Attachment A

Response to Senate Review Panel Recommendations

1. *The lack of a system-level risk assessment limits stakeholders' ability to evaluate the impact of design decisions in terms of the overall bridge's reliability. The panel recommends that a probabilistic risk assessment be conducted for the completed bridge to guide operation, maintenance and monitoring.*

   We find the idea of applying probabilistic risk assessment theories, typically used in the nuclear and off-shore industries, an intriguing idea and look forward to further discussions regarding this with both the panel and our colleagues from other state departments of transportation. The panel is correct in noting that this would be a new advancement in bridge design, construction and maintenance. To date, bridge designers around the world have not employed this extra measure on any projects.

2. *There is a need to develop an organized and concise technical explanation of how the bridge was designed and built. This roadmap will be needed to guide future maintenance and repair work on this bridge and its lessons will benefit future projects of this nature.*

   We do believe this was addressed by the design criteria established and presented for the structure. We agree with the panel that this is important for future maintenance, and in fact, have already initiated the development of an extensive "user's manual" for the new structure.

3. *A robust inspection and maintenance program will be needed to address the issues raised above, and to identify any other undiscovered issues. The project team should develop, and funding should be made available for a detailed structural health monitoring program for the bridge. This program will provide much needed timely information on the condition of the bridge over time, and may point to potential problems in various bridge components. Structural health monitoring is a critical component of a state-of-the-art bridge management system.*

   All California toll bridges have a unique and individualized robust maintenance and inspection program. This bridge has several health monitoring devices already installed on the new East Span. We agree with the benefits and look forward to discussing with the panel the scope of the proposed plans. The Department is in the process of developing a user/maintenance manual for the new bridge. This is a first for the Department and is intended to be a detailed reference that will guide maintenance through the service life of the structure. It is anticipated that a comprehensive draft should be developed by the end of this calendar year.

4. *Expand the risk assessment and monitoring program for all A345BD galvanized anchor bolts used within the project. Evaluate risk factors such as potential reaction of galvanizing with the surrounding cement based materials over time, making these susceptible to future embrittlement and the potential existence of grout voids and other*

imperfections due to possible use of top-down grouting procedures. Also, assess the consequences of a reduction in individual bolt capacity on the performance of the system. Develop an instrumentation and monitoring program capable of detecting any future bolt breakages now embedded in concrete (such as Acoustic Emission Detection).

Monitoring of A354 BD fasteners will be addressed in the user's manual discussed above. In fact, we are nearing the conclusion of an exhaustive assessment of all A354 BD fasteners used on the new structure with nine-person expert review panel. The design and construction team are currently working through a thorough and comprehensive evaluation, which includes an assessment of the factors identified, as well as a comprehensive testing program designed to develop hard data. All these issues are being addressed by the expert panel evaluating the A354 BD fasteners and recommendations are forthcoming.

5. *Study the system performance benefits of combining the two load paths for seismic shear provided by shear keys and the bearings for the SAS now considered acting as mutually exclusive systems. Study the comparative performance between the as-built shear key and bearing systems and the combined system.*

   This was fully evaluated during the design phase and it was concluded by Caltrans and T.Y. Lin, the engineer of record, that the combination would not enhance the performance of the structure. We would welcome the opportunity to have a further discussion with the panel about this and share computer modeling of the bridge performance during an earthquake.

6. *The effect of pretension reduction for existing anchor bolts should be further investigated, factoring in the results of the material tests that Caltrans is now conducting.*

   This has been recognized by the design team and the TBPOC as a potential action and is being considered by the nine-member expert panel reviewing the bolt testing and evaluation. Prior to taking any such action, a full design analysis would of course be conducted to support implementation. We are still awaiting recommendations from the nine-member expert review panel, which would address this specific item. Further, the Engineer of Record, T.Y. Lin, has already opined on this and does not believe this would be prudent.

7. *The panel recommends monitoring of the main cable system of the bridge and evaluating the benefits of a full cable dehumidification system as a future enhancement. Protecting the suspension cable of this bridge is especially important given the envisioned difficulty of future replacement of this element due to its self-anchored and inclined 3-dimensional nature.*

   We agree that the protection of the main cable is important. This was given consideration during the design phase, incorporating input from our structures maintenance personnel. A proven 3-layer protective system is included in the design, augmented by dehumidification of key locations. We are conducting routine visual inspection combined with monitoring of dehumidification units and humidity levels through our

supervisory control and data acquisition (SCADA) system. The SCADA system allows for remote control and monitoring. Complete cable dehumidification is an available option that will remain under consideration if maintenance needs evolve.

8. *The panel recommends further review of the pre-stressing strands that developed corrosion due to prolonged exposure prior to grouting. This review should include an assessment of their risk of developing stress-corrosion over the life of the bridge as well as the consequences on system performance. As these strands cannot be readily inspected on a routine basis, the panel also recommends implementing a suitable instrumentation and monitoring program for detecting any future breakage of strands (such as Acoustic Emission Detection to monitor the health of these tendons).*

   The Department did conduct an extensive review of the status of pre-stressing strands in the Skyway. This review also identified the need for further health monitoring of the bridge, and this is an item that will be addressed in the user's manual. All these reports are available publicly and we would welcome further discussion to ensure previous evaluations addressed these concerns.

9. *Any solution for increasing the current clearances with the cable anchor bolts should include a careful evaluation of the possibility of further movement of these rods during service conditions, in addition to the anticipated movements in a seismic event.*

   The Department has conducted an evaluation and has concluded that a 3 millimeter clearance is sufficient to address anticipated seismic forces. This clearance has been achieved through re-centering of the rods. The maintenance manual will note that clearances should be inspected after a major seismic event as this would be the only situation at this point that could reduce frictional force and allow for movement of the rod within the anchorage plate hole. The re-centering procedure has proven to be relatively simple and efficient, and can be performed again to address the results of such an inspection. This evaluation was presented to and received concurrence from the Toll Bridge Seismic Safety Peer Review Panel. A copy of the presentation provided to the Peer Review Panel is attached.

The following are recommendations related to broader issues identified by the panel:

10. *Consideration should be given to having independent third parties responsible for construction quality assurance services so that there are no real or perceived conflicts of interest between the owner, builder and quality assurance. Caltrans may want to examine these issues in some depth and consider making appropriate changes to how construction projects are managed so that potential conflicts are minimized in the future.*

    We would appreciate an opportunity to discuss this with the panel to develop a better understanding regarding your concerns on this issue. The Department's quality management process includes a Quality Assurance (QA) program that prescribes the policies, procedures, and guidelines to assure the quality of materials and construction. It was developed to comply with Title 23, Part 637 of the Code of Federal Regulations (CFR), which contains distinct elements intended to ensure that there are no real or perceived conflicts of interest. First, the acceptance program in the CFR requires that if

testing data from the builder's quality control testing is used in acceptance decisions, then the quality of the material is to be validated by the Owner's own verification sampling and testing. This Owner verification testing is to be performed on samples that are taken independently of the quality control samples, and must be performed by the Owner's own staff or consultants. We understand the crucial role of the contractor's quality control and the Owner's verification in all projects on the State Highway System, and know that these sampling and testing activities are even more vital on a project of the Bay Bridge's magnitude.

Additionally, the Department's QA program includes an Independent Assurance program that evaluates the qualified sampling and testing personnel and the testing equipment. This evaluation is conducted by an independent unit outside of Construction that evaluates staff and equipment of both the builder and the owner. A dispute resolution system is also included here to address the resolution of any discrepancies occurring between the verification sampling and testing and the quality control sampling and testing. QA was accomplished by utilizing both State employees and consultants.

11. *There is a need for a more robust independent peer review process during design, construction, and operation. The bridge's peer review panel is a highly qualified and regarded group. However, an independent team (separate from the peer review team), would add significant value to the process and alleviate any concerns of conflict of interest.*

    The Department's peer review process for the new East Span was the most robust peer review process ever implemented by the department, and is consistent with the practice adopted for several other major bridge projects. There are opportunities to evaluate the utilization of peer reviews on future mega-projects to provide robust independent input. It should be noted that Caltrans has welcomed any independent peer review of the project, including the Legislature's Senate Review Panel.

12. *Caltrans should consider integrating probabilistic risk assessment into their design guidelines for future critical projects; this would aid in quantifying uncertainties associated with performance predictions, and in understanding the benefits of design conservatism in individual elements of a bridge.*

    See answer to number 1.

13. *Some of the problems that developed are a result of the complex design that was chosen for the bridge. In an engineering system, the greater the complexity of the system, the greater the potential for problems and deficiencies. In discussions with project engineers and review of the documents, the panel understood that the SAS was not the engineers' first choice and that, in fact, it was opposed by many on technical grounds. The SAS was chosen on the basis of aesthetics and broader community input without a full appreciation of the complexity of the undertaking and the potential for problems and cost overruns. In addition, it appears that there have been a number of interruptions during design and construction outside the control of the engineering and construction teams that added significantly to the cost of the bridge. There are important lessons from this for the state as it undertakes future large scale infrastructure projects. There is a need to*

streamline the political, social and community input into such large infrastructure projects. Moreover, greater weight needs to be given to technical and engineering considerations when integrating community input. This streamlining is important when making the initial decisions regarding the overall project. It is even more important to closely manage during project execution to avoid large cost overruns that interruptions will inevitably cause.

This recommendation demonstrates the challenges that a public organization must balance with public input, environmental quality considerations, and engineering complexity. It is hard to argue with a process established to allow local decision making for the selection of the bridge to build.