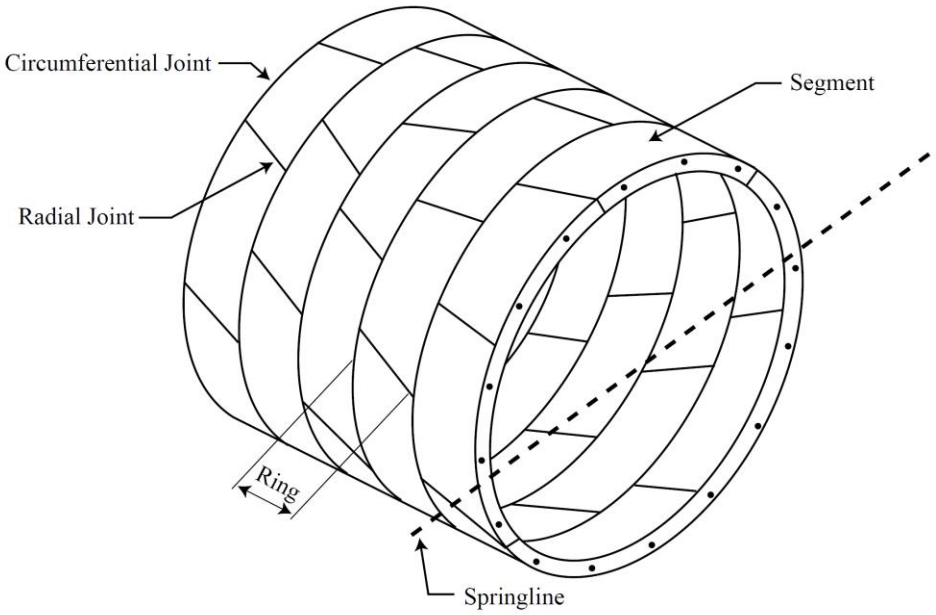


The main considerations cited in the 2015 Draft Design and Construction Enterprise (DCE) Agreement for the choice of tunnel lining were cost and time to construct (p. 9.)[9]

[8] URS, *Delta Risk Management Strategy Final Report*, *Section 6, Seismic Risk Analysis*, 2009. Available at http://www.water.ca.gov/floodsafe/fessro/levees/drms/docs/Risk_Report_Section_6_Final.pdf

[9] California Department of Water Resources, 2015, *Final Draft Agreement Regarding Construction of Conveyance Project between the Department Of Water Resources and the Conveyance Project Coordination Agency,* Available at http://cms.capitoltechsolutions.com/ClientData/CaliforniaWaterFix/uploads/Draft_Final_DCE_Agreement_Combined.pdf

It is clear that cost is driving the current tunnel lining design. The Department of Water Resources and Metropolitan Water District *must* fully analyze and disclose the tradeoffs between cost and strength of the tunnel lining design, including potential leakage in a 2% in 50 year earthquake on nearby faults.



2WaterFix tunnel lining design

The simple fact is that, as currently designed, the Delta tunnels may not be a complete "fix" for earthquake risk in the Delta. If the performance of the tunnel lining design is not analyzed for a Maximum Considered Earthquake, it must not be assumed that the tunnel lining would not be severely damaged in a Maximum Considered Earthquake. The risks of the Delta tunnels being damaged in an earthquake must be fully anazdisclosed in any cost-benefit analysis.

The Department of Water Resources' bond resolution for the WaterFix clearly recognizes the risks of the project. The bond resolution requires payment for the bonds issued for the project, even if the project is not completed or maintained in repair:

> The validity of the authorization and issuance of any of the [California WaterFix Revenue] Bonds shall not be dependent upon or affected in any way by […] (C) the failure on the part of the Department to complete the California Water Fix or to maintain the same or to make all necessary improvements to or replacements thereof or any part thereof.

There is thus a complete disconnect between DWR's WaterFix bond resolution and the WaterFix Phase I Cost-Benefit analysis.

The ASCE Technical Council on Lifeline Earthquake Engineering produced a reference book, Guidelines for the Seismic Evaluation and Upgrade of Water Transmission Facilities, by John Eidinger and Ernesto Avila.[10] The guidelines state the following.

Benefit-cost analysis of seismic upgrades may be considered in four steps:

> 1. Seismic Hazard. The seismic hazard must be specified for the full range of damaging earthquakes affecting the upgrade project site.
>
> 2. Seismic Vulnerability Before Upgrade. The seismic vulnerability of the water system facility or component must be estimated for the before upgrade as-is condition.
>
> 3. Seismic Vulnerability After Upgrade. The seismic vulnerability of the water system facility or component must be estimated for the after upgrade condition.
>
> 4. Benefit-Cost Calculation. Benefits (i.e., the net present value of avoided future damages and losses) are estimated from the above three sets of information, along with the seismic upgrade projects' useful life and the discount rate.

These guidelines clearly prescribe an "apples to apples" comparison, using the same seismic hazard values to assess both the seismic vulnerability before the upgrade, and after the upgrade. DWR's engineers are not doing this. They are using the Delta Risk Management Strategy seismic hazard analysis to estimate the vulnerability of the Delta levees, but stating in the WaterFix procurement documents that the seismic hazard values for the Delta tunnel design still need to be determined.

If the Delta tunnels did start leak in an earthquake, it could have potentially catastrophic impacts on people and property in the Delta, if the leaks occurred under Delta levees. Two engineers with extensive experience in the Delta testified about potential risks of Delta tunnel leakage to Delta levees in the WaterFix Water Right Petition Hearing on March 14, 15, and 16, 2018.[11,12,13] Dr. Clyde Thomas Williams, a PhD Geologist with

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[10] Eidinger, J. and Avila, E., ASCE Technical Council on Lifeline Earthquake Engineering, *Guidelines for the Seismic Evaluation and Upgrade of Water Transmission Facilities*, 1999. Available at http://home.earthlink.net/~eidinger/GuidelinesJ.pdf

[11] California Water Research, blog post, March 30, 2018. *WaterFix Hearing: Tunnels not being designed to withstand maximum earthquake in the Delta*. Available at http://cah2oresearch.com/2018/03/20/waterfix-hearing-tunnels-not-being-designed-to-withstand-maximum-earthquake-in-the-delta/

[12] WaterFix Water Right Change Petition Hearing, *Testimony of Josef Tootle*, Principal Geotechnical Engineer at ENGEO Incorporated. Available at https://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/california_waterfix/exhibits/docs/COSJ et al/part2/SJC_285.pdf

[13] WaterFix Water Right Change Petition Hearing, *Testimony of Chris Neudeck*, District engineer for 26 of

extensive experience with geotechnical design of tunnel and pipeline projects all over the world, also testified on the risks of inadequate seismic and structural design in Part 1 of the WaterFix Hearing.[14,15]

California Water Research worked with Dr. Clyde Thomas Williams to submit CEQA comments that the Delta tunnels must be designated a critical structure, as defined by ASCE-7 standards, and the preliminary design must ensure that the tunnel lining will survive a Maximum Considered Earthquake without severe leakage from the tunnel lining joints.[16] The requirement would be equivalent to the "No Catastrophic Collapse" requirement for 15% design of High Speed Rail tunnels.[17]

The Department of Water Resources, Metropolitan Water District and the WaterFix proponents must fully assess and remediate risks to water supply, and to people and property in the Delta in the seismic and structural design of the Delta tunnels and shafts, and must fully evaluate and disclose the time to repair the Delta tunnels in a maximum earthquake in the Delta.

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the Reclamation Districts in the Delta. Available at https://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/california_waterfix/exhibits/docs/COSJ et al/part2/SJC_291.pdf

[14] California Water Research, Blog post, WaterFix tunnel lining could leak in a large earthquake in the Delta. Available at http://cah2oresearch.com/2017/10/08/waterfix-tunnel-lining-could-leak-in-a-large-earthquake-in-the-delta/

[15] WaterFix Water Right Change Petition Hearing, testimony of Dr. Clyde Thomas Williams, PhD geologist. Available at https://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/california_waterfix/exhibits/docs/dd_jardins/DDJ-163_tw_testimony.pdf

[16] California Water Research, Final EIR/EIS Comments on Conceptual Engineering and CEQA for the WaterFix Project. Available at https://flowinguphill.files.wordpress.com/2018/04/tunnel-engineering-comments.pdf

[17] California High Speed Train Project, Technical Memo 2.10.4, Interim Seismic Design Criteria, June 2009. Available at http://www.tillier.net/stuff/hsr/TM-2.10.4-Interim-Seismic-Criteria-R0-090608-.pdf. Accessed on January 16, 2017.

Sincerely,

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Conner Everts
Executive Director, Southern California Watershed Alliance

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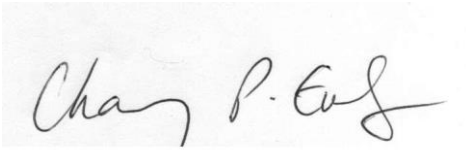

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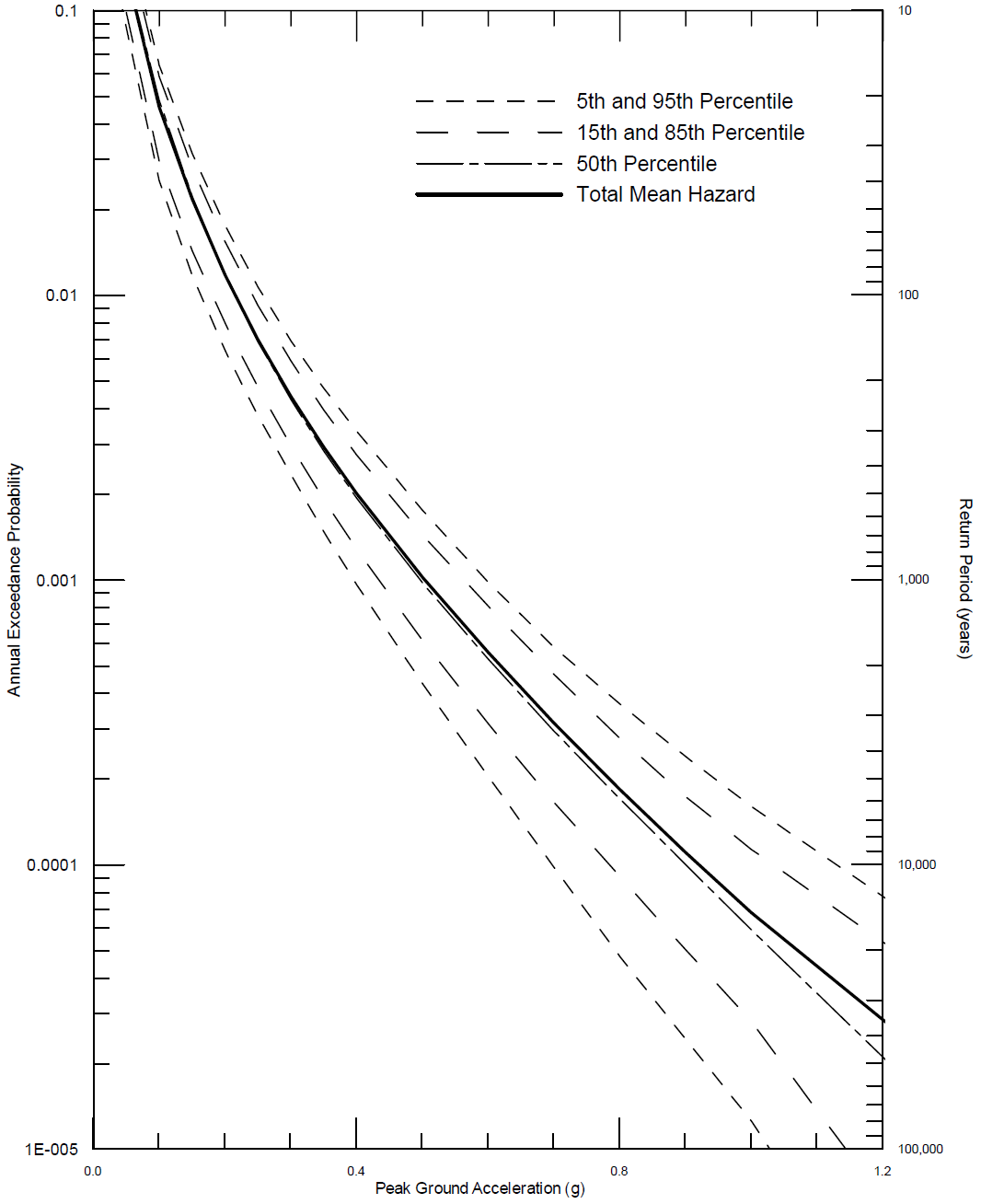

URS	DELTA RISK MANAGEMENT STRATEGY CALIFORNIA	TIME DEPENDENT SEISMIC HAZARD CURVES FOR MEAN PEAK HORIZONTAL ACCELERATION FOR CLIFTON COURT FOR 2005	Figure 6-7
Project No. 26815900			

3 Probabilistic ground motions for Clifton Court Forebay. Includes probability of quakes from all nearby faults.