SAN FRANCISCO - OAKLAND BAY BRIDGE
EAST SPAN SEISMIC SAFETY PROJECT

CPSF S-1 Modified Alignment and the Impacts to the EBMUD Sewer Outfall

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EXECUTIVE SUMMARY

Introduction
The purpose of this report is to discuss the issues associated with a southern alignment for a new east span of the San Francisco – Oakland Bay Bridge (SFOBB) and the East Bay Municipal Utility District (EBMUD) outfall facilities. Specifically, this report explores the issues related to the City and County of San Francisco’s (CCSF) proposed southern alignment, S-1 Modified.

The purpose of the SFOBB Safety Project is to provide a seismically upgraded vehicular crossing for current and future users between Yerba Buena Island (YBI) and Oakland. This project will provide a “lifeline”, providing emergency relief access following a maximum credible earthquake (MCE). It is imperative that the SFOBB Seismic Safety Project be completed as quickly as possible as the present structure is vulnerable and the United States Geological Survey (USGS) has concluded that the Bay Area faces a 70-80% probability of experiencing a major earthquake in the next 30 years.

EBMUD Sewer Outfall
The East Bay Municipal Utility District (EBMUD) supplies water and provides wastewater treatment for parts of Alameda and Contra Costa Counties. The wastewater system serves approximately 610,000 people in a 215 square kilometer (83 square mile) area along the Bay’s east shore, extending from Richmond on the north, southward to San Leandro.

Critical operations of the EBMUD wastewater treatment are disinfection, dechlorination, and discharge of treated effluent into the San Francisco Bay. This operation is performed in the outfall and dechlorination system.

The existing EBMUD sewer outfall was constructed in 1950 and is aligned south of the existing SFOBB. The outfall alignment runs adjacent to the roadway and bridge and is offset approximately 85 meters (280 feet) to the south on its eastern end to 220 meters (720 feet) at its western end where the diffuser is located. The outfall consists of three different sections: the onshore pipeline, the offshore pipeline, and the marine diffuser. The 2.4 meter (96 inch) inside diameter, outfall is 4,989 meters (3.1 miles) long and extends approximately 1,600 meters (1 mile) into the Bay.

A dechlorination facility is located on the Oakland Touchdown and is accessed by Burma Road. The dechlorination facility and the outfall in combination are critical elements to the operation of the EBMUD main wastewater treatment plant. Sodium hypochlorite is added at the treatment plant and is used to disinfect the secondarily treated effluent. Sodium bisulfate is added at the dechlorination facility to remove the chlorine and meet water quality requirements of the National Pollutant Discharge Elimination System (NPDES) discharge permit.

The outfall is a low maintenance facility, and EBMUD does not frequently inspect or perform maintenance on the outfall pipes. The outfall was inspected after the Loma Prieta Earthquake (epicenter 97 kilometers away) and no significant damage was identified. If the outfall were damaged, secondarily treated effluent with elevated levels of chlorine could be prematurely released into the Bay, impacting sensitive environmental resources in the surrounding area. The outfall is considered to be in good condition, and EBMUD currently has no plans to replace it.
CCSF S-1 Modified Alignment

The California State Department of Transportation (Caltrans) has considered and performed preliminary engineering on a range of possible alternatives for the SFOBB Safety Project, including several southern alignment alternatives, which are included in the Draft Environmental Impact Statement (DEIS). One of the southern alignments considered was designated as the S-1 alignment. The S-1 alignment was withdrawn from further due to the risks, in terms of both delay and dollars, associated with conflicts between the S-1 alignment and the EBMUD outfall. Subsequently, CCSF proposed the S-1 Modified alignment because of concerns over impacts of northern alignments on development opportunities on Yerba Buena Island.

The S-1 Modified alignment consists of a relatively straight alignment between the Yerba Buena tunnel at the west end of the project to the Oakland Touchdown area at the east end of the project. Large radius curves are used at each end to conform to the existing roadways. The alignment is very similar to the S-1 alignment, which was considered and withdrawn during the NEPA/404 integration process (see Appendix D).

The primary concerns with the S-1 Modified alignment are its impacts on the EBMUD outfall and the proposed gateway park adjacent to the Oakland Touchdown. The Oakland Army Base Reuse Authority (OBRA), the East Bay Regional Park District, the National Park Service, the Port of Oakland, and the City of Oakland plan to develop a gateway park along the western tip and southern shoreline at the Oakland Touchdown. The S-1 Modified alignment has a skewed crossing with the EBMUD outfall, and the eastbound structure and roadway interfere with the outfall structure for approximately 1,700 meters (5,580 feet); 1,200 meters (3,940 feet) in water and 500 meters (1,640 feet) on land. The S-1 Modified alignment also bisects the proposed gateway park. In addition, the S-1 Modified alignment conflicts with the historic Key Pier Substation.

Design and Construction Issues

This report identifies activities or risks that result in increased costs for an S-1 Modified alternative related to the protection of and construction around the existing EBMUD outfall. These include:

- Land and marine outfall survey
- Geotechnical studies of outfall foundation, bedding material, and surrounding geology
- Possible removal of the Key Pier Substation (historic resource)
- Protection of outfall at roadway at-grade crossings
- Relocation of maintenance access points outside of traveled way
- Design and construction of unique foundations at each conflicting bent for land-based structure
- Seismic analysis to model interaction between the outfall and the new bridge foundations
- Design and construction for a marine-based eccentrically loaded structural system around the outfall
- Condition assessment for the outfall – before and after construction
- Monitoring program during construction
- Development of an emergency response plan
- Extended construction schedule for seasonal restrictions to avoid impacts to aquatic resources
- Relocation of the dechlorination facility
- Increased risk to damaging the outfall by access dredging
- Increased risk to damaging the outfall in the construction of trestles
- Increased risk in damaging the outfall during handling and installation of piles
- Increased risk to damaging the outfall during column and superstructure construction
- Future liability for restricted access for maintenance and repair
- Limited shutdown period of the outfall if damaged

Cost Assessment
A cursory review of the listing of potential risks and costs result in costs between 50 and 80 million dollars for the S-1 Modified alignment even without consideration of repair and work stoppage associated with damage to the outfall.

If the S-1 Modified alignment were selected, it may be more appropriate to relocate the outfall. The estimated cost of the relocation of the outfall is in the tens of millions of dollars (the original preliminary estimate by EBMUD was $100 million). This would require a separate environmental document and would delay the SFOBB project by 3 to 5 years. The outfall would have to be relocated before the construction of the new bridge.

Conclusion
This report presents the issues and information relating to the California Department of Transportation’s (Caltrans) position that it would be prudent for the SFOBB project to avoid direct impacts to the EBMUD sewer outfall facilities. The increased cost of construction, complexity in design, impact to bridge aesthetics, and high potential for schedule delay exceed the potential benefit of additional development opportunities on Yerba Buena Island.

The S-1 Modified alignment increases the risk in damage to the outfall from:
- Inadequate design information about the outfall and how it will respond seismically with the new bridge
- Dredging activities on top of and in close proximity to the outfall for the access channel
- Handling and installation of large steel pipe piles adjacent to the outfall
- Construction of columns and superstructure
- Dragging barge anchors
- Accidental grounding of barges moored above and adjacent to the outfall
- Vibration from pile driving activities
- Construction of a trestle structure
- Increased construction difficulties in a marine environment

In addition, the SFOBB project schedule and cost are at increased risk due to:
- Additional geotechnical studies
- Seismic modeling of the interaction between the outfall and the new bridge foundations
- Redesign of the structure
- Design and relocation of affected EBMUD facilities including the dechlorination plant and portions of the land-based outfall
- Seasonal restrictions for certain types of construction equipment to protect marine life
- Construction delays for redesign of pile and foundation layout due to unexpected site conditions and impacts to the outfall
• Gateway park proponents would object to the loss of park lands
• Bridge aesthetic proponents would object to several different pier types

There are several other reasonable alignment alternatives which avoid the outfall. With the high probability of a major earthquake in the region, it is imperative that the SFOBB East Span Seismic Safety Project be completed as soon as possible to avoid catastrophic failure of the bridge and loss of lives.
1.0 INTRODUCTION

1.1 Purpose
The purpose of this report is to discuss the issues associated with a southern alignment for a new east span of the San Francisco – Oakland Bay Bridge (SFOBB) and the East Bay Municipal Utility District (EBMUD) outfall facilities. Specifically, this report explores the issues related to the City and County of San Francisco’s (CCSF) proposed southern alignment, S-1 Modified.

The purpose of the San Francisco – Oakland Bay Bridge East Span Seismic Safety Project is to provide a seismically upgraded vehicular crossing for current and future users between Yerba Buena Island (YBI) and Oakland. This project will provide a lifeline facility, provide emergency relief access following a maximum credible earthquake (MCE) bridge connection between YBI and Oakland.

1.2 SFOBB East Span Seismic Safety Project

1.2.1 Project History
The SFOBB is historically important in the Bay Area and worldwide. Construction of this structure began in 1933 and was completed and opened to traffic in 1936. At the time of its construction, the bridge was the world’s longest vehicular bridge, and the Yerba Buena Island Tunnel, a double-decked structure, was the largest bore tunnel of its time. The foundations for the majority of the East Span are supported on douglas fir timber piles that extend 21 meters (70 feet) into the Bay mud sediments (see geologic profile on the following page). The SFOBB provides regional access between the San Francisco, the Peninsula and the East Bay. Currently, approximately 350,000 people in 274,000 vehicles use the bridge each day. As a component of Interstate 80 (I-80), it is also a critical link in the Interstate Highway System. The SFOBB East Span, which carries vehicles between Yerba Buena Island (YBI) and Oakland, is a double-deck structure 3,696 meters (12,127 feet) in length with five traffic lanes in each direction, east- and westbound.

On October 17, 1989, the Loma Prieta earthquake struck the San Francisco Bay Area, causing 62 deaths and $5.6 billion in property damage, and leaving 8,000 people homeless. The epicenter of the earthquake was 97 kilometers (60 miles) away.

On the SFOBB, the earthquake caused the failure of the upper and lower spans at Pier E9 (shown above), resulting in one death. A truss broke free from its support causing the upper span to fall down on the lower span. In addition, all 24-2.5 centimeter (1 inch) diameter bolts attaching the north and south fixed shoes to their supports sheared off at
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each of the Piers E18 through E22. These shear failures allowed the shoes to slip back and forth in the east-west direction. However, the displacements were not great enough to result in collapse of additional spans.

The East Span was closed for four weeks while the damage was repaired. The closure of the bridge had tremendous impact to commuters who had to be rerouted to other Bay crossings, including other modes of transportation such as ferries or BART. It also had an effect on the overall quality of life in the region.

There are no analyses that have been conducted to quantify the economic impact specific to the closure of the SFOBB. However, the Association of Bay Area Governments (ABAG) did conduct an assessment of the regional macroeconomic impacts of the Loma Prieta Earthquake. ABAG concluded that the maximum loss to the Gross Regional Product was in the range of $181 to $725 million. ABAG noted that San Francisco suffered a significant loss ($73 million) in taxable sales activity, and that “a major portion of the loss in economic activity in San Francisco may have been due to a loss in transportation access” (“Macroeconomic Effects of the Loma Prieta Earthquake”, ABAG (1991)).

1.2.2 Project Purpose and Need
The purpose of the East Span Seismic Safety Project is to provide a seismically upgraded vehicular crossing for current and future users between YBI and Oakland. This project will provide a “lifeline” connection between YBI and Oakland. A “lifeline” connection provides for post-earthquake emergency relief access linking major population centers, emergency relief route, emergency supply and staging centers, and intermodal links to major distribution centers.

The existing East Span must be replaced or retrofitted because:
- The East Span is not expected to withstand a maximum credible earthquake (MCE*) on the San Andreas fault (an earthquake of magnitude 8 on the Richter scale) or Hayward fault (an earthquake of magnitude 7 1/4).
- The East Span does not provide a “lifeline” connection for the expected high level of transportation service necessary for emergency response and support for the economic livelihood of the Bay Area following a MCE.

A MCE on the San Andreas fault could generate over 30 times more energy than the Loma Prieta earthquake. The Hayward fault is located in an area that is more densely populated than the area where the Loma Prieta earthquake hit. A MCE on either the San Andreas or Hayward fault would cause heavy damage that could be much more widespread than the Loma Prieta earthquake, including the collapse of thousands of buildings, extensive infrastructure damage, and major loss of life. The magnitude of such a natural disaster would necessitate the kind of emergency access provided by a bridge serving as a “lifeline” connection.

A MCE on either the San Andreas or Hayward faults would be expected to inflict far greater damage to the SFOBB it experienced from the 1989 Loma Prieta earthquake. This is due to the potential for the epicenter of an event on either the San

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* A maximum credible earthquake (MCE) was referred to in the DEIS, which reflects a deterministic approach to describing earthquakes. Based on recommendations from the Metropolitan Transportation Commission’s (MTC’s) Seismic Advisory Board and Engineering Advisory Panel, the earthquake discussions in the FEIS have been changed to reflect a probabilistic approach (i.e., describing earthquakes in terms of their return period).
Andreas or Hayward faults to be nearer the bridge as well as the potentially greater magnitude of the MCE compared with that of the Loma Prieta earthquake. According to the United State Geological Service (USGS), a MCE on the Hayward Fault will cause more damage than a MCE on the San Andreas Fault. On the existing SFOBB East Span, a MCE could cause multi-span collapse, potentially resulting in numerous immediate casualties and requiring a year or more to reopen the bridge or years to build a replacement. As a result, immediate emergency response and more long-term economic recovery would be delayed.

According to a report by the USGS, the Bay Area faces a 70% probability of an earthquake over the next 30 years causing damage equal to or greater than the $20 billion Northridge earthquake (magnitude 6.7) of 1994. The Bay Area faces an 80% probability of an earthquake of magnitude 6.0 to 6.7 over the same period. Therefore, it is imperative that the SFOBB East Span Seismic Safety Project be completed as soon as possible.

1.2.3 Project Alternatives
Caltrans has considered and performed preliminary engineering on a range of possible project alternatives for the SFOBB East Span project. The following alternatives were considered in the Draft Environmental Impact Statement:

- No-Build
- Retrofit Existing Structure
- Replacement Alternative N-2
- Replacement Alternative N-6
- Replacement Alternative S-4

No-Build Alternative
The No-Build Alternative would retain the existing SFOBB East Span. The No-Build Alternative assumes that the interim retrofitting of the East Span has been completed as a prior project. The Interim Retrofit Project is currently under way to strengthen bents and columns on the viaduct section on the YBI and strengthen piers, bents, and trusses at selected locations on the structure, so that the existing East Span would be able to withstand a lower level, more likely earthquake. This work is scheduled for completion in early 2000. The No-Build Alternative was evaluated primarily as a basis for comparison with the build alternatives. The No-Build Alternative does not satisfy the project purpose and need.

Retrofit Existing Structure Alternative
The Retrofit Existing Structure Alternative would retrofit the existing bridge to withstand a MCE. The seismic retrofit strategy is based on strengthening and stiffening of the substructure (below deck, towers, and foundations). This work would include additional large diameter piles and new pile caps around the existing foundations, isolator bearings at the top of
the towers, and new piers and trusses. Two new large deepwater piers would be added to the center of the cantilever span. A space frame to restrict deformation would extend from the base of the lower deck to the bottom of the upper deck on the outside of the cantilever section. However, the bridge would experience substantial damage in the event of a MCE, likely rendering it unusable for post-earthquake recovery efforts, therefore not meeting the “lifeline” criteria. This alternative would not permit changes to the lane configurations on the existing bridge; therefore, current highway design standards could not be attained. Photo simulations of the Retrofit Existing Structure alternative are shown below.

N-2 Alternative
Replacement Alternative N-2 would construct a new bridge (two-side-by-side bridge decks, each deck consisting of five lanes) north of the existing alignment and would dismantle the existing structure. The alignment has been designed to minimize the length of the new bridge by closely following the alignment of the existing East Span. East of the YBI tunnel, the alignment would transition from a double-deck viaduct structure to two parallel structures. The 3,585 meter (11,759 foot) long span would reach the Oakland shore along the northern edge of the existing Oakland Touchdown area and conform to the existing traffic lanes to the west of the SFOBB Toll Plaza. Alternative N-2 would include a pedestrian/bicycle path on the south side of the eastbound structure. The path would be 4.7 meters (15.5 feet) wide and 0.3 meters (1 foot) higher than adjacent lanes. This alternative would meet the project purpose and need.

N-6 Alternative
Replacement Alternative N-6 (shown below) is similar to N-2, but the proposed bridge would be aligned north of the existing structure and Alignment Alternative N-2. This alignment has been designed to maximize views to the north of YBI while minimizing intrusion into portions of the Bay where geologic conditions increase the complexity and cost of constructing bridge piers. The overall length of Alternative N-6 is approximately 3,620 meters (11,877 feet). The Alignment approaching the Oakland Touchdown area is similar to Replacement
Alternative N-2. Alternative N-6 would include a pedestrian/bicycle path on the south side of the eastbound structure. The path would be 4.7 meters (15.5 feet) wide and 0.3 m (1 foot) higher than adjacent traffic lanes. This alternative would meet the project purpose and need.

S-4 Alternative
Replacement Alternative S-4 would be located south of the existing East Span. The alignment would exit the YBI Tunnel on a double-deck viaduct and transition to two parallel structures. The 3,550 meter (11,644 foot) long span would reach the Oakland shore south of the existing East Span and transition to the existing roadway west of the toll plaza. Alternative S-4 has been developed to avoid offshore conflicts with the alignment of the existing East Bay Municipal Utility District (EBMUD) sewer outfall, which parallels the existing East Span to the south. Alternative S-4 would include a pedestrian/bicycle path on the south side of the eastbound structure. The path would be 4.7 meters (15.5 feet) wide and 0.3 meters (1 foot) higher than adjacent traffic lanes. This alternative would meet the project purpose and need.

1.2.4 Other Alternatives
In addition, Caltrans considered several other project alternatives that were ultimately withdrawn from further consideration. The alternative alignments and the reasons for withdrawal are identified in the Draft Environmental Impact Statement and are summarized here as follows:

N-1 Alternative
Replacement Alternative N-1 is a 3,685-meter (12,087-foot) long replacement alternative located to the north of Alternative N-6. However, based on geologic data, it was determined that approximately one-half of the N-1 alignment would fall within areas of deep young Bay mud, increasing the complexity, schedule, and cost of constructing the bridge substructure while potentially reducing seismic performance. Therefore, Alternative N-1 was withdrawn from further consideration.

N-3 Alternative
Replacement Alternative N-3 would place the main span tower close to YBI, where geologic conditions are most favorable for the tower footing, to facilitate the construction schedule by reducing the amount of in-Bay excavation. N-3 is located to the south of Alternative N-6. However, the tower location would require the roadway horizontal and vertical alignments to be modified to less than optimum configurations, resulting in restricted sight distances, which affect driver response and, therefore safety. Therefore, Alternative N-3 was withdrawn from further consideration.

N-4 Alternative
Replacement Alternative N-4, a modification of the N-3 alignment, provides for a 180 meter (591-foot) tangent (straight) roadway section at the YBI tunnel approach on the westbound alignment. This alternative was designed to satisfy design standards by preventing westbound traffic
from entering the tunnel portal on a curve. However, because of the deep water location of the main span tower, resulting in increased project cost and lengthened construction schedule, Alternative N-4 was withdrawn from further consideration.

**N-5 Alternative**
Replacement Alternative N-5, a modification of Alternative N-3, consists of a larger curve radius for the westbound alignment entering the YBI tunnel portal, reducing or eliminating sight distance concerns. However, based on the desire to place a tangent roadway section at the westbound alignment approach to the YBI tunnel portal and the need to place and maintain the main span tower as close to YBI as possible, Alternative N-5 was withdrawn from further consideration.

**S-1 Alternative**
Replacement Alternative S-1 was defined as the most direct alignment between YBI and the Oakland Touchdown. However, this alignment would not meet superelevation design standards for curves at the YBI tunnel approach, requiring a mandatory design exception and affecting roadway safety. Furthermore, this alignment would create significant conflicts with the EBMUD outfall. Therefore, Alternative S-1 was withdrawn from further consideration.

**S-2 Alternative**
Replacement Alternative S-2 provides broader radius curves than the S-1 alternative at the YBI Tunnel approaches, avoiding the need for design exceptions. Furthermore, this alignment would avoid offshore conflicts with the EBMUD outfall. However, construction staging to maintain five lanes of traffic in each direction would require construction of temporary detour structures out to the cantilever section of the existing East Span. Further investigation indicated that the tie-in of the temporary detour structures to the cantilever section would be complex and potentially could compromise structural integrity of the existing structure. Therefore, Alternative S-2 was withdrawn from further consideration.

**S-3 Alternative**
Replacement Alternative S-3 is a refinement of S-1, which would also eliminate the need for design exceptions for superelevation of roadway curves. However, this alignment would require construction of detour structures similar to those described for Alternative S-2, raising concerns for structural integrity of the existing East Span cantilever section. Therefore, Alternative S-3 was withdrawn from further consideration.

### 1.2.5 Section 4(f) Evaluation
Section 4(f) of the Department of Transportation Act of 1966, codified in Federal law at 49 U.S.C. §303, declares that “[i]t is the policy of the United States Government that special effort should be made to preserve the natural beauty of the countryside and public park and recreation lands, wildlife and waterfowl refuges, and historic sites.”

Section 4(f) further specifies that “[t]he Secretary [of Transportation] may approve a transportation program or project…requiring the use of publicly owned land of a public park, recreation area, or wildlife and waterfowl refuge of national, State, or local significance, or land of a historic site of national, State, or local significance (as determined by the Federal, State, or local officials having jurisdiction over the park, area, refuge, or site) only if –

- there is no prudent and feasible alternative to using that land; and
- the program or project includes all possible planning to minimize harm to the park, recreation area, wildlife and...
waterfowl refuge, or historic site resulting from the use.”

Section 4(f) further requires consultation with the Department of the Interior and, as appropriate, the involved offices of the Departments of Agriculture and Housing and Urban Development in developing transportation projects and programs which use lands protected by Section 4(f).

The East Bay Regional Park District, the National Park Service, the Port of Oakland, the Oakland Base Reuse Authority (OBRA), and the City of Oakland plan to develop a gateway park along the western tip and southern shoreline at the Oakland Touchdown area of the SFOBB. Portions of the land in this area are currently part of the Oakland Army Base with the remainder owned by Caltrans and the Port of Oakland.

The Oakland Army Base has been recommended for closure. OBRA is the designated local redevelopment authority for the base. OBRA’s Reuse Plan designates 5.9 hectares (14.7 acres) at the westernmost portion of the Army Base for the proposed gateway park.

The United States Department of Interior (DOI) submitted a comment letter in response to the Draft Environmental Impact Statement for the SFOBB East Span Seismic Safety Project. The DOI letter asserted that the gateway park constituted a Section 4(f) resource due to its advanced state in its planning process.

The Federal Highway Administration (FHWA) has determined that the proposed gateway park is protected by the provisions of Section 4(f). Therefore, any alignment through the proposed gateway park area would constitute a use of a publicly owned public park. This would occur with any southern alternative. Where there is a prudent and feasible alternative which avoids a 4(f) use, the Secretary of Transportation may not approve such an alternative. The proposed park has multi-agency and public support.
EXISTING CONDITIONS - EBMUD OUTFALL

2.1 EBMUD Wastewater Treatment Facilities

The East Bay Mud Municipal Utility District (EBMUD) supplies water and provides wastewater treatment for parts of Alameda and Contra Costa Counties. The wastewater system serves approximately 610,000 people in a 215 square kilometer (83 square mile) area along the Bay’s east shore, extending from Richmond on the north, southward to San Leandro.

Domestic, commercial and industrial wastewater is treated for the cities of Alameda, Albany, Berkeley, Emeryville, Oakland and Piedmont, and for the Stege Sanitary District, which includes El Cerrito, Kensington and part of Richmond. Each of these communities operates sewer collection systems that discharge into one of five EBMUD intercepting sewers.

Wastewater collected by the interceptors flow to the District’s Wastewater Treatment Plant, in Oakland near the eastern entrance of the San Francisco-Oakland Bay Bridge. The plant provides secondary treatment for a maximum flow of 636 Million Liters per Day (MLD) (168 Million Gallons per Day (MGD)). Primary treatment can be provided for up to a peak of 1,520 MLD (415 MGD). The average annual flow is approximately 303 MLD (80 MGD).

Primary treatment removes floating material, oils, greases, sands, silt and organic solids heavy enough to settle in water. Secondary treatment biologically removes most of the suspended and dissolved organic and chemical impurities that rob lifegiving oxygen from the waters of the Bay if allowed to decompose naturally.

The treatment steps are pre-chlorination (for odor control), screening (to remove large objects), grit removal, primary sedimentation, secondary treatment using high-purity, oxygen-activated sludge, final clarification, sludge digestion, dewatering and composting. The treated effluent is then disinfected, dechlorinated and discharged one mile off the East Bay shore through a deep-water outfall into San Francisco Bay.

EBMUD’s Wet Weather Program involved design and construction of more than $250 million in improvements over 10 years, including four new treatment plants, two storage basins, 12 kilometers (7.5 miles) of new interceptors, and expansion of the main Wastewater Treatment Plant. The program is now complete. Construction of the 598 MLD (158-MGD) Oakport Wet Weather Treatment Plant was completed in 1990. It accepts peak flows diverted from the District’s South Interceptor to prevent
untreated overflows during wet weather from entering the Bay.

Two projects totaling $100 million were completed in 1992 that increased the capacity of the main Wastewater Treatment Plant from 1,098 MLD to 1,571 MLD (290 to 415 MGD) to accommodate peak flows. These projects included major modifications to the influent and effluent pumping stations, the solids-handling system, the chlorination facilities, the process control system, and a 42 million liter (11-million gallon) storage basin to hold peak storm flows for later treatment.

Construction was completed in 1992 on two major pipeline projects, the South Foothill and Adeline Street Interceptors. These "joint-benefit" relief sewers serve the District and the cities of Oakland, Berkeley and Emeryville, providing greater hydraulic capacity to eliminate wet weather overflows.

In 1993, the 379 MLD (100 MGD) Point Isabel Wet Weather Treatment Plant was completed. It accepts peak flows from the District's North Interceptor. The 106 MLD (28 MGD) North Interceptor Wet Weather Facility was completed in 1994, and diverts flows from the main Wastewater Treatment Plant to the Point Isabel plant. Additional projects in the Wet Weather Program are in the design and construction phases.

2.2 EBMUD Outfall Facility

The existing EBMUD sewer outfall was constructed in 1950 and is aligned south of the existing SFOBB. (Selected as-built plans of the EBMUD outfall are included in Appendix A.) The outfall alignment runs adjacent to the roadway and bridge and is offset approximately 85 meters (280 feet) to the south on its eastern end to 220 meters (720 feet) at its western end where the diffuser is located. The outfall consists of three different sections: the onshore pipeline, the offshore pipeline, and the marine diffuser.

The onshore pipeline consists of 2.8 meters (108-inch) diameter concrete pipe, typically in 2.4 meter (8 foot) long segments, that starts at the EBMUD wastewater treatment plant. It parallels Burma Road west through the dechlorination facility, and terminates at the drop structure and manhole at the western tip of the Oakland touchdown. The onshore pipeline is buried under minimal cover, 0.5 meters to 1.5 meters (2 to 5 feet), at slopes varying from 0 to 0.3% and is approximately 2,835 meters (9,300 feet) in
total length. The pipe segments are founded on 20 ton capacity timber piles spaced at 1.2 or 1.8 meters (4 or 6 feet) on center (o.c.). Access manholes are located approximately every 153 meters (500 feet) along the onshore pipeline. The drop structure at the western end of the pipeline was used while 2.4 meters (8 feet) of sand backfill was placed on the top of the pipe. Access manholes are located approximately every 153 meters (500 feet) along the offshore pipeline.

In 1974, the diffuser was reconstructed to consist entirely of 2.4 meters (96 inch) diameter pipe and was extended to a total length of 213 meters (700 feet). The reconstructed diffuser pipe has 254 millimeter (10 inch) diameter ports (openings) staggered on both sides at 2.4 meters (8 feet) on center (o.c.). An access manhole is located at the beginning (eastern end) of the diffuser section. The original diffuser constructed at the end of the outfall consisted of 1, 1.5, 2, and 2.4 meters (42-, 60-, 78-, and 96-inch) diameter pipes and was approximately 91 meters (300 feet) long.

The diffuser is located a mile off the Oakland Touchdown shoreline in a deep channel of the Bay to assist with dispersion of the treated effluent. The Regional Water Quality Control Board (RWQCB) regulates

...
the release of treated effluent into the San Francisco Bay. This agency issues a discharge permit to EBMUD in accordance with the National Pollutant Discharge Elimination System (NPDES), as required by the Clean Water Act.

A dechlorination facility is located on the Oakland Touchdown and is accessed by Burma Road. The dechlorination facility and the outfall in combination are critical elements to the operation of the EBMUD main wastewater treatment plant located just east of the Oakland touchdown area. Sodium hypochlorite is added at the treatment plant and is used to disinfect the secondary treated effluent. Sodium bisulfate is added at the dechlorination facility to remove the chlorine and meet water quality requirements of the NPDES discharge permit. The length of outfall pipe leading to the diffuser provides the mixing and reaction time necessary to de-chlorinate the effluent prior to discharge into the San Francisco Bay. Dechlorination of the effluent prior to entering the Bay is a continuous, 24-hour/day process. The dechlorination facility was placed in a specific location to maximize operational efficiency. Maintenance access to the dechlorination facility is required several times a day to recharge the system and ensure proper operations. The dechlorination facility must remain accessible 24 hours a day.

Generally, the treatment facility has no storage basins other than the excess capacity in the interceptor systems and outfall pipes. The outfall can be shut down for brief periods, generally no longer than 4 hours during the low flow cycles of the early morning, to avoid backing up the wastewater system. Shutting down the system for longer than 4 hours would backup wastewater into the collection system and eventually onto the streets.

If the outfall were damaged, secondarily treated effluent would be prematurely released into the Bay affecting water quality due to elevated levels of chlorine. EBMUD could be fined up to $25,000 per day due to violation of its NPDES permit.

The outfall is a low maintenance facility, and EBMUD does not frequently inspect or perform maintenance on the outfall pipes. The outfall was inspected after the Loma Prieta Earthquake and no significant damage was identified. The outfall is considered to be in good condition, and EBMUD currently has no plans to replace it.
3.0 CCSF ALIGNMENT
ALTERNATIVE – S-1
MODIFIED

3.1 History
The Metropolitan Transportation Commission (MTC) is the regional body responsible for coordinating local deliberations for the location, design, and potential funding strategies for a replacement structure. Its Bay Bridge Design Task Force reviews and recommends bridge designs and possible bridge amenities to Caltrans. In this role, MTC and the task force provide a regional voice on the project. In July 1997, Mayor Willie Brown of the City of San Francisco expressed his support for a northern alignment in a letter to the MTC. Shortly thereafter, the Design Task Force issued its recommendation for a replacement bridge on a northern alignment.

In commenting on the Draft Environmental Impact Statement in the fall of 1998, the City and County of San Francisco (CCSF) and the United States Navy (USN) expressed concerns regarding the recommendation of MTC for a northern alignment. CCSF and USN expressed concern over the potential impacts that a northern alignment might have to the historic resources located to the north of the existing bridge and to the development potential of the land on Yerba Buena Island.

Although a southern alignment (S-4) was included in the Draft EIS, CCSF procured the services of an engineering consultant to develop a southern alignment. This
alignment is very similar to the S-1 alignment included in the Draft EIS as considered and withdrawn. A modified S-1 alignment was also considered and withdrawn in the Draft EIS, but this alignment is different than the S-1 Modified alignment proposed by CCSF. For this report, all references to the S-1 Modified alignment are to the alignment proposed by CCSF. Due to the similarities between the two alternatives, the CCSF alignment is known as S-1 Modified. All southern alignments must conform to the YBI tunnel and its approach; therefore all southern alignments are virtually the same on Yerba Buena Island.

3.2 S-1 Modified Alignment

The S-1 Modified alignment consists of a relatively straight alignment between Yerba Buena tunnel at the west limit to the Oakland Touchdown area at the east limit. Large radius curves are used at each end to conform to the existing roadways. The alignment lies adjacent and to the south of the existing Bay Bridge.

A major concern with the S-1 Modified alignment is the conflict with the EBMUD outfall. The S-1 Modified alignment crosses the EBMUD outfall on a small skew angle and the eastbound structure and roadway with the outfall structure for approximately 1,700 meters (5,580 feet); 1,200 meters (3,940 feet) in water and 500 meters (1,640 feet) on land. This conflict occurs in the area near the Oakland Touchdown area where the span lengths of a proposed new bridge vary from 80 meters (260 feet) to 120 meters (390 feet).

The eastbound roadway of the S-1 Modified alignment also crosses directly above the drop structure and dechlorination facilities.

The westbound roadway crosses directly above the Key Pier Substation, potentially requiring demolition of the structure. The Key Pier Substation is a contributing structure to the historic significance of the Bay Bridge, a National Registry property, and is also individually eligible for the National Register of Historic Places as a surviving remnant of the Key System. As such, it is afforded the protections of Section 4(f) of the US Transportation Act of 1966. (See page 7 for more explanation of section 4(f)).

3.3 Comparison to S-1 and S-4 Alignment Alternatives

The S-1 and S-1 Modified alignments are nearly identical and have similar impacts to the EBMUD outfall, adjacent facilities, Key Pier Substation, and the proposed gateway park area. At YBI, both alignments conform with existing structures at the same point. However, the two alignments differ in the radius of their approach curves to the conform point.
The S-4 and S-1 Modified alignment are virtually identical on Yerba Buena Island. Just east of Yerba Buena Island, S-4 continues to curve to the south so that the westbound roadway is located south of the EBMUD outfall diffuser structure. This places the S-4 alignment completely south of the existing offshore portion of the outfall. The S-4 alignment was specifically developed to avoid conflict with the offshore portion of the EBMUD outfall. Once the S-4 reaches the Oakland Touchdown area, the S-4 alignment must cross over the onshore portion of the outfall. The skew angle between the S-4 alignment and the outfall is much greater and results in a conflict area on land of approximately 400 meters (1,300 feet) in length. The greater the skew angle of an alignment with the outfall, the smaller the length of impact on the outfall. The S-4 alignment eliminates impact to the outfall in the marine environment as well as eliminating direct impacts to the historic Key Pier Substation, outfall drop structure, and dechlorination facility on land. However, FHWA has concluded that the S-4 alignment, as with all southern alignment alternatives, involves the use of Section 4(f) land designated by OBRA as a future park.
4.0 SEISMIC CONDITIONS AND CONSIDERATIONS

To resolve conflicts between the S-1 Modified alignment and the EBMUD outfall, the following alternatives exist for modifying the structure to accommodate the outfall:

- Skew and offset the bridge bents.
- Offset the bridge columns.
- Modify the bridge pile caps.

Each alternative has its own benefits and disadvantages.

4.1 Skewing Bents

The most common method to avoid an obstacle is to skew the bents and outrigger the columns. In theory, this is a feasible alternative for the SFOBB East Span. However, in post-earthquake evaluations of bridges that the presence of skew within a bridge is detrimental to bridge performance (Maroney & Zelinski et al, 1994; Fung, LeBeau, Klien, Belvedere & Goldschmidt, 1971; ATC6). Therefore, skew within the bridge are not acceptable, a philosophy consistent with bridge design in California.

4.2 Offsetting Bridge Columns

Another structural alternative to span the sewer outfall on the CCSF S-1 Modified alignment is to progressively move the column off of center within the bent as far along the length of the bridge as possible while maintaining some acceptable distance between the bridge foundations and the sewer outfall system. Figures 4a-g are provided to illustrate such a design. As these images are at an Advanced Planning Study (APS) level, they should be viewed in a qualitative sense while not emphasizing their quantitative interpretation. Figures 4a-c show the physical conflict between the bridge and the sewer outfall at three representative locations along the length of the bridge. The conflicting conditions at station 71+00, 72+30, and 76+40 are shown in Figures 4a, 4b, and 4c, respectively. The bridge piles are either in direct conflict with the outfall or are closer to the outfall than is acceptable. By review of these images, it is clear that some form of redesign is necessary to advance this alternative.

Fundamentally, the following two actions could be used to address this problem; (1) minimize the interaction between the bridge and the outfall by adding space and some form of protection between the bridge and the outfall, and (2) modify the bridge structure to some degree. Figures 4d and 4e illustrate proposed concepts that offset the bridge columns and place protective space and sheet piling around the sewer outfall. In good geotechnical material, the standard spacing of vertical piles to reduce interaction to acceptable levels is three diameters of clear spacing. In poor geotechnical material, the spacing should be increased.

As shown in Figures 4d and 4e, interaction between the bridge piles and the outfall would certainly take place during construction as well as during large seismic events like those predicted in the Bay Area by the USGS. This soil-structure interaction poses a tremendous problem, which will require significant research. In the configurations shown in Figures 4d-f, the bent cap is likely to require greater depth as it is required to cantilever larger dimensions. In some cases, the connection between the column and the superstructure will start to extend outside of the superstructure itself, as is shown in Figures 4d and 4e. This type of joint configuration is recognized as much more difficult and is avoided whenever possible. Figure 4f illustrates a conceptual design for conditions similar to those represented by Figure 4c. Once again, the basic protective design strategy is to provide
space as well as a barrier between the bridge piles and the outfall.

At station 76+40, the dimension of the outrigger column is too great to support the roadway by a single column and therefore would require a multi-column pier (Figure 4f). This type of bent configuration has been constructed in California and is more vulnerable to seismic events. However, it is highly undesirable for the SFOBB East Span due to the drastic change in vibrational characteristics it would create. Such bridge type selection is well recognized as poor when selected in regions of significant seismic risk. Modern bridge design strives to achieve similar vibrational characteristics for adjacent bents within a frame.

Figure 4f illustrates an additional issue to be addressed in the pile configuration near the outfall. The sewer outfall is a continuous system over its entire length. The seismic response motion of the outfall at any location along its length is a function of not only ground motion, and as in Figure 4f response motions of the bridge, but also response motion of the outfall system along its entire length. The bridge piles will restrain the movement of the sewer outfall at discrete locations while allowing other locations to freely move in significantly greater displacements, resulting in deformation and possibly failure of the outfall. Similar conditions have led to structural failures in past earthquakes (e.g. Northridge, Petrolia). Due to this occurrence, it may be necessary to consider vertical piles at the bents near the outfall to minimize differential displacements of the outfall. Such steps in bridge design, however, represent unacceptable compromises in the quality of the new bridge.

In theory, the designs illustrated in Figures 4d-f allow for spanning the outfall. However, the seismic reliability of both the bridge system as well as the sewer outfall is significantly reduced with these designs. It would be extremely difficult to quantify, with reasonable certainty, the interaction between the outfall and the bridge structure. The tremendous variation in stiffness and vibrational behavior from bent to bent has been recognized as poor bridge design. Caltrans has gone as far as to restrict such variation for many years in its bridge design. The designs are highly undesirable simply because of the variation in structure configuration. The dependence of both the outfall and the bridge on seismic interaction between the two systems makes the designs even less attractive.

4.3 Modifying the Bridge Pile Caps
Figure 4g illustrates an additional alternative in which the bridge system spans the outfall using modified pile caps. Essentially, the pile group is dispersed around the sewer outfall and the pile cap spans the outfall using either a rigid beam or a cantilever design. The foundation design, which has been optimized for this site and for bridge seismic performance, is completely changed when this modification is made. A reprioritization of performance is given to the sewer outfall in this design. The piles may need to be vertical, instead of battered, to reduce the influence of the piles on the outfall during a seismic event. The pile cap will not only increase in lateral dimensions but will also increase in depth due to the spanning requirements. As a result, the inertia demands acting on and within the bridge system will greatly increase. This represents a large change in vibrational
character, which as previously noted, not only represents poor bridge design, but also complicates the structural fusing at the base of the column during large seismic events. This design alternative would also be forced to address the issue of interaction between the bridge system and the outfall. This alternative represents very poor bridge design practice and should not be accepted.

4.4 Challenge to the Classification of the Seismic Problem

The analysis of bridge systems has been a focus of seismic research for decades. Dr. Joseph Penzien and Dr. Harry Seed were pioneers in idealizing and classifying the problem into a solvable form which hundreds, if not thousands, of engineers have built additional research upon in the years since. The seismic analysis of buried pipe has not enjoyed such attention. Because of this, the seismic response prediction of the outfall will require careful evaluation starting at a relatively low level of experience.

Past earthquakes have demonstrated that bridges must be designed carefully, evaluating potential failure mechanisms and taking appropriate steps to limit threatening response. Part of this process is to carefully develop bridge input motions from the site response and the surrounding soil and structure interaction. In this case, the behavior of the outfall and its surrounding foundation and backfill material would be included. To span the outfall, the input motions for the bridge structure would be partially defined by the response of the outfall and the bridge soil-structure interaction characteristics would be partially defined by the outfall and its surrounding materials.

One fundamental unknown would be to quantify the strain (a complex measurement of deformation) state over time of the material between the outfall and the bridge foundations in addition to all of the unknowns associated with the outfall and the bridge system independently. This should be recognized as a tremendously large and complex problem that is likely to require a simultaneous mathematical solution. Obtaining this solution will require research prior to its application in production. Any bypassing of such a phase is an assumption of risk to the bridge and the outfall.

The discretization of a bridge system for seismic analysis is relatively simple. Recognizing the location of seismic motion input is also fairly clear, being located at the base of each pier, or supporting element founded within or on the earth. A pipeline is a more continuously, and partially, connected system because it is connected to the earth at all locations. A pipeline and its surrounding material have inertia and stiffness characteristics much different than the surrounding earth. These differences cause the pipe and backfill material to have the potential to move out of phase with the surrounding soil. Therefore, the mesh required to simulate and to predict the response of the sewer outfall is very different and likely to be incompatible with the mesh associated with the bridge system.

These issues alone make it clear that if the bridge is to span the sewer outfall and both the bridge and the sewer outfall are to remain functional to specified performance levels, significant research is required in areas of seismology, geotechnical engineering, and structural engineering.
5.0 DESIGN CONSIDERATIONS

5.1 JMI Report
CCSF procured the services of J. Muller, International (JMI) to prepare an assessment of the design issues associated with the S-1 Modified alignment and the EBMUD outfall. The report was reviewed by Caltrans and was determined to be inadequate for purposes of evaluating the design, construction, cost, and schedule issues associated with the S-1 Modified alignment as proposed by JMI. A response by Caltrans to the CCSF on the JMI report is included as Appendix B of this report.

5.2 Utility Encroachments

5.2.1 Caltrans Policy on Utility Encroachments
Caltrans general policy is to avoid utility encroachments on freeways. Utility encroachments of this type are permitted only where space is available and where no other reasonable alternative is available.

With approximately 1700 meters (5,580 feet) of the EBMUD outfall within the footprint of the eastbound roadway and structure of the S-1 Modified alignment, it is appropriate to review the Caltrans policies regarding longitudinal encroachments.

Placement of longitudinal utility encroachments within freeway and expressway right-of-way is prohibited under Department policy. However, should unusual circumstances warrant consideration of such placement, requests for an exception to the policy are reviewed by the Caltrans Program Manager, Design and Local Programs. Encroachments requiring facility maintenance or repair within access control lines are avoided. Public safety and maintenance personnel have serious concerns with utility placements that will require maintenance personnel to be present in the traveled way and access control lines.

5.2.2 AASHTO Guidelines on Utility Encroachments
There are two AASHTO publications governing utility encroachments. The titles and applicable excerpts are as follows:

"Where a utility already exists within the proposed right-of-way of a freeway and it can be serviced, maintained, and operated without access from the through traffic roadways and ramps, it may remain as long as it does not adversely affect the safety, design, construction, operation, maintenance or stability of the freeway. Otherwise, it must be relocated..."

"Conditions which are generally unsuitable or undesirable for pipeline crossings should be avoided. These include locations such as in deep cuts, near footings of bridges and retaining walls, ...

"On longitudinal installations, utility locations parallel to the pavement at or adjacent to the right-of-way line are preferable so as to minimize interference with the safe operation of the highway..."

"Vertical and horizontal clearance between the pipeline and a structure or other highway or utility facility should be sufficient to permit maintenance of the pipeline and other facilities."
5.2.3 Utility Encroachment Examples
Several examples of Caltrans' utility encroachment policy are evident in the Bay Area, including other toll bridge projects.

New Benicia-Martinez Bridge

The alignment for the new Benicia-Martinez bridge was originally located to the east of the Union Pacific Railroad bridge due to the oil refineries' facilities immediately west of the existing bridge. Instead of moving the bridge alignment slightly east placing it over the utility corridor on the bottom of the Carquinez Strait, Caltrans found it more appropriate to avoid the extensive structural design and potential risks that would occur and moved the bridge alignment further east. Later, the new bridge had to be relocated even further east due to concerns of the Union Pacific Railroad and the US Coast Guard.

Carquinez Bridge Retrofit

An example where Caltrans allowed for an exception to its policy is the retrofit of the 1958 Carquinez Bridge, which requires the relocation of an existing PG&E 0.6 meter (26 inch) diameter gas main. The gas main currently runs across the downstream side of the existing structure along the outside edge of the truss and near the deck level. The following two options were investigated for relocating the gas main: relocating the gas main to the upstream side of the bridge or relocating the gas main to the bottom of the channel. Given the State's need to implement this toll bridge seismic safety project quickly, relocation of the gas main on the structure was selected. Relocating the gas main on the structure allowed seismic safety to occur much sooner than relocating the gas main to the bottom of the channel and additionally, minimized design work and significantly lowered costs.

I-80 HOV Lanes Project

In order to avoid the encroachment of the EBMUD Sewer North Interceptor upon the I-80 HOV Project, Caltrans relocated the interceptor outside of their right of way from the EBMUD Wastewater Treatment Plant to University Avenue. The cost of the
relocation was in excess of $20 million. During the construction of the interceptor relocation, EBMUD was sued for water quality issues related to the relocation of the interceptor. The lawsuit delayed the construction and completion of the project.

5.3 Design Data Requirements

5.3.1 EBMUD Outfall Survey

To support a final design effort for a new bridge structure along the S-1 Modified alignment, the existing outfall must be precisely located. This would require geophysical surveys, marine potholing, and surveying approximately 1,200 meters (3,930 feet) of the outfall in water and 500 meters (1,640 feet) on land. The exact location of the outfall in the Bay can be determined through a variety of means including physical identification, side-scan sonar, sub-bottom profiling, and seismic reflection profiling.

Regardless of the survey approach, accurately pinpointing the location of the outfall would result in an increase in costs for project surveys.

5.3.2 EBMUD Outfall Geotechnical Study

Construction activity as well as the seismic interaction between bridge piles and the surrounding soil, particularly those piles in close proximity to the outfall, can affect the competency of the outfall foundation and bedding material, causing damage to the outfall. In order to model and assess the level of interaction and the design criteria needed to protect the outfall, the competency of both the outfall and the surrounding material must first be determined. This would likely be accomplished by taking a series of core samples of the outfall bedding material and in situ testing of the surrounding soils.

Understanding the geologic and geotechnical conditions of the site is critical. If a design is developed using incomplete information or assumed data, the risk of damage or failure during construction increases significantly. If unknown conditions result in an unsuitable foundation design, damage to the outfall could occur and construction will be halted until a redesign can be completed. Given the complexity of the foundation design, construction could be delayed for many months while additional geotechnical data is gathered and the foundations are redesigned.

This marine sampling and analysis program would increase design costs by as much as $1 million. This estimate is based on the sampling program that was recently conducted in the Bay for the SFOBB Seismic Safety Project. There are also the costs of the delay to the project, both in time and money.

5.4 N-6 Replacement Alternative

While a new design would be required to address the unique aspects of the EBMUD outfall and a S-1 Modified alignment, the current proposed design for the new East Bay span on the N-6 alignment can be used to highlight the technical issues for a S-1 Modified alignment.
The description herein focuses on the alignment limits that would have an impact on the EBMUD outfall. The design concept currently being prepared at risk by Caltrans on the N-6 alignment consists of two five lane roadways with standard shoulders. At the Oakland Touchdown, the roadway begins at approximately elevation 3.5 meters (11.5 feet) rising at a rate of 1.8% to reach an elevation of 45 meters (148 feet) at the end of the outfall diffuser. On land, the roadway elevation is 12 meters (40 feet) at the outfall drop structure and 9 meters (30 feet) at the dechlorination facility. The current grade at the Oakland Touchdown area is approximately at elevation 3 meters (10 feet). Given the soil conditions of the Oakland Touchdown as highly compressible, it is likely that the roadway would be constructed on structure until elevation 5.7 meters (18.7 feet) and then on lightweight fill. This occurs approximately where the proposed grade is one meter above the original grade. The span lengths of the structure on land would be approximately 40 meters (131 feet).

In the water, span lengths for the bridge vary, depending on proximity to the shoreline. The span length start at 42 meters (138 feet) at the Oakland Touchdown, and increase to 160 meters (525 feet) at the outfall diffuser. The structure depth varies with the span lengths but generally, there is a minimum clearance of 4 meters (13 feet) at the lowest point over water (mean sea level) at the Oakland shoreline increasing to 36 meters (120 feet) above the water at the outfall diffuser.
5.5 Land-based Design Issues

5.5.1 Vertical Clearances at Existing Facilities

The alignment of the eastbound roadway restricts vertical clearance at the EBMUD outfall drop structure and dechlorination facility. Referencing the current proposed profile for the N-6 alignment, assuming the S-1 Modified is similar, the vertical clearance at the drop structure and dechlorination facility would be 7 meters (23 feet) and 3.6 meters (12 feet), respectively. Maintenance access requirements for the drop structure are generally minimal with provisions for personnel access being adequate. This can be provided with the current proposed profile. The dechlorination facility requires access by large maintenance vehicles needing a vertical clearance of 5.1 meters (16.5 feet).

Given the restrictions on maintenance access, the dechlorination facility would need to be relocated. The most likely location would be near or within the EBMUD wastewater treatment facility located approximately 2.7 kilometers (1.7 miles) to the east. Relocation of the dechlorination facility would require construction of a channel and weir system to provide the appropriate mixing and reaction time for chemical treatment of the effluent prior to dechlorination. Currently, much of this process occurs in the outfall between the water treatment plant and the existing dechlorination facility. The cost for relocating the dechlorination facility has been estimated by EBMUD to be $2.7 million (see Appendix C).

The westbound roadway of the S-1 Modified alignment crosses directly above the historic Key Pier Substation. This building has historical significance as a remnant of the Key System and as a contributing structure to the Bay Bridge. The S-1 Modified
protection of the existing outfall will increase design and construction costs. The outfall is supported by timber piles, which provide a more stable foundation than the roadway if the roadway is constructed on fill. Embankment surcharge would be used to consolidate the soil in the vicinity of the abutment before the final grade is constructed. Placement of a surcharge load on top of the soft compressible soil of the Oakland Touchdown area would cause settlement of the soil. As the soil around the outfall piles consolidates, the soil would move downward relative to the piles, creating a downdrag force on the outfall piles and would result in settlement of the outfall.

An alternative to relocation of any of these facilities would be to raise the profile of the roadway to accommodate access requirements to these facilities. However, additional costs, in the millions of dollars, would be incurred for the taller structural elements, larger foundations, and extension of the structure to meet grade.

5.5.2 At-Grade Crossings
The eastbound roadway of the S-1 Modified alignment would cross the outfall at a small skew angle for approximately 500 meters (1,640 feet). The smaller the skew angle, between the outfall and the alignment, the greater the length of impact on the outfall. In this area, the roadway could be either on structure or on fill. If the roadway is constructed on fill, the shallow cover of engineered material over the outfall may require reinforcement for the heavy vehicular loadings of truck traffic. Also, maintenance access will need to be addressed in accordance with Caltrans policy on longitudinal encroachments. Determining the need of and providing for
EBMUD has indicated that the allowable load on the pipeline is zero. Correspondence from EBMUD is included in Appendix E.

An option that eliminates the surcharge loading and differential settlement issue, and changes the manhole access conflict is to use a roadway structure over the conflict area of the outfall. The use of structure in this area would increase project costs. Furthermore, the maintenance access issues would still need to be addressed since vertical clearance for maintenance equipment between the manhole and the roadway structure may not be adequate.

An alternative to protecting the outfall in place or relocating maintenance manholes would be to relocate the section of outfall outside the roadway area. This would be consistent with Caltrans policy and AASHTO guidelines regarding longitudinal encroachments of utilities. The result would be an increase in cost to relocate a land portion of the outfall.

5.5.3 Pier and Foundation Design
The pier and foundation layout would need to accommodate the small skewed angle crossing of the outfall under the eastbound roadway alignment. With the S-1 Modified alignment, the outfall would affect up to 11 of the piers supporting the eastbound roadway. Each pier and foundation system would need to be uniquely designed as the location of the outfall with respect to the roadway is constantly changing from bent to bent. This increased design effort for each unique location is compounded by the seismic design criteria for the project. The behavior analysis of this section of the bridge would be extremely difficult to analyze due to the complexity of modeling numerous unique foundations and how the bridge will react as a whole.

This would increase design and construction costs since each of the pier and foundation systems will be unique within the limits of the outfall crossing.

5.6 Marine-Based Design Issues

5.6.1 Horizontal Clearance
An acceptable horizontal clearance between the new bridge foundation and the existing outfall must be determined. The clearance should account for both construction period activities as well as interaction of these elements during a seismic event.

Caltrans typically assumes a minimum clearance of three diameters between pipe piles to ensure that only a low level of soil interaction occurs between the piles. This is essential so that the capacity of the pile is not reduced by the soil interaction of an adjacent pile. Where the consequences of failure are high, Caltrans uses five diameters of clearance to further reduce the risk. Using this design approach, the clearance between the piles and the outfall should be of adequate distance so that the pile interaction with the surrounding soils does not adversely affect the foundation and bedding material of the outfall (ie the distance between the piles and the outfall should be 3 to 5 diameters).

To reduce soil interaction issues during the placement and driving of the piles, sheet piling could be placed to protect the outfall.

Another factor in determining horizontal clearance is the level of movement anticipated for each of the structures during a seismic event. It is likely that the new bridge structure and the outfall, with unique phases and periods, would respond...
differently to a seismic event. Some analyses must be performed to identify a minimum clearance so that the two structures do not physically collide during a seismic event.

Design costs will increase to perform the necessary seismic and geotechnical studies to determine the horizontal clearance requirements.

5.6.2 Pier and Foundation Design

The current design of the foundations call for grouping six 2.5 meters (8.2 feet) diameter steel pipe piles with a relatively large pile cap of 15.5 meters (50 feet) long and 20 meters (65 feet) wide. In order to provide reasonable access to the outfall for future repairs, the area directly above the outfall must be kept clear of obstruction. The primary concern for the foundation design is the size and location of the pile caps.

One approach suggested in the JMI report, to accommodate the outfall pipe within the foundation design, was to construct the pile supports around the outfall pipe and construct the pile cap above the outfall as shown in the adjacent figure. The offshore portion of the outfall is constructed in 7.3 meter (24 foot) sections, so the pile caps would span over entire sections of the outfall. While the JMI design approach provides a single column with concentric loading, it does not provide for reasonable access to the outfall within the limits of the pile cap nor does it provide an adequate horizontal clearance between the piles and the outfall. This approach was determined infeasible for both technical and maintenance/repair access reasons.
An alternative approach to accommodate access to the outfall pipe and to provide reasonable horizontal clearance is to use a series of eccentrically loaded piers and outrigger pier systems to support the roadway superstructure above the skewed outfall crossing. Based on the current proposed design, up to 11 sets of piers would be affected by the outfall.

As with the land-based structure, the location of the outfall is constantly changing relative to the new bridge structure as the outfall pipe crosses the eastbound roadway structure on a small skewed angle. This presents unique challenges for both foundation design and development of the structural system. The changing foundation requirements from pier to pier translates into a complex response of the structural system to seismic event. It is also likely that the optimal span lengths would change with a changed structural system. The optimal span lengths developed for concentrically loaded supports would not necessarily be optimal for a series of eccentrically loaded supports.

These design complexities would result in an increase in the design costs. In addition, although an estimate cannot be determined until a design concept is fully developed, it is reasonable to assume significant construction costs for an eccentrically loaded support system as compared to the current proposed design. Whenever the contractor cannot repetitively use foundation forms and must form each pier individually, the construction costs increase.

5.6.3 Bridge Aesthetics
Aesthetic considerations of structure design have been key project issues in public discussions. At MTC Bay Bridge Task Force meetings, East Bay community representatives have asked bridge designers to give the skyway structures a more dramatic visual appearance.

The design concept for the structures responds to recommendations of the MTC Bay Bridge Design Task Force addressing aesthetic design issues. Recommendations also called for particular attention to the design of supporting piers.

As shown in the visual simulation on the next page, substructure design concepts would use piers with geometric configurations similar to the suspension span tower. Piers are set at consistent span lengths to reinforce the gradual rising of the ribbon-like roadway superstructure.

Under the S-1 Modified alignment, the roadway would continue to provide a single ribbon when viewed from nearby and remote vantage points. But, the introduction of the outriggers and irregularly shaped piers spanning the outfall would disrupt the design concept of the identical pier shapes that in the current design repeat at consistent distances and change only in height. (See the previous graphic showing the "S-1 Modified Alignment - Bridge Piers"). Additional visual disruption would result if the span lengths are changed at the outfall crossing.

The most apparent difference between the replacement alternatives N-6, and S-1 Modified is the curve in the N-6 alignment versus the relatively straight line of the S-1 Modified alignment.

When viewed from the air, if one were approaching the Bay Area by plane, the curved form of the N-6 alignment would present a strong and fluid line which transitions from the West Spans of the bridge, through Yerba Buena Island, and then turns gracefully south to connect to the
Oakland shore. This same graceful form would be apparent to distant elevated viewers on land, such as from the Oakland and Berkeley hills, and from portions of San Francisco. Although the S-1 Modified alignment also incorporates a curve south towards the Oakland shore, it is a small and abrupt radius by comparison, and is dominated by the long straight portion of its alignment.

The N-6 alignment curves north of the existing bridge alignment, offering a progression of views west towards the Bay, with expansive views of the San Francisco skyline and north to Mt. Tamalpais, Angel Island and the North Bay. This alternative provides an alignment for the main span suspension portion of the bridge that aligns with and compliments the west spans of the Bay Bridge. In addition, the N-6 alignment offers a dramatic oblique view of the main span suspension tower for motorists traveling in a westerly direction. This view of the main span tower coupled with the curve in the alignment results in a sense of anticipation as one approaches the main span. In a similar fashion, views to the main span from the downtown areas of both Oakland and San Francisco are also enhanced because of the oblique view from which they are viewed.

In the S-1 Modified alignment, motorists would still see the main span suspension tower, but rather than seeing it from a variety of angles, as with the N-6 alignment, motorists would have a single vantage point that provides a constant line of sight. This alignment would result in a relatively static view of the bridge and surrounding landscape. Views to the west span and the San Francisco skyline to the south would be slightly more apparent, though views to the north would be less dramatic than with the N-6 alignment since YBI would block much of the view.

In either of the proposed alternatives, N-6, or S-1 Modified, eastbound travelers would experience expansive views to the Port of Oakland in the foreground, and to downtown Oakland and the east bay hills in the distance. In this direction the N-6 alignment would offer a visual experience similar to that on Route 24 in Alameda County, as one exits the Caldecott Tunnel; a panorama of views of the Bay and City skylines are revealed as motorists proceed on the curving roadway. The N-6 alignment, because of its orientation would result in enhanced views of the Port of Oakland facilities, and the downtown Oakland skyline.

In summary, closer views of the bridge benefit more from the N-6 alignment, than the S-1 Modified alignment because the main span is aligned with the west spans, and because it can be seen at a more favorable viewing angle. The N-6 alignment provides a visual experience where the motorist’s views of the bridge, and views out to the surrounding Bay area landscape are revealed in a series of visual experiences; the view is constantly changing. In the S-1 Modified alignment, the visual experience is dynamic only due to a change in distance as motorists proceed toward a visible touchdown point.
6.0 CONSTRUCTION ISSUES

6.1 Condition Assessment and Monitoring

- The risk of damage to the EBMUD outfall during construction of a new east span bridge would increase significantly with the S-1 Modified alignment. Many activities would expose the outfall to a high risk for damage. These activities include dredging, pile placement and driving, the use of heavy marine equipment and heavy bridge construction equipment, often as close as six feet above the outfall.

To identify any damage due to construction activities for a new East Span bridge, a pre-construction assessment would have to be conducted and a monitoring program developed. The pre-construction assessment would include a video survey of the outfall, visual inspection by divers, and sampling of the Bay waters at various points along the outfall to determine ambient levels of water quality. During construction, the outfall would have to be monitored for movement and separation, damage that would cause premature release of the effluent. Periodic inspection and water sampling may be required to ensure that the outfall is in proper operating condition.

A National Pollutant Discharge Elimination System (NPDES) discharge permit has been granted to EBMUD. This permit identifies the conditions for discharging the treated effluent into the San Francisco Bay waters. If the conditions of the permit are violated, then EBMUD can be subject to fines up to $25,000 per day.

After construction of the bridge has been completed, a post-construction condition assessment would have to be performed to ascertain any permanent damage caused by construction. EBMUD may require a period of time after construction is complete before conducting a post-construction condition assessment to ensure that the surrounding geology has settled into a stable condition.

Due to the increased risk for damage, the more substantial monitoring program required for the S-1 Modified alignment would increase costs.

6.2 Environmental Concerns

Environmental concerns related to the higher risk for outfall damage may also affect construction activities. Premature release of the secondarily treated effluent, which is likely to have elevated concentrations of chlorine, in addition to violating the Regional Water Quality Control Board (RWQCB) discharge permit, would have impacts on the sensitive environmental resources including eel grass beds, migratory birds, and marine life. Also, premature release of the secondarily treated effluent would likely occur in the shallow water. Due to slow currents in shallow water, the dispersion of the discharge may be inadequate, increasing the impact to the surrounding environment.

With the increased risk associated with the S-1 Modified alignment, additional permit restrictions and requirements might be imposed by the governing federal agencies, such as US Fish and Wildlife Service, Army Corps of Engineers, RWQCB, the National Marine Fisheries Service, and the California Department of Fish and Game. The additional requirements would be intended to reduce the risk of impact to sensitive environmental resources and could include:

- Restrictions on construction activities within the water during breeding and migratory seasons of marine life
- Regular sampling of the water quality along the construction zone
An assessment determination of the permit requirements could only be acquired through presentation of the likely construction activities and discussion of likely impacts in consultation with the permitting agencies.

If seasonal restrictions are placed on the construction activities due to the higher risks associated with construction for the S-1 Modified alignment, then there would be an increase in costs, with the associated extended construction schedule.

6.3 Emergency Response Plan
As part of the monitoring program, an emergency response plan should be prepared so that corrective action could be taken immediately to minimize impacts of damage to the outfall or dechlorination facility. The plan should contain the following elements:

- **Recognition** – Recognition of facility damage must be made as soon as possible. The sooner damage to the outfall or dechlorination facility is recognized, the sooner corrective action and recovery can take place. Typical indicators of a leak would include unusual odors, unusual colors, or abnormal gauge readings. As soon as damage is recognized, a preliminary evaluation of the problem, if it can be safely done, should be performed. In addition, the affected area should be evacuated and demarcation boundaries indicated to identify an exclusion zone.

- **Notification** – Communication will need to be established immediately to ensure the safety of all personnel on-site. The EBMUD Superintendent and Process Control Officer should be notified as soon as possible so that they can assist in minimizing the impact of a release of effluent. The Source Control Division should also be notified because the release requires notification of the RWQCB.

- **Documentation** – Accurate records are necessary so that EBMUD can learn from a premature effluent release and so that a recurrence can be prevented. Accurate logs of the indicators of a spill and the times they are noticed should be maintained. In addition, photographs should be taken when appropriate or informative. Documentation will be used to review the actions taken and to submit a formal report to the EBMUD Superintendent.

- **Corrective Action** – Changes should be made immediately to minimize the impact of the facility damage. These changes would include decreasing the influent pumping rate, diverting flow to out-of-service sedimentation tanks, and securing appropriate isolation valves. The level of response will be determined and proper protective equipment assembled. All incidents will be treated as extremely dangerous until an on-site evaluation has been completed.

- **Reporting** – The Source Control Division will notify the RWQCB in accordance with the Standard Provisions and Reporting Requirements of the NPDES permit. This may require immediate telephone notification and/or formal written notification.

Development of an emergency response plan would result in an increase in cost. This assumes that the plan would not require that costly emergency response equipment is on standby during construction activities.
6.4 Land-Based Construction

6.4.1 Construction Access
Construction activity at the Oakland Touchdown will be significant and long-term because this area will involve extensive construction for the bridge approach structure and abutment as well as serving as a staging area for the SFOBB project. Activities involving heavy machinery and construction materials would be occurring directly above the EBMUD outfall with the S-1 Modified alignment alternative. Protective measures would have to be implemented which would allow for the activities necessary for construction to occur while reducing the risk of damage to the outfall.

Initially, it must be determined which portions of the onshore outfall need to be protected. These areas would be dictated by the requirements of construction access necessary during construction of the new bridge. Several falsework protection systems are available to protect the outfall from both live and impact loads associated with construction activities.

One temporary protective system involves using a construction mat supported by beams and piles. The piles would straddle the outfall and would be driven into pre-drilled holes to minimize the impact of soil interactions on the outfall. A beam system would span the distance between the piles and above the outfall. The construction mat would be placed on top of the beam system and would be capable of withstanding impact loads.

A second temporary protective system would be construction of a steel reinforced concrete cap on top of the outfall. The concrete cap would possibly need support from predrilled piles. This method, however, would severely limit maintenance and repair access to the portions of the outfall being protected.

Three existing outfall manholes would require protection or relocation due to their proximity to construction activities for the S-1 Modified alignment alternative. These features of the outfall can be protected using concrete barricades. However, they must remain accessible with minimal delay so that any maintenance or repair requirements during the construction period could occur.

6.4.2 Pile Driving
The risk of damage to the outfall from pile construction on the Oakland Touchdown is significant because of the large number of piles that need to be placed. Approximately 245 approach structure piles for the eastbound roadway would be constructed within close proximity to the outfall pipeline. The onshore piles will range from 0.61 meters (2 feet) to 1.8 meters (6 feet) in diameter.

Although the piles are smaller in diameter than piles to be used for the offshore bridge spans, the large number of piles driven puts the outfall at risk. The piles would require pre-drilling and placement at an adequate lateral distance from the outfall so that any soil displacement effects on the pipeline are minimized. The outfall would need to be thoroughly surveyed so that piles can be accurately placed.

6.4.3 Abutment Construction
The abutment for the eastbound approach structure would be located close to the outfall and an outfall manhole. Abutment construction would involve embankment surcharge, pile driving, and excavation, all of which will put the outfall at risk of damage.
Embankment surcharge would be used to consolidate the soil in the vicinity of the abutment before the final grade is constructed. Placement of a surcharge load on top of the soft compressible soil of the Oakland Touchdown area would cause settlement of the soil. As the soil around the outfall piles consolidates, the soil would move downward relative to the piles, creating a downdrag force on the outfall piles and would result in settlement of the outfall.

Approximately 26 abutment piles would be driven for the eastbound roadway and would create the same risks to the outfall as the approach structure piles. In addition, soil excavation would occur close to the outfall and would require sheet piling between the abutment and the outfall to prevent failure of the engineered foundation of the outfall. The outfall and piles would have to be monitored to ensure that no damage has occurred.

6.5 Marine-Based Construction

6.5.1 Dredging

Dredging would be required above the outfall to provide access for construction barges. Barges will be needed for construction equipment such as cranes and pile drivers as well as transporting construction materials such as the steel pipe piles.

With the S-1 Modified alignment, dredging would be required directly above the outfall. The depth of the dredging channel will need to provide for a draft of 3.6 meters (12 feet) with an extra 0.6 meters (2 feet) for contingency. The required depth for the dredged channel would bring construction activity to within 1.8 meters (6 feet) of the top of the outfall.

Given the proximity of the dredging activity and the type of heavy construction expected to be used for dredging channels, the potential for damage to the outfall is great. Dredging the construction access channel can be accomplished with a variety of barge based equipment including marine excavators, hydraulic cutterheads, clamshells, and hoppers.

Some of the more economical methods may not be appropriate for the sensitive areas above the outfall. With only approximate means for controlling the depth of the dredge, clam shelling may represent too high a construction risk. Also, the impact loads of dropping a clam shell
bucket or a back-hoe bucket into the bay. Muds may be transmitted to the outfall and cause a rupture or, in the worst case, actually penetrate to the outfall itself. Use of non-impact mud removal methods such as cutterhead suction are likely to be restricted seasonally to avoid impacts to the Pacific herring, chinook salmon, steelhead, green sturgeon, and longfin smelt. The seasonal restriction would probably involve the peak juvenile out-migration period (December 1 through May 31). In addition, construction activities occurring during the seasonal Pacific herring spawning period (December to March) would have to be monitored by a qualified biologist to watch for the presence of herring. If spawning is observed in the project area, in-water activities such as dredging would be suspended within 200 meters (656 feet) of observed spawning for a period of up to 14 days.

Protection of the outfall and special care during dredging activities would restrict the dredging methods available. This will increase the amount of time required to construct the bridge. These activities would result in an increase in construction costs.

6.5.2 Trestles
Trestles may be used to provide construction access. However, the use of trestles is dependent on the weight of construction equipment and materials, which they will have to support. Construction of the trestle shares many of the same issues as bridge construction, but on a much smaller scale. Placement of the piles and proximity to the outfall could affect the outfall. The appropriate geotechnical studies and exact location of the outfall would need to be provided to the contractor so that the trestle layout can be designed to minimize risk. Another concern is that vibration from heavy construction equipment would transmit through the piles of the trestle and cause damage to the outfall. These are some of the issues that would need to be addressed in the design of the trestle and the protection of the outfall during construction of the trestle.

6.5.3 Pile Construction
The risk of damage to the outfall from pile construction is directly related to the number and size of the piles that need to be placed. More piles mean longer periods of construction activity in the area. Bigger piles require larger construction equipment and are more difficult to move and place.
With the S-1 Modified alignment, up to 11 piers and foundations would be constructed within close proximity to the outfall. Assuming six piles per pier grouping, over 66 piles would need to be driven approximately 91 meters (300 feet) below Mean Sea Level (MSL). The current design concept includes 68 millimeter (3 inch) thick, 2.5 meter (8.2-foot) diameter steel pipe piles. With pile lengths of 91 meters (300 feet) or more, the piles will weigh more than 350 tons. It is possible that the piles will be delivered in shorter sections. These shorter sections would be placed and field welded. Pile setup in the Bay muds during welding and weld inspection may require a larger pile hammer.

The consequences of mishandling these extremely heavy construction materials can be severe. Following access dredging activities, only a shallow cover of sand material would protect the outfall. Any pile sections dropped on the outfall would result in severe damage and rupture of the outfall. Considering the difficulties of marine construction such as currents, tidal influence and dragging anchors, the risk increases for an incident that would damage the outfall.

On the San Mateo-Hayward Bridge retrofit project (shown below), the contractor used equipment capable of lifting and placing piles 32–52 meters (124-169 feet) long and weighing 95-275 tons each.

Pile construction for the S-1 Modified alignment represents a higher risk to the outfall than the N-6 alignment. This higher risk, which should include protection provisions for the outfall, would be represented in a contractor’s bid as higher construction costs due to the additional construction risk and restraints. The construction of the piles near the outfall would result in an increase in the costs for the construction of the project.

**6.5.4 Column and Superstructure Construction**

Risks associated with the column and superstructure construction are similar to those already stated for marine construction activities over the outfall, including barge grounding and mishandling of construction materials.
Column and superstructure construction would require the use of barges for the marine portion of the bridge contract. The barges would be used for heavy construction equipment and delivery of construction materials.
7.0 MAINTENANCE AND REPAIRS

7.1 Maintenance Requirements
The outfall is a low maintenance facility, and EBMUD does not frequently inspect or perform maintenance on the outfall. The outfall was inspected after the Loma Prieta earthquake and no significant damage was identified. EBMUD considers the outfall in good condition and currently has no plans to replace it.

A dechlorination facility is located on the Oakland Touchdown and is accessed by Burma Road. Maintenance access to the dechlorination facility is required on a daily basis to recharge the system and ensure proper operations. Design issues as they relate to maintaining access to the dechlorination facility is addressed in Section 5.0 of this report.

Maintenance access for the land-based portions of the outfall is provided approximately every 150 meters (500 feet). Design and construction issues are addressed in Sections 5.0 and 6.0 of this report.

7.2 Future Maintenance
EBMUD acknowledges that there is a base cost associated for repairs under the existing condition without a bridge structure over the outfall. However, if the outfall needs repair or pipe sections need replacement, EBMUD would look to Caltrans for those increases in costs due to restricted access caused by the SFOBB project.

Damage caused by a seismic event will also be difficult to assess. With the exception of a direct impact of the two facilities, it will be difficult to assess whether the outfall sustained damage regardless of the proximity of a new bridge structure.

An agreement regarding costs related to damage and restricted access would need to be negotiated between Caltrans and EBMUD. It can be reasonably expected that there would be an increase in future costs to Caltrans.
8.0 COST ASSESSMENT

In order to prepare an accurate cost estimate for the S-1 Modified alignment for purposes of comparison to other alternative alignments, the design development would need to progress to at least the level of a Caltrans Structure Advanced Planning Study. However, a qualitative review of the items resulting in an increase in costs can provide a basis for decision making.

Much of the increase in costs would be the direct result of increased risk of damaging the EBMUD outfall during construction activities. The contractor would generally reflect this additional risk as a higher construction bid.

This report identifies activities or risks that result in increased costs for an S-1 Modified alternative related to the protection of and construction around the EBMUD Outfall. These include:

- Land and marine outfall survey
- Geotechnical studies of outfall foundation, bedding material, and surrounding geology
- Potential demolition of the Key Pier Substation (historic resource)
- Protection of outfall at grade crossings by roadway
- Relocation of maintenance access outside traveled way
- Redesign and construction of unique foundations at each conflicting bent for land-based structure
- Seismic analysis to model interaction between the outfall and the foundations of the new bridge
- Design and construction for a marine-based eccentrically loaded structural system around the outfall
- Condition assessment for the outfall – before and after construction
- Monitoring program during construction
- Development of an emergency response plan
- Extended construction schedule due to seasonal restrictions on certain construction equipment to protect marine life
- Relocation of the dechlorination facility
- Increased risk and construction time for access dredging
- Increased risk in the design and construction of trestles
- Increased risk during handling and placement of piles
- Increased risk during construction of columns and superstructure
- Future costs from restricted access for maintenance and repair

This list represents those issues identified to date and addressed in this report, and is not presented as a comprehensive list of items that would result in increased costs for the S-1 Modified alignment. However, a cursory review of the list would result in costs between 50 and 80 million dollars even without consideration of repair and work stoppage associated with actual damage to the outfall.
9.0 CONCLUSION

Based on the findings of this report, it is concluded that protecting and accommodating the EBMUD sewer outfall for the S-1 Modified alignment would require increased risk to the project schedule and increased costs between 50 and 80 million dollars.

There would be an increased risk in damage to the outfall from:

- Inadequate design information about the outfall and how it will respond seismically with the new bridge
- Dredging activities on top of and in close proximity to the outfall for the access channel
- Handling and installation of steel pipe piles adjacent to the outfall
- Construction of columns and superstructure
- Dragging barge anchors
- Accidental grounding of barges moored above and adjacent to the outfall
- Vibration from pile driving activities
- Construction of a trestle structure
- Increased construction difficulties in a marine environment

There would also be an increased risk to the SFOBB project schedule and costs because of the need for:

- Additional geotechnical studies
- Seismic modeling of the interaction between the outfall and the new bridge foundations
- Redesign of the structure
- Design and relocation of affected EBMUD facilities including the dechlorination plant and portions of the land-based outfall
- Seasonal restrictions for certain types of construction equipment to protect marine life
- Construction delays for redesign of pile and foundation layout due to unexpected site conditions and impacts to the outfall
- Gateway park proponents would object to the loss of park lands
- Bridge aesthetic proponents would object to several different pier types

If the S-1 Modified alignment were selected, it may be more appropriate to relocate the outfall. The estimated cost of the relocation of the outfall is in the tens of millions of dollars (the original preliminary estimate by EBMUD was $100 million). This would require a separate environmental document and would delay the SFOBB project by 3 to 5 years. The outfall would have to be relocated before the construction of the new bridge.

There are other reasonable alignment alternatives which avoid the outfall. With the high probability of a major earthquake in the region, it is imperative that the SFOBB East Span Seismic Safety Project be completed as soon as possible to avoid catastrophic failure of the bridge and loss of lives.

This report confirms the earlier findings that it is prudent for the SFOBB project to avoid direct impacts to the EBMUD sewer outfall facilities. The increased cost of construction, complexity in design, impact to bridge aesthetics, and high potential for schedule delay exceed the potential benefit of the development opportunities on Yerba Buena Island.