SILICON VALLEY – BERRYESSA EXTENSION
PASSENGER RAIL IMPLEMENTATION IN FREIGHT RAIL CORRIDOR

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ABSTRACT

Sustaining Silicon Valley's economic vitality is key to maintaining the leadership of the United States in many key global industries. Besides being the nation's center of computer-related technology services, the region includes major concentrations of biotechnology, bioengineering, and renewable energy firms. The Valley faces several challenges that could constrain its continued expansion. One is efficient movement of goods and people to, from, and within the Valley because of historical low-density land use developments with the automobile as the primary mode of travel.

VTA began studying the project corridor nearly 30 years ago. The corridor consisted of the heavily congested I-880/I-680 freeway corridor that stretches from the Fremont BART Station to downtown San Jose, which is located at the southern end of San Francisco Bay. Also, located in the middle of the two freeways was a Union Pacific Railroad freight rail right-of-way that was purchased by VTA.

VTA's BART Silicon Valley program represents the final link needed to complete the 20-mile gap in the regional rail system around San Francisco Bay and tie together the region's three major metropolitan centers: San Jose, San Francisco, and Oakland.

This paper provides background about this major infrastructure project located in a congested urban area and methods implemented, lessons learned, and challenges overcome. Areas highlighted include; 1) cooperation and coordination with Union Pacific Railroad, 2) VTA/BART relationship, 3) phasing and projects including UP relocation and infrastructure 4) community benefits, environmental, development and others, 5) innovative designs introduced, Lightweight Cellular Concrete bridge approaches, Railroad Intrusion Detection.

SILICON VALLEY – BERRYESSA EXTENSION PASSENGER RAIL IMPLEMENTATION IN FREIGHT RAIL CORRIDOR - INTRODUCTION

Cooperation between multiple agencies, railroads, public and contractors is a necessity when planning and implementing a major passenger rail project. The Silicon Valley – Berryessa Extension is a prime example of how this cooperation can bring a project to fruition.

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FIGURE 1 – Bay Area Rail Map – Silicon Valley

HISTORY OF VTA/BART SILICON VALLEY EXTENSION

When VTA began studying the project corridor nearly 30 years ago, the corridor was referred to as the Fremont-South Bay Corridor and consisted of the heavily congested I-880/I-680 freeway corridor that stretches from the Fremont Bay Area Rapid Transit (BART) Station to downtown San Jose at the southern end of San Francisco Bay (see Figure 1). Also, located in the middle of the two freeways was a Union Pacific Railroad freight rail right-of-way purchased by VTA in 2002VTA's BART Silicon Valley program represents the final link needed to complete the 20-mile gap in the regional rail system around San Francisco Bay and tie together the region's three major metropolitan centers: San Jose, San Francisco, and Oakland.

In November 2000, the voters of Santa Clara County approved the Measure A Transit Improvement Program, a ½-cent local-transit sales tax that would provide funding for 14 transit projects, including extending BART. This 30-year local sales tax went into effect on April 1, 2006.

To begin project delivery activities for the transit projects identified in Measure A prior to the 2006 tax revenue generation date, the VTA Board of Directors adopted a resolution in August 2003 authorizing the issuance of bonds up to $550 million secured by and payable from the 2000 Measure A Transit Improvement Program.

In November 2008, an additional Santa Clara County ballot measure supporting the BART extension passed. The sales tax will generate dedicated revenue to fulfill VTA's obligation to BART for the operation, maintenance, and future capital reserve of the extension VTA constructs. 2008 Measure B stipulated that collection of the eighth-cent sales tax begin when federal and state funds were secured. Federal funds were considered secured and matched at the time VTA received a $900 million Full Funding Grant Agreement in March 2012.

VTA was planning on constructing the full 16-mile extension, however in 2008 it became clear that the project would need to be phased. So VTA broke the project into two phases: The Berryessa Extension, a 10-mile double track corridor from BART's new Warm Springs Extension to the Berryessa area of San Jose. Phase 2: extends the project another 6 – miles through downtown San Jose to Santa Clara, allowing Bay Area residents and visitors to circumnavigate the Bay via rail.

To maintain the momentum and prepare the corridor for the construction of the BART system, VTA began several advance projects to clear right-of-way and fulfill their agreement with UPRR when the agency purchased the UP property and ultimately selected Design-Build delivery to complete the line, track, stations and systems (LTSS) and selected Skanska, Shimmick, Herzog Joint Venture in November 2011.

ADVANCE RAILROAD RELOCATION PROJECTS.

VTA purchased roughly 15 miles of railroad property from Union Pacific Railroad. The rail corridor was made up of two 60-feet wide adjacent corridors. The two corridors were originally owned by Western Pacific Railroad and Southern Pacific Railroad, later by Union Pacific Railroad.

With property in hand, VTA's Advance Railroad Relocation Project consolidated Union Pacific Railroad Operations into the western 60-foot ROW, making room for BART while maintaining freight operations per the purchase agreement.

In addition to relocation of Union Pacific railroad tracks, VTA was also required to mitigate issues regarding a dozen creeks, two petroleum pipelines, and many fiber optic carriers and various other utilities, which crossed or resided on the properties. With relocation of freight operations, railroad facilities, and other facilities constraints, VTA's BART to Silicon Valley Project could begin.

Mission/Warren

FIGURE 2 – Mission/Warren Project Map

Two entities, Caltrans and Alameda County Transportation Authority (ACTA), improved a freeway interchange in Fremont, California. The first phase rebuilt the Interstate 880 and Mission Boulevard junction, which is now a modern three-level freeway interchange. Mission Boulevard is now a six-lane road, which cross-connects Interstate 880 to Interstate 680.

Caltrans and ACTA didn't have a solution for Phase 2. The second phase required Mission Boulevard's two existing railroad bridges to be rebuilt. Caltrans wanted to raise the railroad to meet current highway clearance standards.

The existing structures' clearances were between 14 and 15 feet in height. Directly to the north of Mission Boulevard was Union Pacific Railroad's Warm Springs Yard. This railroad yard supported commerce from the port, as well as freight shipments to its neighboring NUMMI automotive plant.

Directly to the South was a small yard leased to a railroad tenant operating a railcar storage and rail transload business. The business shipped used oil, food products, racing fuel, and plastic granules used for computer chip manufacturing in nearby Silicon Valley.

At that juncture, Caltrans and ACTA were not able to understand the railroad operator's needs, nor find a way to solve the engineering challenges. They put Phase 2 on hold.

VTA met with Caltrans and ACTA to discuss the BART to Silicon Valley Project in concept. VTA's project requirements overlapped with the requirements of the Phase 2 efforts. Since VTA was a railroad operator, it understood the engineering constraints and how to solve them to the satisfaction of the railroad and the needs of Caltrans.

Raising the two railroad yards, while keeping each operational was not a viable option. The solution was a compromise. Lowering Mission Boulevard and raising the railroad while maintain operations and allowable grades. The project was completed and accepted by all stakeholders.

The two existing single-track railroad bridges were replaced with a two-track bridge and lengthen to accommodate widening of Mission Boulevard. The transload railroad yard was reworked from a three-track configuration to a longer two track configuration.

Warren Avenue was parallel to Mission Boulevard and to the south and connected to the driveway access for the transload operator's yard. VTA's future BART transit project required Warren Avenue to be grade separated, severing access to the transload facility. The solution was to build three new bridges across Warren Avenue. One bridge for UPRR double track operations and to support truck traffic to the transload facility. A third bridge would be constructed for two future BART tracks.

FIGURE 3 – Nearly Completed Warren Avenue Grade Separation

Kato Road

In April 2013, the Kato Road Grade Separation Project was completed. It is the first of 11 grade separations to be completed as part of the 10-mile Berryessa Extension. Construction crews began efforts to grade separate in Fall 2011. The project required a partial road closure of Kato Road in Fall of 2011 and eventually

a full road closure in Summer 2012. Spring of 2013 marked the official end of the grade separation construction and the re-opening of Kato Road.

The Kato Road Project was a typical grade separation project with a few extra features that are noteworthy. Kato Road was one of a few cross-connection roads between Interstate 880 and Interstate 680 within several miles of Mission Boulevard. These were important to the local area because in these locations both freeways were relatively close to each other.

Like Warren Avenue, prior to the improvements, Kato Road was an at-grade crossing for the twin 60-feet wide rail corridors. Railroad tracks residing on VTA's property were removed and then constructed on the remaining Union Pacific Railroad Property. The roadway was depressed, and the rail corridor remained relatively at the original track profile elevation.

VTA would construct a two-track bridge for the future BART alignment. The BART tracks would be centered along the property, and 10-feet wide utility corridors resided to each side of the future BART tracks. Both utility corridors were improved with compacted earth access roads. Because the accesses used to connect to Kato Road, VTA would need to replace access which was removed by the grade separation.

Along the Western edge of the property, VTA constructed a new access road bridge, which would be the second bridge across Kato Road. The third bridge was the Union Pacific Railroad's two track bridge structure.

FIGURE 4 – Nearly Completed Kato Road Grade

Along the Western edge, VTA purchased access easements across properties to either side of the grade separation. The access roads and utility corridors held several utilities, including two petroleum pipelines and infrastructure for several different fiber optic carriers.

Track Removal and UP Realignment

In addition to the track removal and UP realignments for Mission Boulevard, Warren Avenue, and Kato Road - VTA had two more noteworthy rail modification efforts.

Union Pacific Railroad served 6 shippers to the south of its Warms Springs Yard. One was the trans-load yard at Warren Avenue. There were three shippers in City of Milpitas, just north of Montague Expressway. These three businesses produced recycled cardboard products, olive oil, and wood pallets. In San Jose, south of Montague Expressway, there were two shippers. One was a distiller, and the other transported hazardous waste.

VTA hired a railroad business agent to study all six businesses. VTA was interested in severing railroad connections to these businesses, if it was fiscally responsible, and if the businesses were willing.

VTA had negotiated with the two shippers in San Jose. They were willing to change their operations from rail shipping to truck shipping - for fair and reasonable prices. With Union Pacific Railroad's assistance, trackage rights South of Montague Expressway were removed. VTA then removed the railroad tracks to make room for future BART. Freight railroad operations were no longer necessary.

Why did VTA decide to purchase and remove trackage rights? There was only a single railroad corridor to the South of Montague Expressway. The cost of construction freight railroad adjacent to a two track BART configuration, which also had operational utility corridors, was a large factor. The single 60-feet wide corridor wasn't wide enough. The areas to either side of the railroad corridor were already completely developed.

VTA entertained partnering with others to remove trackage rights in Milpitas. But there was not enough interest. Those businesses are still in operation and still ship by rail.

UPRR Milpitas Industrial Lead Relocation and Bridge Over BART

One of our final challenges was caused by moving Union Pacific's operations off from VTA's property along the east alignment, and onto Union Pacific's property on the alignment to the west. Union Pacific's major operations ended very close to Montague Expressway at the Milpitas Yard. This facility had one spur, which lead to the three Milpitas shippers located to the east. The future BART tracks would cause the spur to be severed.

To mitigate this issue, VTA grade separated BART from the crossing Union Pacific spur track. Because BART tracks could be designed with a 3% profile grade, VTA decided to lower the BART tracks in a trench and build a new railroad bridging structure for Union Pacific Operations. This structure essentially contained BART in a box culvert below the freight track at this separated crossing structure.

Logistics to move a dozen adjacent utilities, keep the shippers' businesses running, and keep the utilities and nearby City streets operational was also challenging. Luckily the UP and the City allowed VTA to shoo-fly track operations temporarily along Piper Drive, until the grade separation facility could be completed.

The team requested UPRR approval of a 10-degree curve for the permanent Milpitas Industrial Lead over BART Tracks and an at-grade crossing of parallel Piper Drive. This resulted in significant savings for a shorter bridge structure over BART and a shorter at-grade crossing with a better crossing angle at Piper Drive. The design team agreed to construct this curve with concrete ties to gain UPRR approval.

A retaining wall was required to construct the Milpitas Industrial Lead parallel to the BART tracks and a shopping mall access road. The design build team worked with UPRR to gain approval for T-Wall retaining wall for this location which resulted in savings of time and money

FIGURE 5 – UPRR Industrial Lead over BART, Concrete Ties 10-Deg. Curve

FIGURE 6 – T-Wall

COMMUNITY BENEFITS

As with all public transit projects there are additional benefits brought to the communities beyond transportation choices for the residents of the Cities and Counties where these projects are planned and constructed. The Berryessa extension is no different, some of the planned improvements which enhance the community's quality of life include:

Natural Habitat Restoration

When building a project of this size, protecting natural resources including water, soil, plants and wildlife, is paramount. Three significant environmental mitigation projects were completed as part of the Berryessa Extension Project. In San Jose's Alum Rock Park, work was done to remove a fish barrier, expand a floodplain, repair erosion, remove non-native vegetation and improve the overall habitat for steelhead fish. Work was also done to preserve a 1930's historic bridge. In addition, trash was removed from the Upper Penitencia Creek, which passes through the Berryessa Transit Center. This area has now been transformed into a picturesque habitat that includes a meandering floodplain populated by ducks and native plants. It is also conducive to growing the native fish population. Finally, an 8-acre mitigation site at Wrigley Creek in Milpitas was established. At the site, fish and wildlife habitat were enhanced, storage capacity for flood waters was created and special status plant species, such as the Congdon's tar plant, were replanted.

Flood Control

In addition to crossing roadways, the Berryessa Extension Project crosses 10 large creeks. Improvements to these creeks, including re-engineered banks and concrete box culverts, were constructed to help protect the community and the BART system from future flooding. Berryessa Creek, which experienced major flooding in 1982, 1983 and 1998, was widened and re-engineered in two separate locations to increase flow capacity and eliminate sharp curves. The benefits of these improvements were realized in 2017, when the areas with improvements avoided flooding during historical rainfall levels.

Grade Separations

BART is a "fully grade separated system," meaning that the trains travel under or over every major intersection. This makes the BART system efficient because there is no need for trains to stop at intersections. It also allows vehicles, bicycles and pedestrians to safely cross over or under the train tracks. A total of 11 grade separated intersections have been completed as part of the Berryessa Extension Project. In Milpitas, BART trains will travel under Dixon Landing Road, Montague Expressway and Capital Avenue; and, in San Jose, they will travel under Trade Zone Boulevard, Hostetter Road and the Sierra Road/Lundy Avenue intersection. The last mile of the Berryessa Extension Project is elevated above ground. The tracks begin to rise just north of Berryessa Road, are elevated at the Berryessa station and travel over Mabury Road.

New and Improved Roadways

As part of the Berryessa Extension Project roadways were also added, extended or enhanced around the new transit centers to address traffic and provide convenient, direct access to station parking and pick-up/drop-off areas. For example, South Milpitas Boulevard, which was extended from Montague Expressway to Capitol Avenue at the Milpitas Transit Center, provides an additional point of access to the Milpitas BART Station, provides new access for development in the area and alleviates traffic congestion at the Great Mall Parkway/Capitol Avenue and Montague Expressway intersection. Montague Expressway was also widened with an additional lane for both east and west bound traffic which will alleviate congestion in the area for commuters. Berryessa Station Way was newly constructed through the center of the Berryessa Transit Center. This new roadway will reduce traffic impacts on Berryessa and Mabury roads.

New Transit Centers with BART Stations Spur Redevelopment

FIGURE 7 – Transit Oriented Development at Stations

As the project has evolved and moved forward both the City of Milpitas and San Jose have created transit specific plans and re-zoned the areas around the new stations.

Adjacent to the Milpitas Transit Center you will see hundreds of new, high-density housing units, as well as office space, hotel rooms and retail space recently built or under construction.

The City of Milpitas paved the way in 2008 with adoption of the Milpitas Transit Area Specific Plan. In the plan, approximately 437 acres of previously zoned industrial land was slated for redevelopment and uses that better support a major transportation hub.

The plan calls for 7,109 units of housing; 993,843 square feet of office space; 340 hotel rooms; and, 287,075 square feet of retail space centered around the new BART Station and VTA Light Rail.

The area surrounding the Berryessa Transit Center exhibits the redevelopment potential there also, with new housing and new employment opportunities replacing less intensive land uses.

The station is adjacent to the expansive Berryessa Flea Market and parking lots that include land on both sides of Berryessa Road. The Flea Market has been rezoned as a Planned Development Zoning District. Currently, single-family homes and apartments have been developed on a portion of the land north of Berryessa Road. Higher density, mixed use development is anticipated closer to the new station.
The City of San Jose is also expected to initiate an Urban Village Study and workshops later this year for the area. San Jose defines an urban village as a walkable, bicycle friendly, transit-oriented, mixed use, high density setting that provides both housing and jobs.

INNOVATIONS

Lightweight Cellular Concrete (LCC)

FIGURE 8 – Aerial Photo Berryessa Aerial

The alignment near the south end of the project crosses Berryessa Road and Mabury Road via an elevated structure, which also ties into the Berryessa Station. The RFP document considered Mechanically

Stabilized Earth (MSE) Wall approaches at Berryessa Road and Mabury Road. The underlying soils consisted of generally stiff clay with sand and is subject to limited local liquefaction settlement. As the team began looking at the MSE approaches, limited right-of-way and performed further geotechnical exploration it became apparent that the overburden when surcharging the existing ground with the compacted backfill, initial settlement was estimated to be up to eleven (11) inches at the center. The concern with this settlement was the potential drawdown and adverse effect this could have on the nearby residences and utilities.

Several design mitigation options were vetted, those included additional aerial structure and Lightweight Cellular Concrete back fill. The idea of additional aerial structure reducing the length and height of the MSE approach for both the Berryessa approach and Mabury approach were vetting and estimated by the Design-Builder SSH. Because of the cost and the impact to the schedule this approach was quickly set aside.

Ultimately after several meetings and studies an approach of using the Lightweight Cellular Concrete as the backfill for the MSE panels in lieu of soil was selected. The selection of this design and approach was made because the time needed to reach full consolidation prior to placing track structure and the overall settlement was reduced to a point that the potential for damaging settlement to the nearby residence as nearly zero.

The SSH Builder selected Group Delta a geotechnical consultant with experience in the LCC MSE approach. Group Delta's first assignment was to review the soil characteristics and the settlement calculations performed by Parikh which indicated significant settlement with the standard MSE approach. Group Delta performed this and provide a report with their analysis May 21, 2014 with a revision dated July 8, 2014 which incorporated BART, VTA and Parikh review comments.

This revised settlement analysis utilized two methods a 1D simplified analysis and then a 3D analysis for two scenarios based on the simplified 1D calculations. The calculations show a settlement of up to three

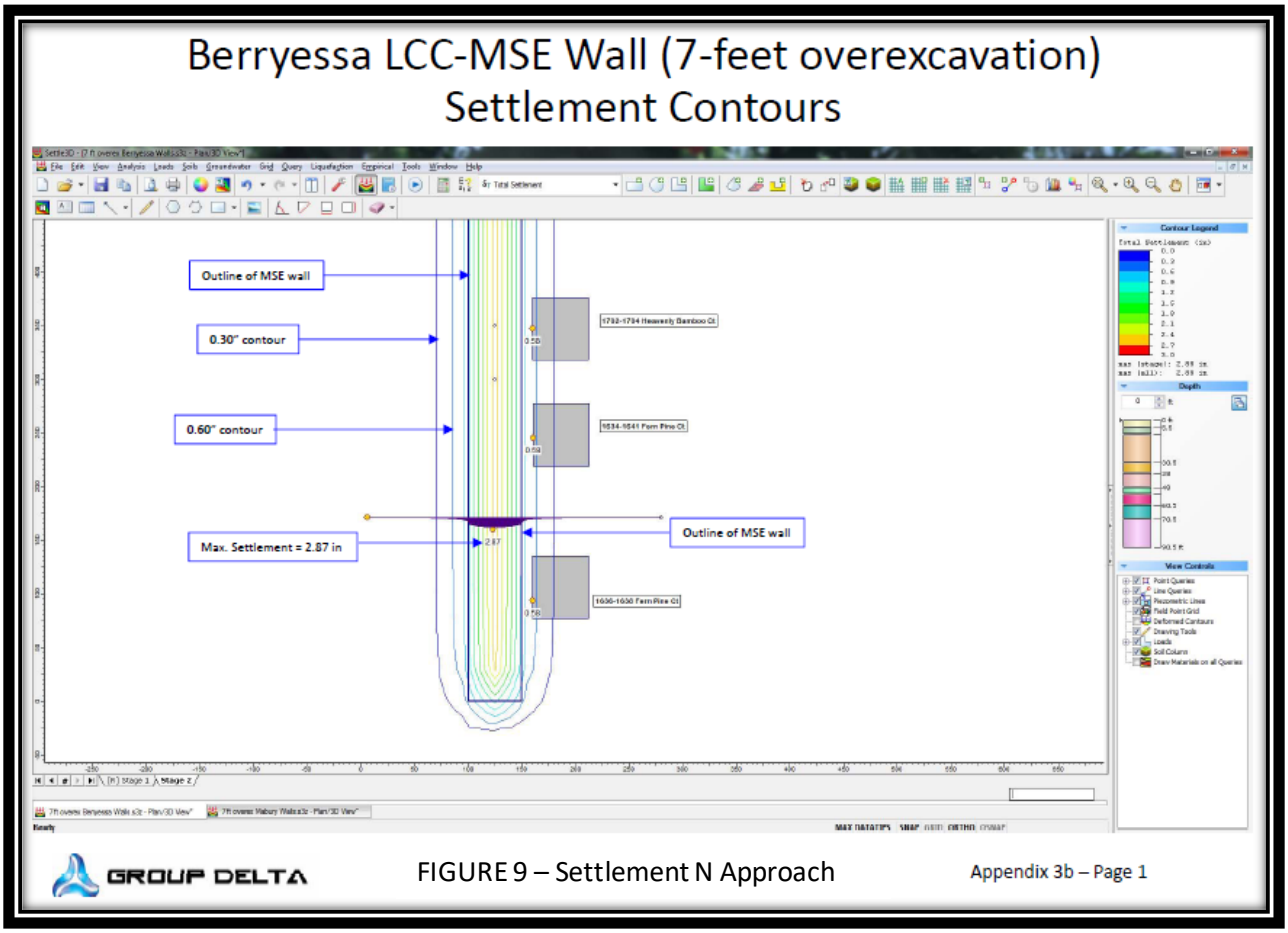

FIGURE 9 – Settlement N Approach

(3) inches and one (1) inch anticipated under the center of the Berryessa and the Mabury MSE walls, respectively.

From this settlement analyses it was recommend that the insitu material be over excavated to a depth of 7 feet below the existing ground and replace with LCC to reduce the overburden and increase the reduction in settlement. With this analysis in place the MSE design commenced utilizing the LCC, shop drawings were prepared and civil design elements such as track drainage, train control and traction power were coordinated with MSE straps and LCC.

One significant design element was the north approach required that both vibration and noise mitigation measures were provided atop of the MSE approach. Per the EIR this area of the guideway was to include a floating track slab to mitigate BART train vibration and wheel noise. Because of this additional load of the concrete floating track slab. Concerns over the interaction of the slab with LCC vs. select backfill material during a seismic event were voiced. Group Delta further provided a FLAC Analyses of the MSE, LCC structure including the introduction of loads for the floating track slab.

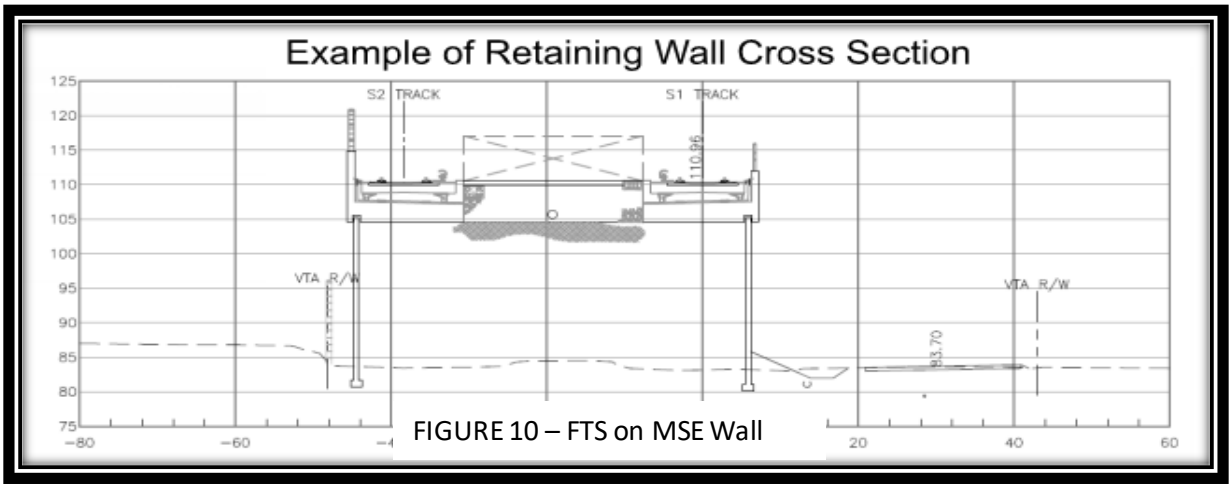

FIGURE 10 – FTS on MSE Wall

FLAC version 7.0 was utilized to analyze a cross section, including subsurface materials to a depth of 140 feet, MSE embankment utilizing LCC and the concrete floating track slab. Taking a conservative approach, the analyses focused on the tallest section of the approach embankment. Live loads were included, per VTA and incorporated into the dynamic analyses.

Vibration Mitigation.

A total of up to 172 single-family and 40 multi-family buildings consisting of 171 residences along the alignment would be affected without vibration mitigation. *(1)*

Two track form types were utilized for vibration mitigation. Tire derived aggregate (TDA) and floating slab track (FST) with a design frequency of 8 Hz were recommended for vibration mitigation for the residences affected. *(1)*

Floating Track Slab

The floating track slab was employed in other areas along the alignment to mitigate ground borne vibration. Per the contract a mock-up and testing were required. The design criteria for the floating track slab was as follows:

1. Floating slab track design shall consist of ballasted track on a pre-cast concrete bathtub supported on natural rubber resilient pads over the invert base slab. The size of the natural rubber pads shall be 12" diameter x 3.25" thick, with a 3.5" diameter hole. floating slab track system shall be designed to achieve a 7.5 Hz (maximum) resonant frequency.

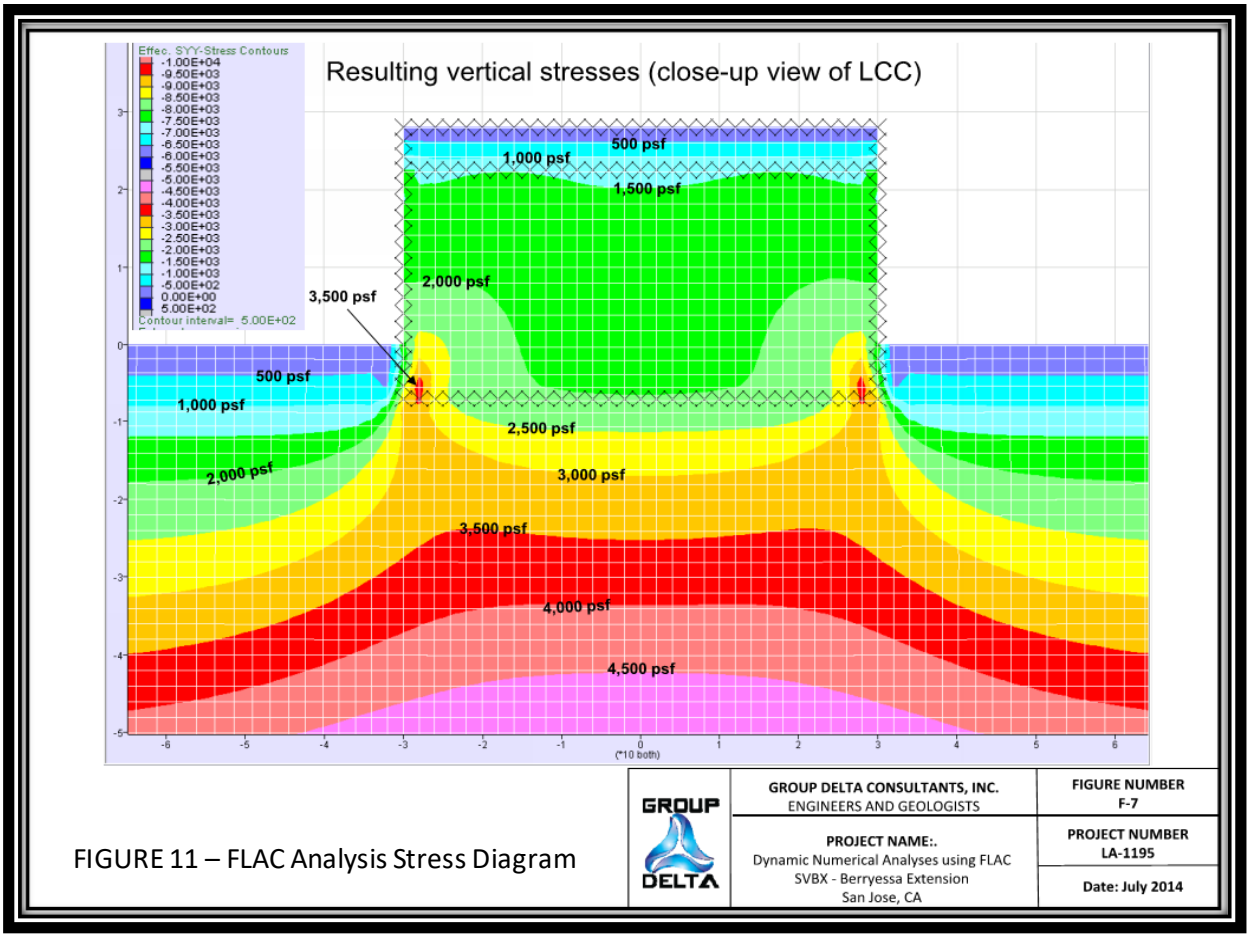

FIGURE 11 – FLAC Analysis Stress Diagram

2. The minimum length of the pre-cast bathtub shall be approximately 12' – 6" and shall be designed to allow for the removal of one ballasted floating slab track while the adjacent track remains in revenue service. The minimum compressive strength of the pre-cast bathtub units shall be Class 5000-psi concrete. The minimum compressive strength of the supporting stem wall shall be Class 4000-psi concrete.

This extension included 9,387 feet of double track floating track slab, including the approximately 970 feet on the MSE approach to Berryessa Road.

Tire Derived Aggregate

At the time of design, TDA had only been installed at VTA's Vasona Light Rail Line and Denver's TREX Light Rail Line. The TDA installation on the Vasona Line demonstrated successful vibration attenuation.

VTA performed further TDA testing on its Vasona LRT to evaluate attenuation effectiveness and durability. The study concluded that the use of TDA as underlayment beneath ballast and tie track to mitigate vibration was both practical and viable. *(2)* The tests also concluded that the TDA was superior to ballast mat but not as effective as floating slab track. A peer review also concluded that the TDA installations were effective

in reducing vibration. *(3)* For this project the 5,050 feet of double track TDA consists of a 12-inch layer of shredded tires placed below 12 inches of ballast and 12 inches of subballast. See Figure 13 below.

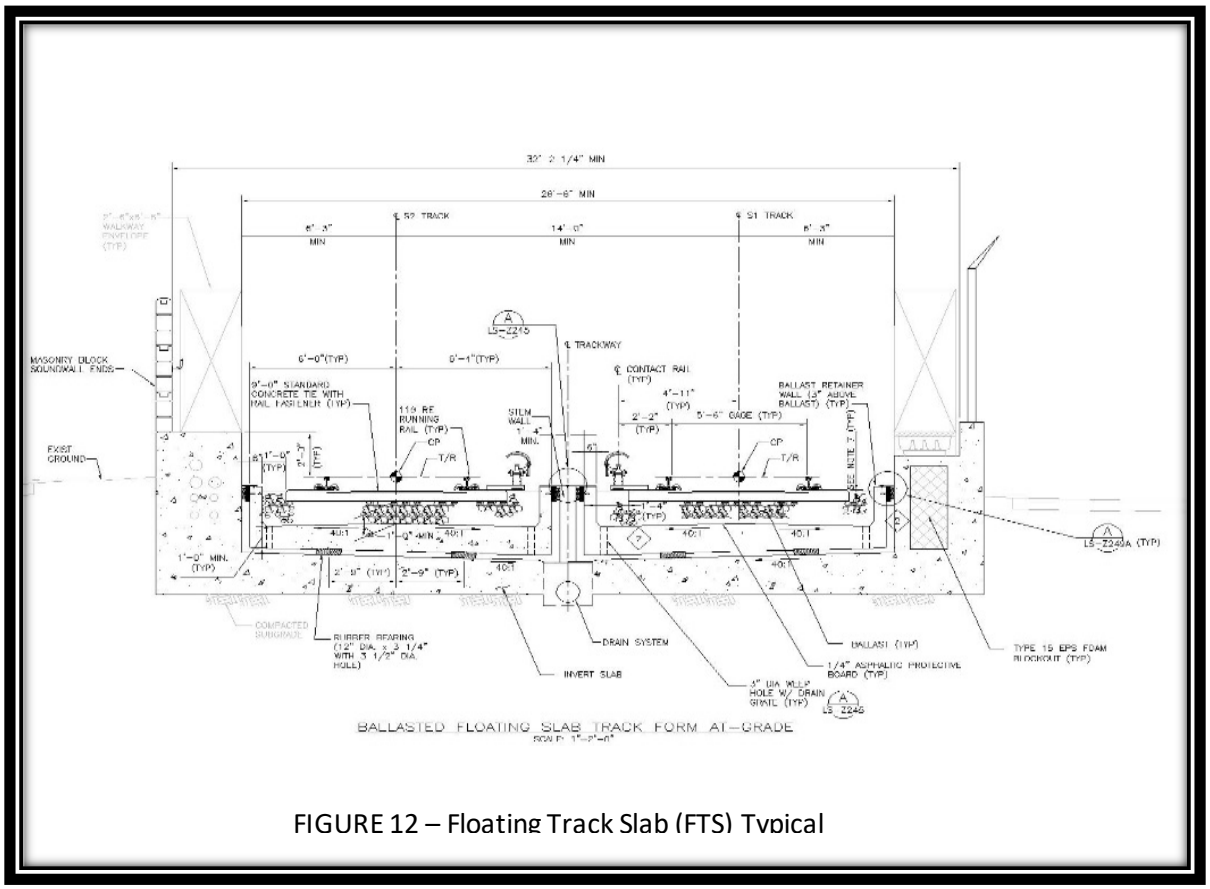

FIGURE 12 – Floating Track Slab (FTS) Typical

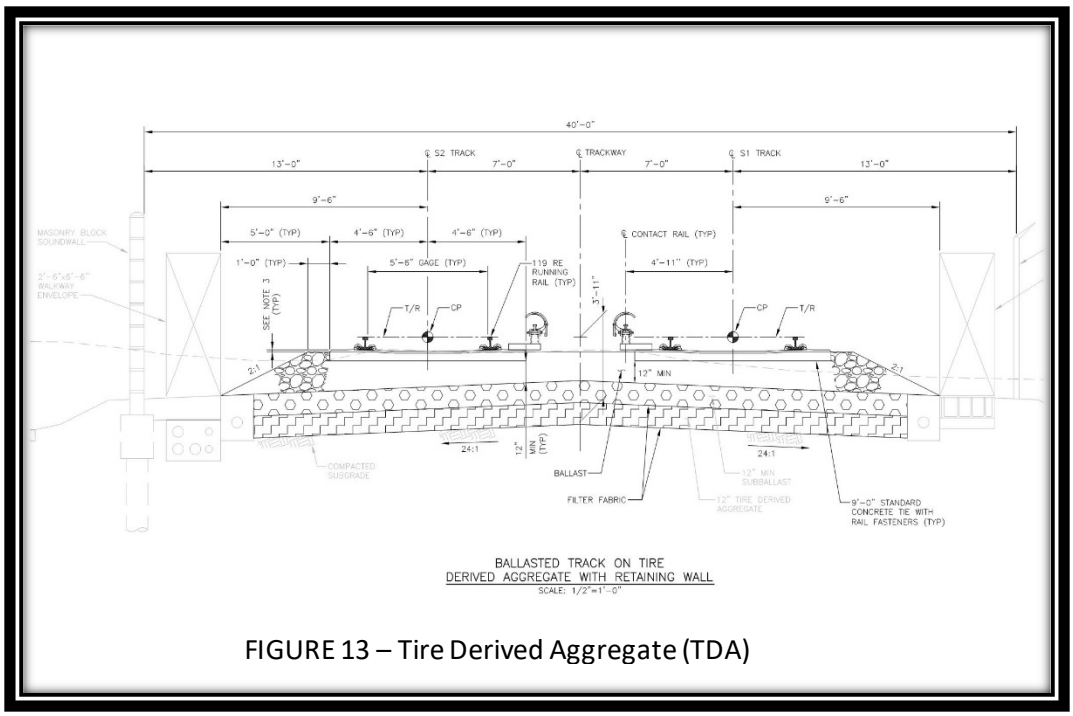

FIGURE 13 – Tire Derived Aggregate (TDA)

ACKNOWLEDGEMENTS

- Santa Clara Valley Transportation Authority (VTA)
- Bay Area Rapid Transit (BART)
- Union Pacific Railroad
- Alameda County
- Santa Clara County

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(1) BART Silicon Valley Second Supplemental Environmental Report (SEIR)
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List of Figures