SAFER Bay Project Summary of Geotechnical Challenges

Overview

The SAFER Bay project presents an unusually complex geotechnical setting because the proposed levees, floodwalls, transition zones, and habitat features must be placed along a Bay shoreline underlain by soft estuarine soils, shallow groundwater, and variable existing fill. The most important issues are foundation weakness, long term settlement, differential movement, seepage, slope stability, seismic performance, corrosion, and the challenge of constructing on saturated low strength ground. These issues affect both structural flood protection and habitat restoration because many project features must perform within narrow elevation tolerances over time.

1. Weak and compressible foundation soils

A primary challenge is the presence of Young Bay Mud and other soft shoreline deposits. These soils are highly compressible, weak in shear, often organic, and locally overlain by undocumented or non engineered fill. In some areas, artificial fill contains debris such as concrete, wood, asphalt, and brick. The result is a highly variable foundation profile that reduces predictability and complicates both design and construction. Because these materials have low strength and high compressibility, they control settlement, stability, and construction access decisions across much of the project corridor.

2. Long term consolidation settlement

New levee and habitat fill will impose loads on underlying Bay mud, causing consolidation settlement over time. This is one of the most significant performance concerns for the project because settlement directly reduces flood protection elevation and freeboard. The design therefore must include initial overbuild to ensure that final elevations, after settlement, still meet flood protection targets. Habitat features such as transition zones and refugia berms are also sensitive because ecological performance depends on final grade relative to tides and sea level rise.

3. Differential settlement

Settlement will not occur uniformly. Differences in Bay mud thickness, soil consistency, existing embankment conditions, and proximity to previously consolidated ground will create uneven settlement along the alignment. Differential settlement can create localized low spots, affect trail grades and drainage, and generate distress where floodwalls tie into levees or where new fill meets existing structures. For a long linear project, differential behavior is a more difficult maintenance issue than uniform settlement because it can undermine continuity of protection.

4. Seepage and piping risk

The project must resist Bay water levels during major coastal flooding events. Where foundation soils are pervious or heterogeneous, underseepage and through seepage can generate elevated hydraulic gradients. If these gradients are not controlled, they can lead to seepage breakouts, piping, sand boils, and loss of levee stability. This is why seepage control is a core design issue. Depending on final reach conditions, seepage mitigation may rely on engineered fill selection, internal low permeability zones, cutoff measures, or other foundation treatments.

5. Static slope stability

Soft foundation soils reduce the available shear strength for embankment support. As a result, levee geometry must be selected with close attention to static slope stability under long term loading, end of construction loading, and flood conditions. Even where broad embankment slopes are used, global stability can remain sensitive to embankment height, fill unit weight, and the thickness of weak foundation soils. Stability is especially important where levees are placed near marsh edges, existing channels, drainage features, or constrained infrastructure.

6. Seismic performance and liquefaction related concerns

The project corridor lies within a mapped liquefaction hazard zone. Although soft Bay mud itself may not liquefy, other subsurface materials such as loose granular soil, surrounding fills and loose cohesionless deposits may be susceptible to liquefaction, seismic settlement, or lateral movement. Earthquake loading can also reduce stability margins for levees and floodwalls and may increase deformation demands on transitions between structural and earthen features. This requires project-specific evaluation of post-liquefaction stability, seismic deformation, settlement, and deformation compatibility.

For levee systems, however, it is important to distinguish between conventional structural seismic compliance and accepted levee practice. Earthen levees are generally not designed to fully satisfy seismic performance criteria under the design earthquake in the same way as occupied buildings or other conventional structures. Instead, levee seismic risk is evaluated in relation to the probability of coincident loading. The controlling concern is whether a damaging earthquake would occur simultaneously with a high water condition that places the levee under maximum hydraulic demand. Because the joint probability of the design seismic event occurring at the same time as an extreme Bay water level is very small, this combined condition is generally not treated as a major standalone risk driver for levee design. Instead, the predicted seismic deformations are compared with more frequent hydraulic loading, to evaluate if the resultant loss of freeboard is likely to lead to overtopping and flooding before a repair effort can be implemented. Implicit in this approach is the understanding that damage to a levee system may need to be repaired to reinstate the design flood protection following an earthquake.

As a result, seismic risk management for levees is addressed partly through design evaluation and partly through operations and maintenance. The design process considers likely modes of deformation and instability, while the residual risk is managed through post-earthquake inspection protocols, condition assessment, emergency response procedures, and action plans for repair or temporary flood fight measures if needed. In practice, this operations-based framework is a standard part of levee safety because it recognizes that inspection, monitoring, and response capability are integral to long term system performance.

7. Ground subsidence

In addition to embankment induced settlement, portions of the Bay shoreline may be subject to ongoing regional or localized subsidence. This can slowly reduce the effective crest elevation even after initial settlement has occurred. The practical implication is that long term flood performance must consider both construction related consolidation and post construction ground lowering. This makes monitoring and adaptive maintenance planning important parts of future project implementation.

8. Constructability on saturated low strength soils

Constructing levees and walls on wet shoreline ground is difficult. The subgrade can have very low bearing capacity, shallow groundwater, and tidal influence. Heavy equipment can cause rutting, bearing failure, mud waves, or lateral displacement of soft foundation soils during fill placement. To address this, construction may require staged loading, lightweight equipment, geotextile stabilization, geogrid reinforcement, or other working platform measures. Site preparation is also complicated by debris removal, utility conflicts, wet soil management, and limited haul or staging space.

9. Fill material suitability

The project needs fill that is suitable for both engineering and environmental purposes. From a geotechnical standpoint, levee fill must be compactable, reasonably low permeability, and strong enough to maintain the required geometry over soft foundations. At the same time, some placed soils will support habitat and must satisfy environmental screening requirements for

Baylands placement. This creates a material selection challenge because the best engineering material is not always identical to the best habitat support material.

10. Corrosion in a saline Bay environment

Floodwalls, sheet piles, utility appurtenances, and embedded metal elements will be exposed to a corrosive environment driven by salinity, moisture, and variable soil chemistry. Corrosion design therefore becomes a geotechnical and structural durability issue, not just a materials issue. Soil resistivity, chlorides, sulfates, pH, redox conditions, and tidal influence all affect long term wall and appurtenance performance. Where steel elements are used, the design must account for long term section loss or include other corrosion protection measures.

11. Groundwater and dewatering

Excavations for floodwalls, utility modifications, seepage controls, and habitat channels may require dewatering in soft Bay deposits. Dewatering must be managed carefully to avoid instability, migration of fines, or impacts to adjacent facilities and marsh areas. Water handling may also require treatment or controlled discharge depending on field conditions. These issues can materially affect both cost and sequencing.

12. Interaction of flood protection and habitat restoration features

A distinctive challenge for SAFER Bay is that the project combines flood control embankments with ecological grading and beneficial reuse of excavated Bay mud. Habitat features such as transition zones, ditch fills, tidal marsh restoration surfaces, and refugia berms depend on careful control of final elevations and side slopes. These features must settle and perform in a predictable way while also supporting ecological function over time. In effect, the project must solve structural and restoration geotechnical problems simultaneously.

Conclusion

The central geotechnical issue for SAFER Bay is not a single design constraint but the combined effect of weak Bay margin soils, long term settlement, hydraulic loading, seismic risk, corrosive conditions, and difficult construction access. The success of the project depends on whether these factors are managed in a coordinated way so that both flood protection and habitat features remain functional over the long term. This is why the geotechnical program is fundamental to the overall justification, design, and phasing of Bay fill for the project.

Document basis

This memorandum is based on the SAFER Bay East Palo Alto Design Criteria Report dated, May 11, 2026, the Menlo Park SAFER Bay Basis of Design dated June 26, 2025, and the SAFER Bay Habitat Restoration Basis of Design dated April 2026.