VTA's BART Silicon Valley Phase II Extension Project
Twin Bore Update
Executive Summary

BACKGROUND:

As a follow up to previous discussions and requests about the twin bore made by the public and Board members, VTA initiated a Twin Bore Update in Summer 2024. This analysis was implemented through experienced subject matter experts versed in tunnel and underground station design, risk management, and construction of large transit infrastructure projects. Previous work on the twin bore was paused in 2008 at a 65% level of design.

The primary focus of this work includes review of the previous twin bore design and evaluation of the necessary updates required due to changes in codes, standards, design requirements, and project corridor. This was followed by development of an updated twin bore construction cost estimate, reflecting current market conditions, quantities, and recent industry trends.

EXECUTIVE SUMMARY:

Reverting the design of VTA's BART Silicon Valley Phase II Extension (BSVII) to a twin bore tunnel configuration would increase the cost by as much as $600 million and would not allow the extension to open earlier than the current projected revenue date of 2037. The twin bore design would also require extensive, and impactful cut and cover construction in Downtown San Jose. These findings are a result of an updated cost, schedule, and impact analysis based on the previous 2008 twin bore design, updated to reflect modern codes and standards. Independent reviewers provided important comments and critiques of this updated analysis. However, these comments do not change the overall conclusion of the analysis.

VTA staff continue to look for cost savings to close the project's funding gap but will not recommend any further analysis of the twin bore design.

DISCUSSION:

Twin Bore Update Background

In Summer 2024 Mott MacDonald/PGH Wong (MMW), VTA's General Engineering Consultant, began preparation of a *Twin Bore Estimate Update* (Attachment A). This effort was supported by development of an independent risk evaluation by Aldea Services (Attachment B), including preparation of top risks, and a technical review of the twin-bore and single bore configuration by Bechtel (Attachment C). Findings from these concurrent efforts further indicate the challenges of a twin bore configuration, including risks associated with large scale excavations, construction in difficult ground conditions, and advancements in large tunnel technology to deliver projects across the world. These three firms worked independently, and with their combined efforts provided a comprehensive assessment of the twin bore configuration in relation to the current single bore project being advanced.

Key areas evaluated as part of the Twin Bore Estimate Update included:

- Review of the 2008 twin bore design, which was paused at the 65% design completion level
- Evaluation of the necessary updates to the previous twin bore design due to changes in codes, standards, and design requirements since 2008
- Incorporation of any recent updated designs for non-tunnel project elements (i.e. Newhall Yard)
- Review of construction, contract packaging, and delivery models to inform schedule
- Development of a summary construction schedule, including the necessary durations for any additional environmental clearance work, design, and preparation of procurement documents
- Preparation of a construction cost estimate, with assumptions for appropriate contingency levels, current market conditions
    - The construction cost estimate covered all construction costs for the program, in order to capture cost changes, positive and negative, required to adapt stations, systems, yard, and other facilities to the twin bore configuration.

Twin Bore Configuration Considerations

The twin bore configuration would consist of two tunnels, approximately 20 feet in diameter, each containing a trackway for BART trains. Stations would be constructed through a cut-and-cover method for the three underground stations, and the entire route would require cross passages connecting the two tunnels for emergency egress purposes. Below are key design and construction considerations addressed in this report and analysis:

- **Cross Passages:** The two tunnels would be connected by thirty-three mined connections to allow passengers to evacuate a train or a tunnel in an emergency. Construction of these cross passages may require ground improvement from street-level or from within the tunnel
- **Mid-Tunnel Ventilation Facilities:** Two structures, near 13th Street and along Stockton Avenue, would be required for emergency ventilation. These would also be constructed through a cut and cover method
- **Cut and Cover Construction for Underground Stations:** The 28th Street/Little Portugal, Downtown San Jose, and Diridon Stations; and the Downtown San Jose track crossover would be constructed through a cut-and-cover method (further details below)

For the twin bore configuration, both the Downtown San Jose and Diridon stations would have unique considerations described below:

- **Downtown San Jose Station:**

  Construction of the Downtown San Jose station structure would span approximately 1,500 feet or about four city blocks along E. Santa Clara Street between Market and 4th Streets including three major intersections, two of which run VTA's Light Rail (1st and 2nd Streets). Impacts to light rail operations are anticipated with bus bridges required; this longer length is due to the operational requirement of a cross-over needed adjacent to the station.

One of the first construction phases would relocate extensive utilities around the station footprint between Market Street and 4th Street to ensure any underground utilities are cleared before major construction can commence. Once utilities are relocated, excavation would begin.

Due to the scale of the work and limited width of Santa Clara Street, the excavation would be executed in a “block by block” approach, whereby the contractor would close the full width of Santa Clara Street for a block and/or a block and an intersection at a time to allow for installation of the deep support of excavation (SOE) walls (approximately 140’) and temporary traffic decking, upon completion of work in a given block and/or block and intersection, vehicular traffic would be reinstated and the work would progress to the next block and/or block and intersection. The process would be repeated until decking was completed for the entire station length, at which time Santa Clara Street would be fully open to vehicular traffic. This approach was selected to allow for the safe and efficient operation of large equipment, reducing the number of changes in traffic re-routing (when compared to a lane-by-lane closure approach) and deterring contractors from applying additional construction risks.

After completion of tunneling and station construction work under the decking, the process would be repeated in reverse to restore Santa Clara Street to its final condition.

- **Diridon Station:**

The Diridon Station would be located just south of W. Santa Clara Street, outside public right-of-way, between Barack Obama Boulevard and White Street. This would require a portion of the station box to be located below the existing Diridon Caltrain tracks, which would necessitate a “jacked box” construction approach for this work. This would involve widening the Diridon station excavation on either side of the Caltrain tracks, to accommodate launch and receiving “pits” utilized in the jacking operation. Precast concrete box segments would then be jacked from the launch pit under the tracks to a stage of completion before the TBMs arrived. The TBMs would then subsequently ‘walked through’ the open excavation and box structure. After tunneling, the station's permanent concrete structure would be built abutting the end of the jacked box to form the final station box.

Schedule and Contract Delivery

Three major heavy civil construction design bid build contracts would be utilized to build the twin bore configuration – (1) East Portal to Downtown San Jose (2) West Portal to Downtown San Jose and (3) Downtown San Jose Station. Dividing this work into three contracts was determined as the optimal approach to ensure contract sizes were not too large, increase competition, and allow for the time-critical construction of the Downtown Station to progress independent of the tunneling work.

The design for twin bore was paused in 2008 at an approximate 65% level, it would require substantial updates before being ready for issuance in procurement documents. The time required to develop this design, along with the time necessary to complete environmental clearance work, prepare three major heavy civil construction procurement documents, issue and award contracts, would be approximately three to four years before heavy construction could begin in 2029, with utility relocations commencing one year prior in 2028. If all major contracts can be awarded and issued in 2029, revenue service would be anticipated in late 2037, though this date does not include any contingency or schedule reserve.

Cost Findings Summary

The estimate prepared by MMW **only** includes elements related to construction, i.e. FTA Standard Cost Categories (SCC) 10 to 50 and allocated contingencies to account for potential changes in quantities as design is advanced. The estimate **excludes** costs associated with right-of-way, vehicles, professional services, finance charges, and unallocated contingency (risk, unknowns, etc.).

The table below summarizes the cost findings of this report in comparison to the respective items in the BSVII project estimate of $12.7B included in the FTA New Starts Engineering acceptance.

Description	Large Single Bore (FTA New Starts Engineering Estimate)	Updated Twin Bore 2008 Design*
Base year direct cost (SCC 10-50)	$5.023B	$5.415B
Allocated contingency	$1.004B	$1.192B
Base year, with allocated contingency	**$6.027B**	**$6.607B**
Escalated to 2029 (assumed start of twin bore construction)	N/A	$7.848B
Year of Expenditure (YOE), with allocated contingency	**$7.281B**	**$8.872B**

*MMW Twin Bore Cost Update Report, August 2025

Twin Bore Risk Analysis

Summarized below are the top ten risks for the twin bore configuration, as identified independently by Aldea:

1. Project cost and schedule risk due to adjacent stakeholders' reactions due to construction impacts from the Twin Bore station excavations
2. Risks to project due to greater than anticipated time to update the 2008 design to achieve seismic code compliance
3. Risk of additional cost growth (beyond Class 4 ranges) from the 2024 estimate due to lack of design completeness (latest TB estimate is Class 4 which can range from -15% to +50%).
4. Risk of damage to the Caltrain electrified tracks at Diridon station occurs during the jacked-box operations due to TB station geometry reconfiguration (changing to Diridon North configuration).

5. Cross-passage construction, unable to proceed in parallel to TBM tunneling delays project completion due to installation delays resulting from worse than predicted ground conditions
6. Cut and cover station boxes expand beyond the area defined in the base estimate due to late changes in spacing requirements
7. Construction costs and schedule impacted due to surface-applied ground treatment for cross-passages being more than anticipated in base estimate
8. Risk of cost, schedule and reputational damage from surface street interruption due to street decking of E Santa Clara St. for San Jose Downtown Station exceeding planned durations.
9. Additional construction costs due to extensive monitoring and instrumentation of existing buildings required beyond that established in preconstruction specifications/design.
10. Risk of schedule delays due to limited number of TBM Manufacturers capable of producing 2 ea. 17-'10"' ID. and 2 ea. 18'-10" ID EPB machines (4 TBM's) within a short timeframe.

Review by VTA BSVII Oversight Committee Subject Matter Expert Gall Zeidler

An initial draft *Twin Bore Estimate Update* report was first provided to VTA in September 2024. It should be noted as this report was produced last summer (2024), it does not include any of the ideas developed as part of the Level 1 & 2 Cost Savings or Level 3 Tunnel Task Force work.

In September 2024, the draft report was transmitted to VTA's BSVII Oversight Committee Subject Matter Expert Gall Zeidler (GZ) for review with observations and feedback received in May 2025 (Attachment D). Subsequently, VTA prepared a memo (Attachment E) providing responses summarizing GZ's observations into the following major categories as described below:

- General
- Design Criteria and other Technical Requirements
- Construction Schedule
- Other Station and Tunnel Configurations
- Recent VTA Cost Saving efforts

A summary of some of major comments from GZ and VTA's response and position are outlined below:

Topic	GZ Comments/Observations	VTA Response/Clarification
Downtown San Jose Station Construction	Suggest use of partial street closures (lane by lane)	Utilize a "block-by-block" approach, to ensure adequate space is available for safe and efficient operation of equipment and installation of 140' slurry walls. Using the partial street closure approach would most likely increase risks and therefore costs while also extending construction duration

Topic	GZ Comments/Observations	VTA Response/Clarification
Design Level	Assume design is about 80% to 85% complete	Design was paused in 2008 at an ~65% level, and would require substantial redesign to bring up to current codes and standards adding time to the schedule
Design Criteria/Assumptions	Concerns over design additions that are not strictly required	Considered necessary updates to design due to changes in codes and standards
Contract Packaging and Delivery Methods	Recommend reviewing contract package size and delivery methods to further optimize schedule	For purposes of study, assumptions made based on industry experience and familiarity with BSVII project specific considerations. The schedule also reflects the time necessary to complete environmental clearance work, advance design, prepare three major heavy civil procurement documents, support the federal funding process including receipt of an FFGA, prior to award of the major contracts.
Construction Schedule	General commentary on durations of various activities and schedule including assuming an earlier start to tunneling.	Developed "conservative but reasonable" assumptions to inform schedule including the necessary time required for all the pre-activities (design, development of contract documents, procurement, etc.) required to allow for major construction to begin in 2029.

Following receipt of VTA's responses, GZ submitted a final Memorandum (Attachment F) providing follow up commentary and clarifications.

In response to GZ's feedback, MMW updated their report to include an Executive Summary providing clarifications, including noting that many observations involving contract packaging, delivery methods, and design variations can be further evaluated if the twin bore configuration were to be advanced. However, for the purposes of this report, any updates would only nominally change the findings and not substantially decrease the overall costs.

Conclusion:

Based on these findings, the twin bore configuration would cost significantly more when compared to single bore configuration currently being advanced due to:

- The additional time required to redesign, reprocure, conduct the necessary environmental work, and obtain necessary approvals before construction could commence
- Design updates necessary from addressing new codes and standards, which in turn address real risks associated with the twin bore
- Extensive excavation required for the three underground stations including major disruption to the downtown community, businesses, and transit customers for the Downtown San Jose Station

VTA staff will continue to look for cost savings to close the project's funding gap but will not recommend any further analysis of the twin bore.

NEXT STEPS:

Findings of this analysis, along with observations and comments received from VTA's BSVII Oversight Committee Subject Matter Expert Gall Zeidler, will be presented at the August VTA BSVII Oversight Committee Meeting.

Attachments:

A – MMW Twin Bore Estimate Update
B – Aldea Twin Bore Risk Analysis Memo
C – Bechtel Twin-Bore vs Single, Large-Bore Tunnel Configuration Technical Review
D – Draft GZ comments on Draft Twin Bore Estimate Update
E – VTA Response to GZ comments on Draft Twin Bore Estimate Update
F – Final GZ Comments on Draft Twin Bore Estimate Update

Attachment A

VTA's BART Silicon Valley Phase II Extension Project

General Engineering Consulting Services

Twin Bore Estimate Update

Revision C
August 6, 2025

MMW TEAM
MOTT MACDONALD
WONG ENGINEERING

Revision History

Rev	Date	Revision Details	Revised by
A	August 22, 2024	Draft Issue	Michael Burnson
B	September 25, 2024	Update to Lower Silver Creek Fault Discussion	Michael Lehnen
C	August 6, 2025	Executive Summary Added & Other Updates	Mark Ramsey

Prepared by

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Tunnel and Heavy Civil Estimator

Reviewed by

Mark Ramsey
Tunnel and Heavy Civil Advisor

Approved by

Michael Lehnen
GEC Project/Engineering Manager

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Abbreviations

Abbreviation	Definition
BART	Bay Area Rapid Transit District
BFS	BART Facilities Standards
BOH	Back-of-house
BSVII Project	VTA's BART Silicon Valley Phase II Extension Project
DBB	Design-Bid-Build
DCM	BSVII Design Criteria Manual
DTSJ	Downtown San Jose
IDS	Interim Design Submittal
MMW	Mott MacDonald/PGH-Wong Joint Venture
NYMF	Newhall Yard and Maintenance Facility
PMT	VTA's Program Management Team
ROM	Rough order-of-magnitude
SEIS/EIR	VTA's 2018 Supplemental Environmental Impact Statement/Environmental Impact Report
SVBX	VTA's Silicon Valley Berryessa Extension
TBM	Tunnel Boring Machine
VTA	Santa Clara Valley Transportation Authority

EXECUTIVE SUMMARY (AUGUST 2025)

This executive summary has been added to the September 25, 2024, revision of the Twin Bore Estimate Update to address general comments and feedback provided by VTA's BART Silicon Valley Phase II (BSVII) Oversight Committee Subject Matter Expert.

This Twin Bore Estimate Update was developed in 2024 dollars and escalated to year of expenditure dollars, after an evaluation and incorporation of the necessary updates to the previous 2008 twin bore design. This analysis was not intended to be comparative to other estimates or other configurations, as this was a stand-alone estimate update.

The Twin Bore Estimate Update was developed in the summer of 2024 and finalized in August 2024 prior to VTA initiating their Level 1, 2, 3 Cost Saving effort which the entire Project Team was engaged with. As such, this report does not reflect any approved cost saving concepts that could potentially be incorporated into the twin bore configuration.

Assumptions made within the Twin Bore Estimate Update regarding procurement strategy and contract packaging for a twin bore configuration with three cut-and-cover stations were made to provide a basis of the estimate and the schedule. The contract packaging scope, in particular, was adjusted in the Twin Bore Estimate Update to account for schedule considerations with construction of the Downtown San Jose Station being the primary driver for the critical path.

Schedule assumptions were made to account for the time needed to conduct environmental clearance, update and finalize design, procure contracts, and obtain the Full Funding Grant Agreement before contract award. The assumptions for the procurement strategy and contract packaging should be considered conceptual for the purposes of this analysis and if this configuration were to advance, would need to be further evaluated, particularly in relation to market trends at the time of procurement.

While some of the production rates and schedule durations may be considered conservative by others, the durations used for the Twin Bore Estimate Update have been based on industry experience and recent similar projects. If this configuration were to be further advanced, additional schedule optimizations may be considered as additional information becomes available (including industry input, market conditions at time of procurement, alternative technical concepts from contractors, etc.).

The Twin Bore Estimate Update only utilized relevant design criteria deviations that had previously been agreed to with BART. The GEC recognizes that there may be other design criteria deviations that could be considered for potential cost savings; however, would require further technical analysis if this configuration were to be advanced.

1 INTRODUCTION AND PURPOSE

The purpose of this current Twin Bore Estimate Update (Update) is to review and update as necessary the BART Silicon Valley Phase II Extension (BSVII) Project's twin bore/cut-and-cover station configuration to include reflection of current market considerations in the industry post-COVID-19 pandemic. This report, supporting documentation and back-up materials are being prepared at the direction of the Santa Clara Valley Transportation Authority (VTA). The following background information and figures are provided to give the reader a historical context and background on the evolution of the twin-bore/cut-and-cover station concept.

As background, the initial design, stopped in 2008 at an approximate 65% design level, consisted of the following elements of work:

- Two 17'-10" internal diameter (ID) tunnels, intended to be constructed by pressurized face Tunnel Boring Machines (TBM) installing a single pass, segmental precast concrete tunnel lining (PCTL) system. The twin tunnels included 33 mined cross passages spaced at regular intervals along the alignment to connect the tunnels, cast-in-place (CIP) concrete invert and walkway structures, tunnel lighting, drainage and other required services and appurtenances.
- Three underground cut-and-cover stations, comprised of slurry diaphragm wall support of excavation (SOE) systems, cast-in-place concrete internal structures housing required public and back of house (BOH) spaces, station entrances, building services and architectural features and finishes necessary to provide a fully functional BART station accommodating the required 700' long station platforms. A brief discussion of each station location and intended construction approach follows:
    - <u>28th Street/Little Portugal Station</u>: located in the same location as the current BSVII 28th Street/Little Portugal Station, bounded by N28th Street, N30th Street, and the US101 on-ramp and freeway. Due to limited restrictions on and around the site, the contractor would have flexibility to stage and prosecute the work in an open cut type environment, without the need for temporary traffic decking over the station excavation.
    - <u>Downtown San José Station</u>: located directly under Santa Clara Street, between Market and 4th Streets. Due to the scale of the work and limited width of Santa Clara Street, it was envisioned that the work would be prosecuted in a "block by block" approach, whereby the contractor would close the full width of Santa Clara Street for a block and/or a block and an intersection at a time to allow for installation of the SOE and temporary traffic decking, upon completion of work in a given block and/or block and intersection, vehicular traffic would be reinstated and the work would progress to the next block and/or block and intersection. The process would be repeated until decking was completed for the entire station length, at which time Santa Clara Street would be fully open to vehicular traffic. After completion of tunneling and station construction work under the decking, the process would be repeated in reverse to restore Santa Clara Street to

its final condition. This approach is explained in detail in Appendix C – Twin Bore/Cut-and-Cover DTSJ Station Construction. Required utility relocations would be performed in advance of the heavy civil and station construction work. It should be noted that the 2008 design included a track double crossover adjacent to the Downtown San Jose Station, which resulted in a nearly 1500' long excavation and cut-and-cover box structure.

- Diridon Station: The 2008 design reflected the 'Diridon South' location, with the station box structure cutting diagonally across the existing Diridon parking lot between Autumn Street (now Barack Obama Boulevard) and Cahill Street, a good distance south of Santa Clara Street. Due to various considerations, the option reflected in VTA's 2018 approved EIS/R is the 'Diridon North' location, which cites the station box just south of Santa Clara Street behind the sidewalk – outside the Santa Clara Street right-of-way – between Barack Obama Boulevard and White Street. The Diridon North option would require a portion of the station box be located below the existing Diridon trackyard, which would require special considerations, as discussed further in this report. Temporary traffic decking would only be required where Cahill and Montgomery Streets cross over the station excavation.

- Two cut-and-cover mid-tunnel ventilation shaft facilities, one located at Santa Clara and 13th Streets and one at Stockton and Schiele Avenues. These two facilities would be constructed in a similar manner to the stations as relates to the heavy civil work, and both would require utility relocations and temporary traffic decking due to their location under the public streets. However, they are much smaller facilities and the decking would span only approximately 50' along the Santa Clara Street and Stockton Avenue.
- Trackwork, consisting of direct fixation track in the underground portions of the alignment and ballasted track in at-grade and transition areas of the alignment, and special trackwork in the form of single and double crossovers at various locations along the alignment.
- Systemwide systems, including traction power, train control, communications, and other required systems to provide for a fully functional extension of the BART operating system.
- Santa Clara Station and Newhall Yard & Maintenance Facility (NYMF). which in 2008 were configured in a much different manner than the current BSVII configurations, and for purposes of this Update will not be considered as explained later in this report.

To illustrate some fundamentals of the twin bore/cut-and-cover station configurations and approach, exhibits and excerpts from the 2008 design drawings are shown below.

Figure 1-1 and Figure 1-2 below illustrate Downtown San José Station general arrangement sections.

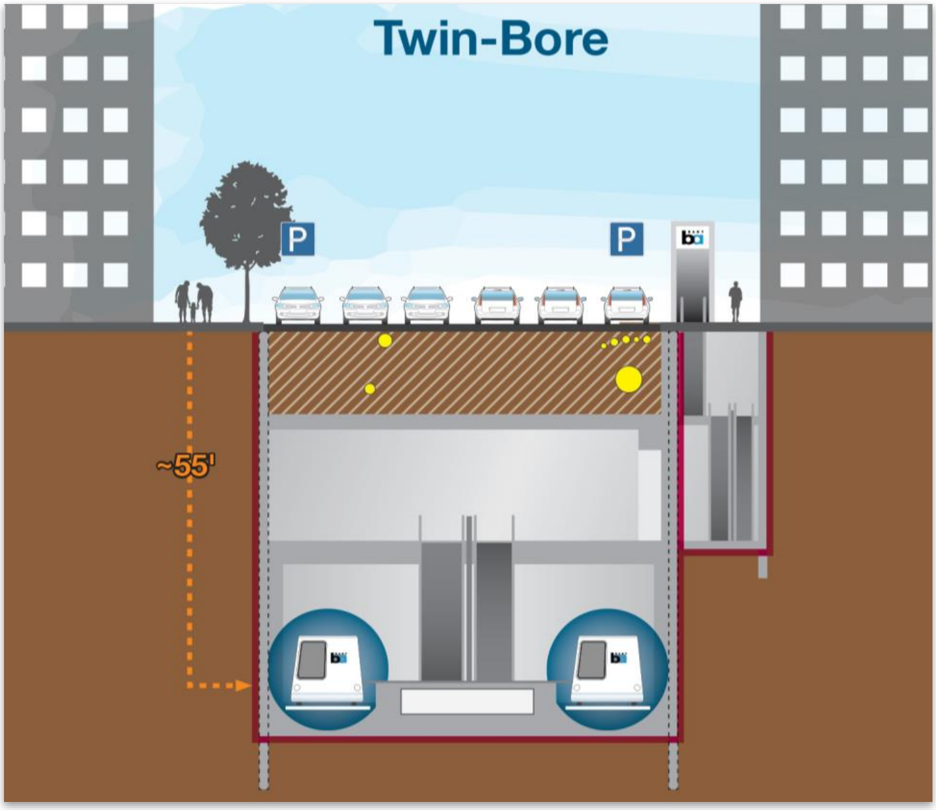

Figure 1-1 Downtown San José Station Typical Cross Section

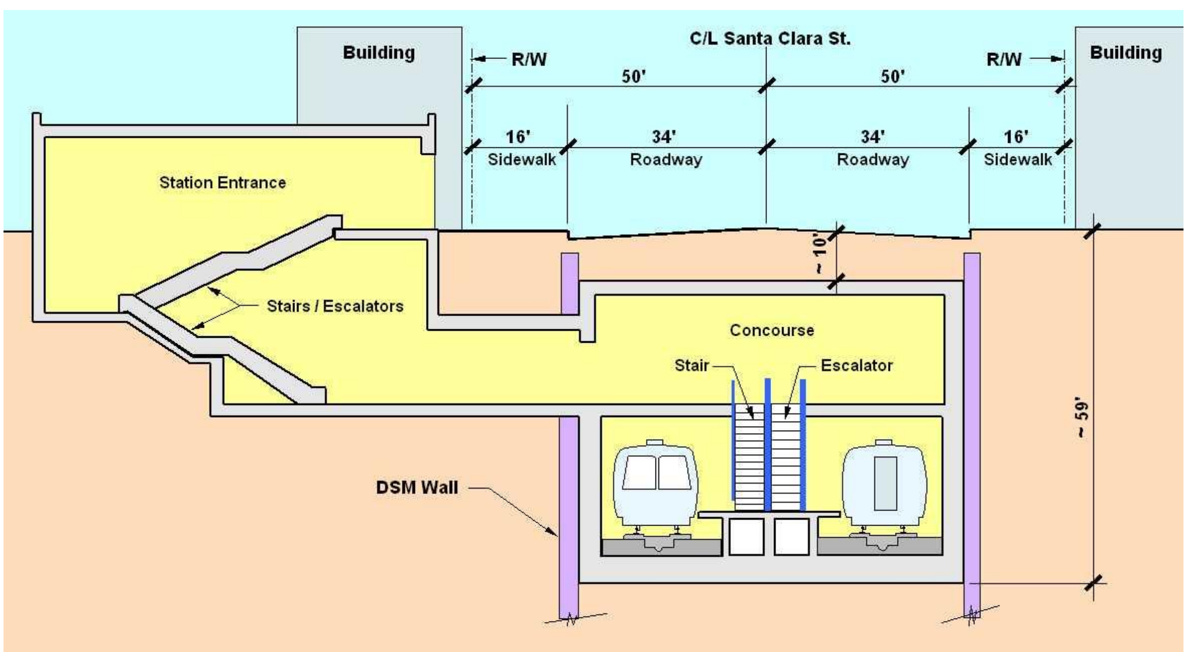

Figure 1-2 Downtown San José Station Cross Section at Station Entrance

Figure 1-3 and Figure 1-4 below show a general arrangement section of the twin bore tunnel configuration and a cross section through the West Portal detailing the TBM launch location for the twin tunnels.

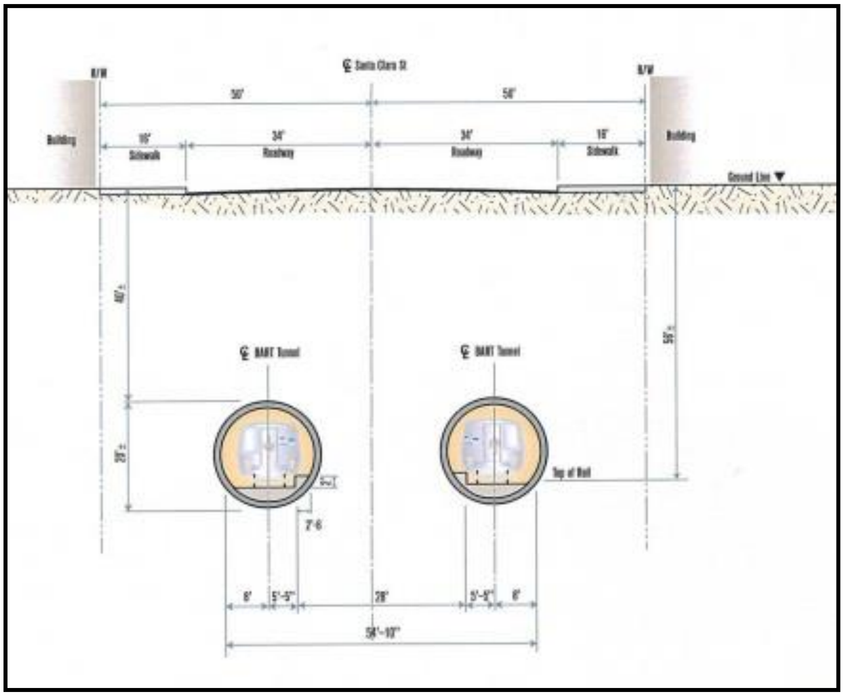

Figure 1-3 Twin Bore Tunnel Typical Configuration

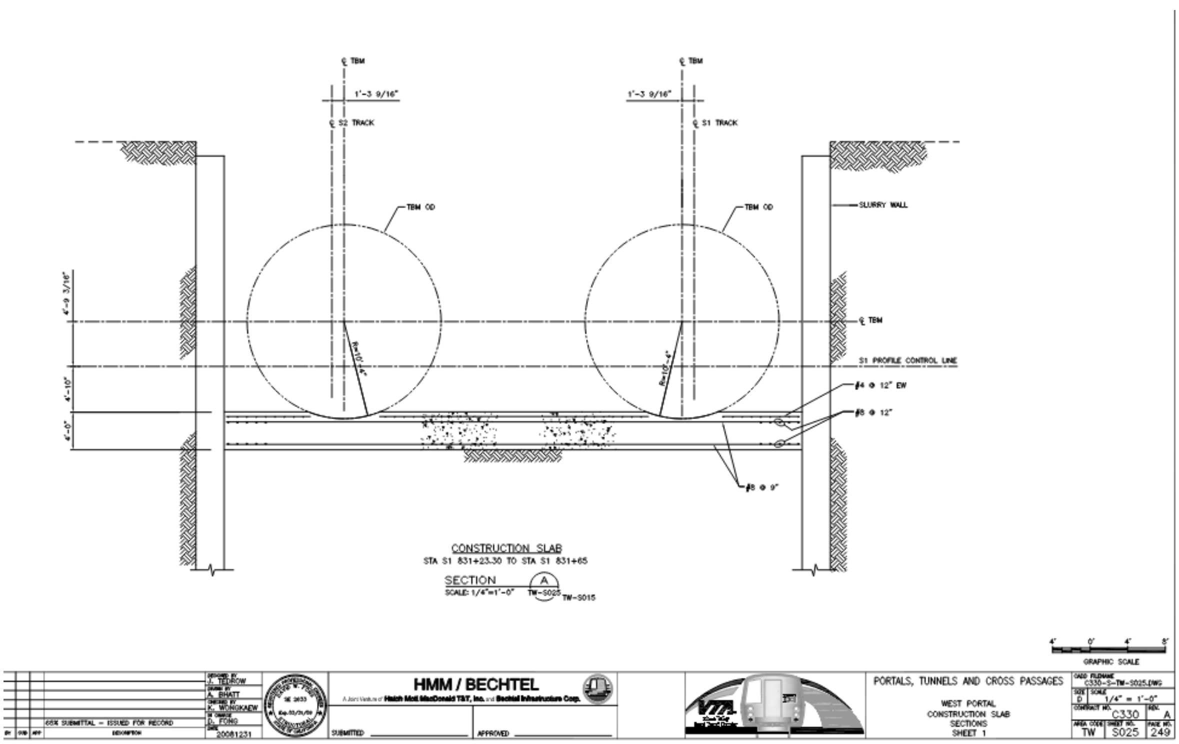

Figure 1-4 West Portal – Construction Slab

Plans and longitudinal sections of the Downtown San Jose Station are shown in Figure 1-5 and Figure 1-6 below, illustrating the general layout approach to the cut-and-cover stations. 28th Street/Little Portugal and Diridon are similar, though without the additional box length needed to house the track crossover.

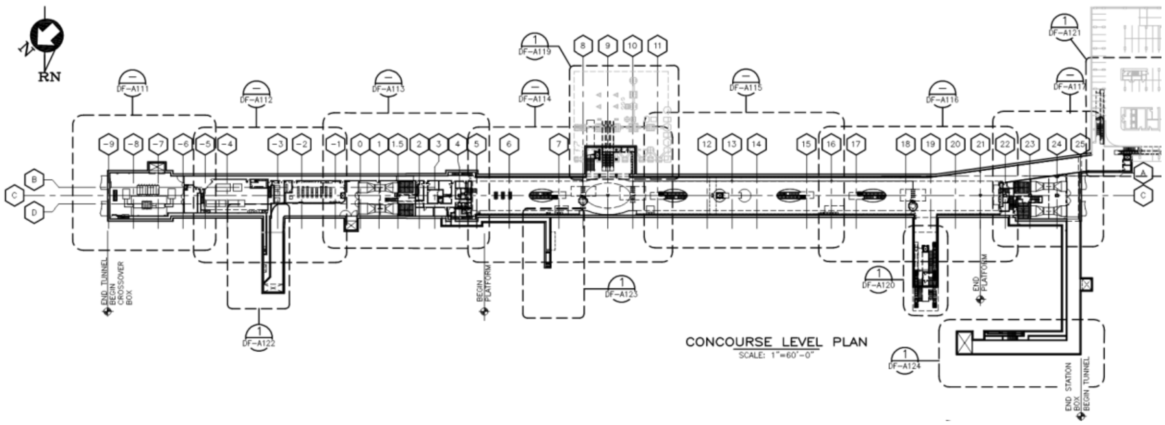

Figure 1-5 Downtown San José – Plan View

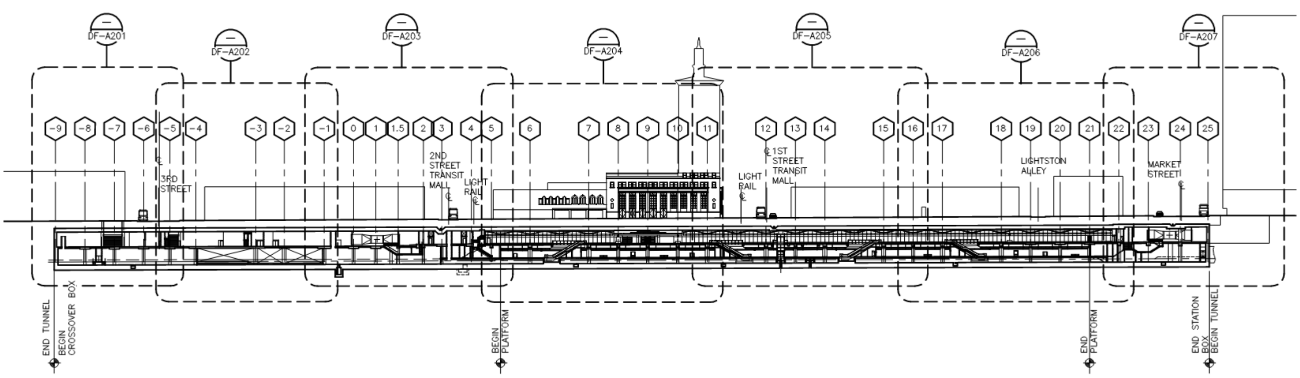

Figure 1-6 Downtown San José – Longitudinal Section

Figure 1-7 to Figure 1-10 below represent the cut & cover station excavation for the Downtown San Jose station. Figure 1-7 illustrates how the excavation of the station will be supported and decked.

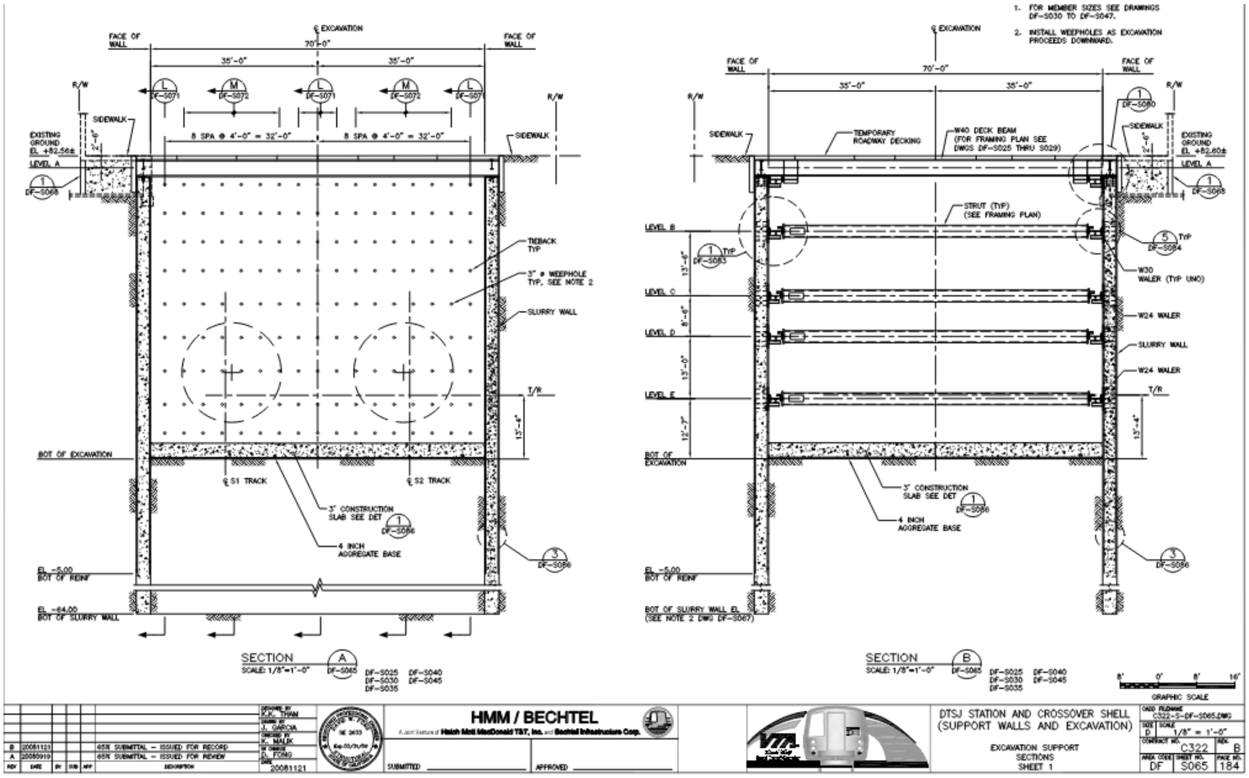

Figure 1-7 Downtown San José – Excavation and Support

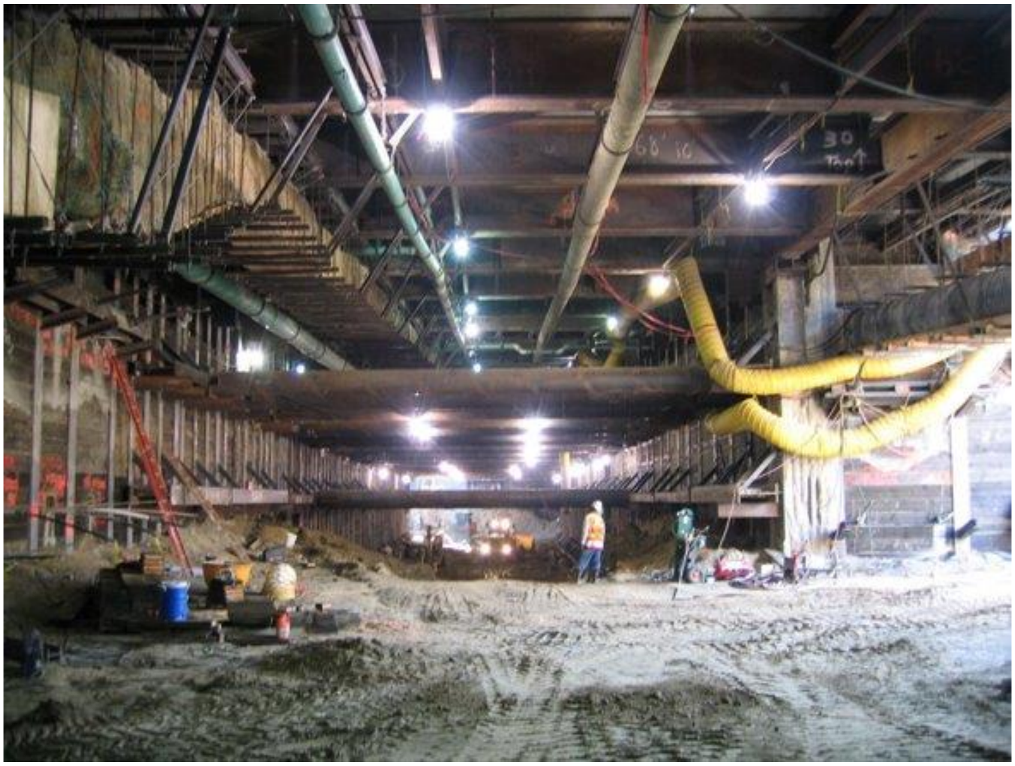

Figure 1-8 Cut and Cover Underground Station Construction

Figure 1-9 Twin Bore Tunnel with Excavation Support

Figure 1-10 Typical Deck Covering over Excavation

MMW studied the 2008 design and developed a detailed list of the changes necessary for the 2008 design to be compliant with current codes and standards. This study detailed an increase to the tunnel diameter as the tunnels pass through the Silver Creek Fault and the need for increased smoke reservoirs within the cut-and-cover stations. The increased smoke reservoir was accommodated by assuming the concourse within each station would no longer be continuous throughout the station. This modification required relocating the planned back-of-house rooms in this area to a single level basement adjacent to the station. This is further described below.

2 TWIN BORE ESTIMATE UPDATE

2.1 Scope of Update

This Update report represents the MMW opinion of probable construction cost for the BSV II (Silicon Valley Phase II Extension Project) twin bore tunnel alternative configuration. MMW utilized the original twin bore estimate quantities and linear schedule as the basis for the 2024 update, with revisions as discussed in this report. MMW also used the current Interim Design Submittal (IDS) cost estimate for the Systems, Newhall Yard Maintenance Facility, Santa Clara Station and Garage, and the 28th St Parking garage elements of the work, since they are assumed to be generally agnostic to the tunnel configuration and their costs would be nearly the same for either the twin bore or single bore concepts.

The Update assumed a contracting package and delivery approach different than the contract packaging and delivery approach for the Single Bore configuration. MMW believes this revised approach would provide VTA with the most efficient and cost-effective delivery of the twin bore/cut-and-cover station configuration, based on the current status of the BSVII Program and other trends in the industry. The approach is comprised of following:

- All construction contracts are assumed to be design–bid–build (DBB), with the design being advanced and completed concurrent with revisions to the environmental clearance process.
- Utility Relocations for Downtown San Jose (DTSJ) and other stations, mid-tunnel vent shafts and portals will be an early works package.
- A single DBB Track and Systems contract.
- A single DBB contract for the Santa Clara Station and the Newhall Yard Maintenance Facility.
- Three independent DBB heavy civil contracts for the twin bore tunnels and stations:
    1. East Portal to Downtown San Jose – including tunnels, cross passages, 13th Street mid-tunnel vent shaft, tunnel concrete and 28th Street/Little Portugal Station including all station finishes.
    2. West Portal to Downtown San Jose – including tunnels, cross passages, Stockton Street mid-tunnel vent shaft, tunnel concrete and Diridon Station including all station finishes.
    3. Downtown San Jose Station including all station finishes.

2.2 Key parameters

Consistent with MMW's IDS cost estimate, key parameters of the Update are:

- Estimate initially developed the FTA Standard Cost Categories for Construction (SCC 10 through 50) in 2024 dollars.

- With the Update in 2024 dollars, allocated contingencies were applied in accordance with the percentages in Table 4-5. After this, the combined total of base 2024 dollars and allocated contingencies was escalated to the beginning of construction (assumed to be Jan 2029) and then escalated to the mid-point of construction. The escalation rate used for this Update was 3.5% to be consistent with the current Single Bore estimates on the Project.
- This update excludes unallocated contingencies.
- Updated labor rates per State of California – Department of Industrial Relations – Director's General Prevailing Wage Determinations.
- Updated equipment rental rates per CALTRANS Labor Surcharge & Equipment Rental Rate Book & Miscellaneous Equipment Rental Rates.
- Updated commodity pricing to reflect current market conditions.
- The Update utilizes detailed quantities as developed for the 2008 design. However, certain aspects of the 2008 design required revision:
  - Necessary modifications of the 2008 tunnel/cut-and-cover configuration to meet current code, criteria and other requirements with conceptual engineering. These modifications include modifying the 2008 cut-and-cover stations to having non-continuous concourses and relocating the back-of-house rooms previously in this area to a single-story basement adjacent to the stations.
  - Adoption of other project elements from MMW's current Interim Design Submittal (IDS), where applicable and as described in subsequent sections of this report.
  - Application of unit and other costs as described in the IDS Basis of Estimate Report for the single bore configuration.

2.3 Twin Bore Estimate Update Method

2.3.1 Configuration and Quantities Updates

Appendix A includes sketch SK-002 to display the 2024 estimate update configuration. The following sections (2.3.2 to 2.3.6) are a summary of configuration changes that were approximated to the 2008 twin bore/cut-and-cover configuration. These configuration changes are considered engineering proxies; more engineering effort will be required for validation purposes. Where configuration changes were made, the methods for assessing changes to the corresponding quantities are summarized.

2.3.2 SCC 10 – Guideway

The internal diameter of the twin bore guideway running tunnels in the 2008 design was 17′-10″. A study was performed to provide guidance on an appropriate tunnel diameter based on the most current version of the BART Facilities Standards (BFS) and completed studies for the Lower Silver Creek Fault, which was re-classified as potentially active subsequent to the 2008 design. The results of this work indicated an 18′-2″ internal tunnel diameter outside the limits of the potential fault zone (a 4″ increase over the 2008 design) and a 19′-0″ internal diameter in the potential fault zone. These results were used in the Update.

Figure 2-1 Twin Bore Transit TBMs

Also, cross passages between the twin bore tunnels through the fault zone would require careful design considerations as relates to potential rupture displacements which may occur during a seismic event, including accommodation of movements between the cross passages and the tunnels.

After careful schedule considerations, the estimate utilizes a four TBM approach excavating from both east and west portals within the separate heavy civil contracts toward the Downtown Station. These TBMs are estimated to average 32 ft/day inclusive of all maintenance and cutterhead interventions to make repairs to the ground engagement tools. For this approach to be successful, power for two simultaneously operated TBM's (about 10-15 MVA) must be supplied at each portal.

2.3.3 SCC 20 – Stations

The version of the BFS used as the basis of the mid-2000s design did not include" the instantaneous fire growth" requirements included in the current version of the BFS (and the BSVII DCM). The 2008 design of the stations included a BART standard full-width concourse for the entire length of the underground station platforms. Many back-of-house (BOH) rooms were at the concourse level outside the public areas. Incorporation of the instantaneous fire growth criteria requirements into the underground station designs will necessitate creation of smoke reservoirs above the trackway, thereby precluding placement of BOH rooms on portions the concourse level.

One potential alternate location for the BOH rooms would be in a single level basement structure located adjacent to the primary station box, similar to the current IDS design for the single bore tunnel concept. This approach, including the cost estimates developed for the IDS design, was assumed for this Update. See Figure 2-2 below, showing the relation of the single level basement structure adjacent to the circular station entrance shaft in the current IDS single bore design.

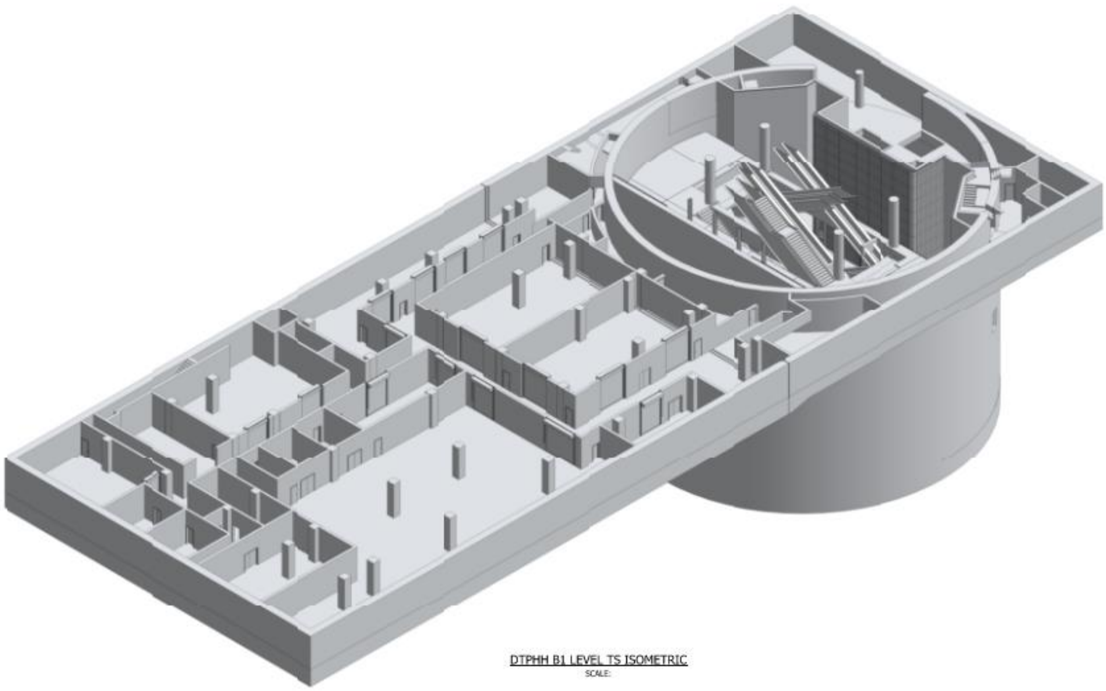

Figure 2-2 Single Level Back-of-House (BOH) Basement Structure (shown on the left)

At the Downtown San José (DTSJ) Station, the potential entrance locations cleared in the SEIS/EIR vary in some instances from those included in the 2008 design. MMW and the PMT agreed on which entrance locations would be the preferred options for the 2020 twin bore update, and the ROM costs associated with construction of the agreed locations were compared to those included in the 2008 cost estimate. For a ROM for the agreed DTSJ Station entrances, the costs were updated and applied to the Twin Bore Estimate Update.

At the Diridon Station, the 2008 design was based on the" Diridon South" alignment. The current preferred option cleared in SEIS/EIR is the" Diridon North" alignment, which places a portion of the station box under the Caltrain tracks. There are various means of constructing the box under the tracks without taking the tracks out of service, and for purposes of this Update it was assumed that a jacked box approach would be implemented, and a ROM cost for this approach was included.

Box jacking would involve widening the Diridon station excavation on either side of the Caltrain tracks, to accommodate launch and receiving "pits" utilized in the jacking operation. Precast concrete box segments cast to the required station size would then be jacked from the launch pit under the tracks to a stage of completion before the TBMs arrived. The TBMs would then subsequently 'walked through' the open excavation and box structure. After tunneling, the station's permanent concrete structure would be built abutting the end of the jacked box to form the final station box. Renderings and photos of jacked box operations are shown in Figure 2-3 and Figure 2-4 below:

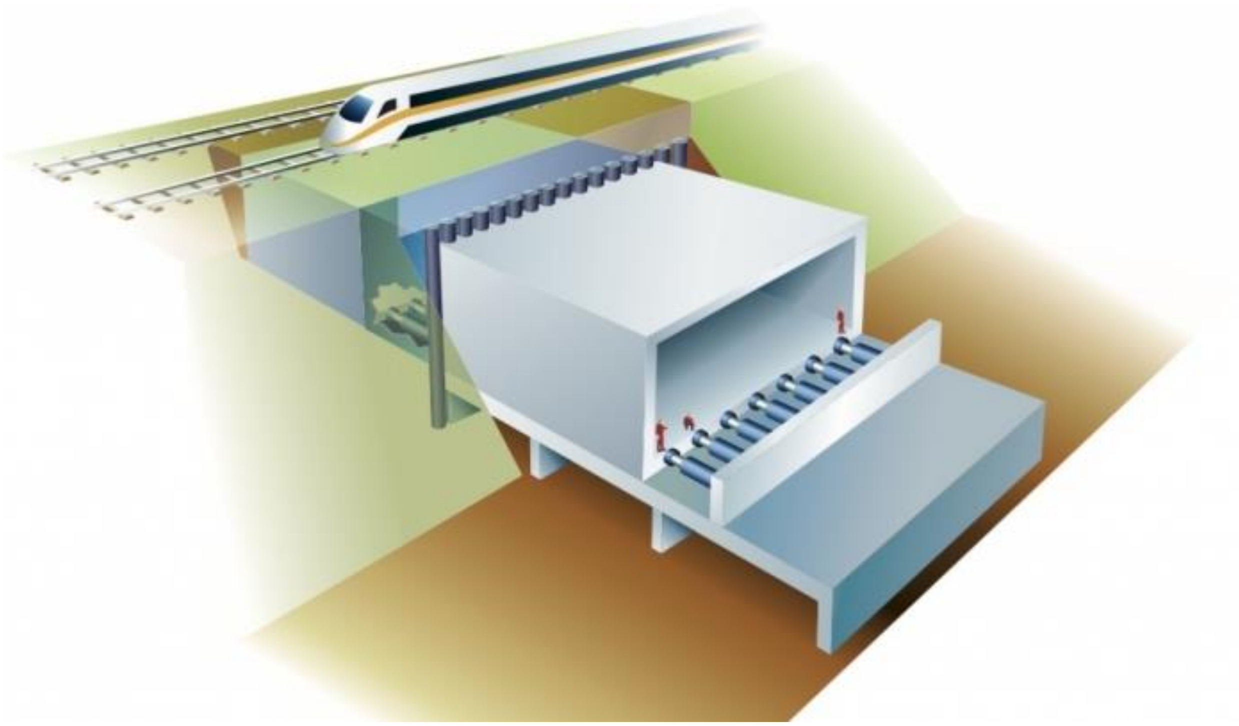

Figure 2-3 Concept Rendering of Jacked Box Operation under Railroad Tracks

Figure 2-4 Construction of Jacked Box under Operating Railroad Tracks

2.3.4 SCC 30 – Support Facilities (Yard, Shops and Administration Buildings)

The 2008 design of the Newhall Yard and Maintenance Facility (NYMF) was substantially different than the current IDS design included for the single bore configuration. Since the NYMF is independent of the tunnel and underground station configurations, the current IDS estimate was used in this Update.

2.3.5 SCC 40 – Sitework & Special Conditions

The cost for building demolition for the Update is based on demolishing the environmentally cleared construction staging areas for this configuration.

Because the utility relocation scope for a twin bore configuration is significantly different than a single bore configuration and new utility services have been installed since 2008, the utility relocation estimate for the twin bore configuration was developed by the VTA's PMT in 2020. This utility relocation estimate was escalated to 2024 dollars for this Update. The scope of the utility relocation estimate includes either relocating or replacing utilities to be supported in places that currently conflict with a future cut-and-cover structure.

2.3.6 SCC 50 – Systems

The systems scope from the single bore IDS configuration is essentially the same as the systems scope for the twin bore configuration. Due to this, the current IDS estimate with minor modifications was used for this Update.

A detailed review and update of the design and installation of the various systems and their sub-systems would be undertaken during further design development work as discussed in Section 5; however, any potential cost differences would be considered within the level of accuracy of the Update and would not significantly impact the results.

2.3.7 Schedule Basis

A linear schedule was developed to match the revised assumptions and contract packaging for the 2024 Update approach previously described. This linear schedule can be found in Appendix B. Below are Figure 2-5 and Figure 2-6 which provide a summary timeline and schedule of the three Heavy Civil contract packages.

Description	Twin Bore Contracts & Estimated Schedules					
	Utility Relocates	Heavy Civil - 1 East Portal to DTSJ	Heavy Civil - 2 West Portal to DTSJ	Heavy Civil - 3 DTSJ Station	Systems	NYMF, Santa Clara Station & Garage
Notice to Proceed	Jan-28	Jan-29	Jan-29	Jan-29	Mid 2031	Mid 2030
Mobilization, Submittals, Long Lead Materials	-	12	12	18	22	14
Construction	18	74	75	69	44	52
Testing with BART Oversight	0	0	0	0	15	0
Total Duration (months)	18	86	87	87	81	66

Figure 2-5 Summary Timeline for Heavy Civil Contracts

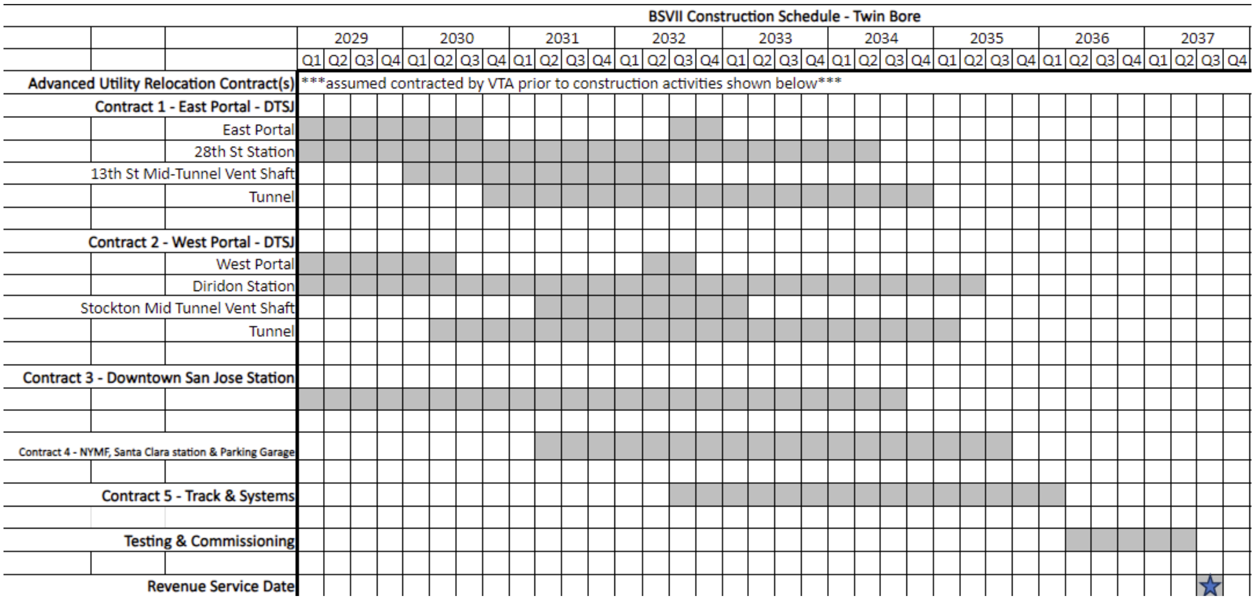

Figure 2-6 Summary Schedule for Heavy Civil Contracts

The schedule assumes that 3 heavy civil packages are procured by the VTA prior to the start of construction, or Notice to Proceeds issued, in January 2029. This would require the 3 heavy civil procurements to be released in late 2027, followed by award of three contracts in late 2028. The linear schedule is intended to reflect a possible construction schedule based on the high level of design and estimate development. Design, procurement, environmental clearances, funding approvals, utility relocations, and property acquisition are assumed to continue and not impact the estimated schedule NTP (Notice to proceed) date.

The following methods have been used to update the costs for this Update:

- For project elements included in SCC 10 and SCC 20, the line-item cost was determined by applying the updated quantity of that item to the corresponding unit cost, derived from the current IDS estimate. The unit costs were typically built from the bottom up considering the cost of permanent materials, labor – crew makeups and productivities, consumables, and equipment.
- For SCC 30, the cost is the same as the cost in the current IDS estimate.
- For SCC 40, the cost is the same as the cost in the current IDS estimate.
- For SCC 50, the cost is the same as the cost in the current IDS estimate, modified after reviewing with VTA's PMT.

For a more comprehensive description of the bases of the above costs (unit cost and element components), please refer to the IDS Basis of Estimate Report for the single bore configuration. That report defines assumptions regarding labor, equipment, and other rates.

3 CLARIFICATIONS AND EXCLUSIONS

With design development of the project elements within SCC 10-50 ranging from conceptual stages to well-developed, the cost estimate can be characterized as a Class 4 Estimate using the AACE cost estimate classification system.

Specifically excluded from this Update are SCC codes 60 – 100 and the following:

- Costs related to abandonment of the current contracted approach,
- Design costs for the twin bore/cut-and-cover station approach,
- Unallocated contingency,
- Project financing, and
- Latent contingency

4 TWIN BORE ESTIMATE UPDATE SUMMARY

4.1 Summary Results – Total Project

Table 4-1 shows the Twin Bore Estimate Update for SCC 10–50 in base 2024 dollars, not including allocated contingencies.

Table 4-1 Summary of 2024 Estimated Costs for the Twin Bore Configuration, by SCC 10–50

SCC	Description	2024 Updated Estimate Total (Base Year $ w/o Contingency)
10	**GUIDEWAY & TRACK ELEMENTS**	**$2,079,327,743**
10.06	Guideway: underground cut & cover	$137,345,362
10.07	Guideway: underground tunnel	$1,873,618,432
10.09	Track: direct fixation	$32,211,879
10.11	Track: ballasted	$9,157,462
10.12	Track: special (switches, turnouts)	$11,765,462
10.13	Track: vibration and noise dampening	$15,229,146
20	**STATIONS, STOPS, TERMINALS, INTERMODAL**	**$1,864,416,255**
20.01	At-grade station, stop, shelter, mall, terminal, platform	$71,511,895
20.03	Underground station, stop, shelter, mall, terminal platform	$1,565,900,130
20.06	Automobile parking multi-story structure	$130,204,764
20.07	Elevators, escalators	$96,796,467
30	**SUPPORT FACILITIES: YARDS, SHOPS, ADMIN. BLDGS**	**$254,744,353**
30.03	Heavy maintenance facility	$184,242,500
30.05	Yard and yard track	$70,501,853
40	**SITEWORK & SPECIAL CONDITIONS**	**$397,740,744**
40.01	Demolition, clearing, earthwork	$41,493,262
40.02	Site utilities, utility relocation	$242,042,264
40.07	Automobile, bus, van accessways including roads, parking lots	$114,090,377
40.08	Temporary facilities and other indirect costs during (Included in Indirect markup)	$0
50	**SYSTEMS**	**$819,188,402**
50.01	Train control and signals	$188,359,057
50.03	Traction power supply: substations	$200,758,849

SCC	Description	2024 Updated Estimate Total (Base Year $ w/o Contingency)
50.04	Traction power distribution: catenary and third rail	$30,143,801
50.05	Communications	$343,137,587
50.06	Fare collection system and equipment	$46,003,464
50.07	Central control	$10,785,644
SUBTOTAL SCC CATEGORIES 10-50		**$5,415,414,497**

4.2 Twin Bore Update Results by proposed contracting packages

The results of the Twin Bore Estimate Update are presented in this section as a summary of the six contract packages envisioned by MMW. The summaries below will focus on the three heavy civil packages defined as follows:

Early Works Contract(s) – Utility Relocations

- Utility relocations for the underground stations, tunnel portals and mid-tunnel vent shafts

Santa Clara Station & Newhall Yard Maintenance Facility Contract

- Santa Clara station
- Santa Clara parking garage
- Systems within the Newhall Yard
- Heavy Maintenance and Storage Facility

Track & Systems Contract

- Trackwork
    - Direct Fixation, Ballasted, Special and Vibration and Noise Dampening
- Emergency Ventilation System
- Train Control & Signals, Communications, Traction Power supply, Fare Collection and Central Control

Heavy Civil Contract 1: East Portal to Downtown San Jose Station:

- Twin Bored tunnels including cross passages and East Portal
- 28th Street/Little Portugal Station SOE, concrete and fit out, and site restoration (plus parking garage)

- 13th Street Mid-Tunnel Vent Shaft SOE, concrete and fit out
- Tunnel Concrete and services

Heavy Civil Contract 2: West Portal to Downtown San Jose Station:

- Twin Bored tunnels including cross passages and West Portal
- Diridon Station SOE, concrete and fit out, and site restoration.
- Jacked box under Caltrain.
- Stockton Street Mid-Tunnel Vent Shaft SOE, concrete and fit out.
- Tunnel Concrete and services

Heavy Civil Contract 3: Downtown San Jose Station:

- Downtown San Jose Station and adjacent cross over SOE, concrete, fit out, and site restoration by the block-by-block approach.

The three contract costs are listed in Table 4-2, along with other comparison metrics.

Table 4-2 Cost Estimate by Various Metrics

	Unit	Qty	Unit Rate (See Note 1)	Ext (See Note 1)
Total 'bid' prices for each of the segments				
Contract 1: East Portal to Downtown San Jose Station	LS	1	$1,403,692,453	$1,403,692,453
Contract 2: West Portal to Downtown San Jose Station	LS	1	$1,461,471,440	$1,461,471,440
Contract 3: Downtown San Jose Station	LS	1	$882,971,695	$882,971,695
Total cost for entire length of bored tunnels incl SCC 10.07				
	RF	22,856	$81,975	$1,873,618,834
	RM	4.33	$432,706,382	$1,873618,834
Total cost for all four stations, including per each (include enabling works at each station site)				
28th St/Little Portugal	LS	1	$464,098,904	$464,098,904
Downtown San Jose	LS	1	$882,971,695	$882,971,695
Diridon	LS	1	$554,813,705	$554,813,705
Santa Clara	LS	1	$163,767,039	$163,767,039
Subtotal Stations only SCC 10-50:				$2,065,651,343
Total cost for (2 locations) both parking garages				$146,759,994
	Stalls	1,795	$81,760	
Total cost for NYMF (minus yard systems)				
	LS	1	$396,594,280	$396,594,280
Total cost for utility relocations				
	LS	1	$242,042,264	$242,042,264
Total Cost for Track & Systems				
	LS	1	$1,170,047,034	$1,170,047,034
Total Cost for Santa Clara & NYMF				$648,963,337
	LS	1	$648,963,337	

1. Bid prices in Q2 2024$ for SCC codes 10-50, excluding contingency, escalation, financing, AACEI Class 4 Accuracy

4.3 Recommended Allocated Contingencies

Table 4-3 provides recommended allocated contingencies to apply to the Twin Bore Estimate Update. Additionally, VTA has requested an FTA SCC summary of the twin bore Update to include escalation and year of expenditure analysis. These are summarized below in Table 4-4 and Table 4-5 respectively.

Table 4-3 Recommended Contingencies for the 2024 Twin Bore Configuration, by SCC

SCC	Description	Recommended Allocated Contingency
10	**GUIDEWAY & TRACK ELEMENTS (ROUTE FEET)**	
10.06	GUIDEWAY: UNDERGROUND CUT & COVER	25%
10.07	GUIDEWAY: UNDERGROUND TUNNEL	25%
10.09	TRACK: DIRECT FIXATION	15%
10.11	TRACK: BALLASTED	15%
10.12	TRACK: SPECIAL (SWITCHES, TURNOUTS)	15%
10.13	TRACK: VIBRATION AND NOISE DAMPENING	15%
20	**STATIONS, STOPS, TERMINALS, INTERMODAL (NUMBER)**	
20.01	AT-GRADE STATION, STOP, SHELTER, MALL, TERMINAL, PLATFORM	20%
20.03	UNDERGROUND STATION, STOP, SHELTER, MALL, TERMINAL PLATFORM	25%
20.06	AUTOMOBILE PARKING MULTI-STORY STRUCTURE	15%
20.07	ELEVATORS, ESCALATORS	15%
30	**SUPPORT FACILITIES: YARDS, SHOPS, ADMIN. BLDGS**	
30.03	HEAVY MAINTENANCE FACILITY	20%
30.05	YARD AND YARD TRACK	20%
40	**SITEWORK & SPECIAL CONDITIONS**	
40.01	DEMOLITION, CLEARING, EARTHWORK	15%
40.02	SITE UTILITIES, UTILITY RELOCATION	15%
40.03	HAZ. MAT'L, CONTAM'D SOIL REMOVAL/MITIGATION, GROUND WATER TREATMENTS	15%
40.07	AUTOMOBILE, BUS, VAN ACCESSWAYS INCLUDING ROADS, PARKING LOTS	20%
50	**SYSTEMS**	

50.01	TRAIN CONTROL AND SIGNALS	15%
50.03	TRACTION POWER SUPPLY: SUBSTATIONS	15%
50.04	TRACTION POWER DISTRIBUTION: CATENARY AND THIRD RAIL	15%
50.05	COMMUNICATIONS	15%
50.06	FARE COLLECTION SYSTEM AND EQUIPMENT	15%
50.07	CENTRAL CONTROL	15%

Table 4-4 provides the SCC cost breakdown of each 2024 Twin Bore Update SCC cost category.

Table 4-4 2024 Twin Bore Configuration Allocated Contingency and Total Base Year Dollars Analysis

SCC	Description	2024 Estimate Total – Base Year $ w/o Contingency	Base Year Dollars – Allocated Contingency	2024 Updated Base Year $ Total
10	**GUIDEWAY & TRACK ELEMENTS**	**$2,079,327,743**	**$512,995,541**	**$2,592,323,284**
10.06	Guideway: underground cut & cover	$137,345,362	$34,336,340	$171,681,702
10.07	Guideway: underground tunnel	$1,873,618,432	$468,404,608	$2,342,023,040
10.09	Track: direct fixation	$32,211,879	$4,831,782	$37,043,661
10.11	Track: ballasted	$9,157,462	$1,373,619	$10,531,081
10.12	Track: special (switches, turnouts)	$11,765,462	$1,764,819	$13,530,281
10.13	Track: vibration and noise dampening	$15,229,146	$2,284,372	$17,513,518
20	**STATIONS, STOPS, TERMINALS, INTERMODAL**	**$1,864,416,255**	**$439,827,596**	**$2,304,240,851**
20.01	At-grade station, stop, shelter, mall, terminal, platform	$71,511,895	$14,302,379	$85,814,274
20.03	Underground station, stop, shelter, mall, terminal platform	$1,565,900,130	$391,475,032	$1,957,375,162
20.06	Automobile parking multi-story structure	$130,204,764	$19,530,715	$149,735,478
20.07	Elevators, escalators	$96,796,467	$14,519,470	$111,315,937

30	**SUPPORT FACILITIES: YARDS, SHOPS, ADMIN. BLDGS**	**$254,744,353**	**$50,948,871**	**$305,693,223**
30.03	Heavy maintenance facility	$184,242,500	$36,848,500	$221,091,000
30.05	Yard and yard track	$70,501,853	$14,100,371	$84,602,224
40	**SITEWORK & SPECIAL CONDITIONS**	**$397,740,744**	**$65,365,630**	**$463,106,374**
40.01	Demolition, clearing, earthwork	$41,493,262	$6,223,989	$47,717,251
40.02	Site utilities, utility relocation	$242,042,264	$36,323,566	$278,480,671
40.07	Automobile, bus, van accessways including roads, parking lots	$144,090,377	$22,818,075	$136,908,452
40.08	Temporary facilities and other indirect costs during (Included in Indirect markup)	$0	$0	$0
50	**SYSTEMS**	**$819,188,402**	**$122,878,260**	**$942,066,663**
50.01	Train control and signals	$188,359,057	$28,253,859	$216,612,915
50.03	Traction power supply: substations	$200,758,849	$30,113,827	$230,872,677
50.04	Traction power distribution: catenary and third rail	$30,143,801	$4,521,570	$34,665,371
50.05	Communications	$343,137,587	$51,470,638	$394,608,225
50.06	Fare collection system and equipment	$46,003,464	$6,900,520	$52,903,984
50.07	Central control	$10,785,644	$1,617,847	$12,403,490
SUBTOTAL SCC CATEGORIES 10-50		**$5,415,414,497**	**$1,192,015,899**	**$6,607,430,395**

Table 4-5 BSV II Twin Bore Escalation & Year-of-Expenditure Results

SCC	Description	2024 Updated Base Year $ Total ($M)	2029$ Total ($M)	YOE Total ($M)
10	**GUIDEWAY & TRACK ELEMENTS**	**$2,592**	**$3,079**	**$3,425**
10.06	Guideway: underground cut & cover	$172	$204	$227
10.07	Guideway: underground tunnel	$2,342	$2,782	$3,094
10.09	Track: direct fixation	$37	$44	$49
10.11	Track: ballasted	$10.5	$13	$14
10.12	Track: special (switches, turnouts)	$13.5	$16	$18
10.13	Track: vibration and noise dampening	$17.5	$21	$23
20	**STATIONS, STOPS, TERMINALS, INTERMODAL**	**$2,304**	**$2,737**	**$3,045**
20.01	At-grade station, stop, shelter, mall, terminal, platform	$85.8	$102	$113
20.03	Underground station, stop, shelter, mall, terminal platform	$1,957	$2,325	$2,587
20.06	Automobile parking multi-story structure	$149	$178	$198
20.07	Elevators, escalators	$111	$132	$147
30	**SUPPORT FACILITIES: YARDS, SHOPS, ADMIN. BLDGS**	**$305.7**	**$363**	**$435**
30.03	Heavy maintenance facility	$221	$263	$315
30.05	Yard and yard track	$85	$100	$120
40	**SITEWORK & SPECIAL CONDITIONS**	**$463**	**$550**	**$592**
40.01	Demolition, clearing, earthwork	$48	$57	$61
40.02	Site utilities, utility relocation	$278	$331	$356
40.07	Automobile, bus, van accessways including roads, parking lots	$137	$163	$175
50	**SYSTEMS**	**$942**	**$1,119**	**$1,375**

50.01	Train control and signals	$216	$257	$316
50.03	Traction power supply: substations	$231	$274	$337
50.04	Traction power distribution: catenary and third rail	$34.7	$41	$51
50.05	Communications	$394	$469	$576
50.06	Fare collection system and equipment	$53	$63	$77
50.07	Central control	$12	$15	$18
SUBTOTAL SCC CATEGORIES 10-50		**$6,607**	**$7,848**	**$8,872**

5 FURTHER WORK

The MMW opinion of the cost of construction expressed in this report is based on a preliminary bottom up estimating method described above resulting in an accuracy equivalent to a Class 4 estimate. If VTA elects to re-engage a twin bore/cut-and-cover option, a significant amount of multi-disciplinary engineering and architectural design efforts would be necessary to reach a suitable level of design advancement which could serve as the basis for quantity takeoffs, vendor and specialist sub-contractor inquiries to inform a Class 3 estimate.

This design development effort and Class 3 estimate preparation could be performed concurrently with the necessary updates to the project's environmental clearance and funding approvals.

END

Appendix A 2024 Estimate Update Configuration

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REV	DATE	BY	CHK	APP	DESCRIPTION

DESIGNED BY	Y. LIAO
DRAWN BY	M.WH
DWG. CHECK	
ENG. CHECK	
COORD. CHECK	
REVIEWED BY	

APPROVED

MMW TEAM
MOTT MACDONALD
WONG ENGINEERING

Santa Clara Valley Transportation Authority

BART SILICON VALLEY PHASE II EXTENSION PROJECT

TWIN BORE ESTIMATE CONFIGURATION
AUGUST 2024

DRAWING FILE IDENTIFIER: 385606-MMW-PWIDE-XX-SK-PM-000002		
CONTRACT NO.	SCALE AT D SIZE: NTS	REV.: P01.1
SUITABILITY DESCRIPTION: FOR REVIEW AND COMMENT		SUIT. CODE: S3
	SHEET NO.: SK-002	PAGE NO.

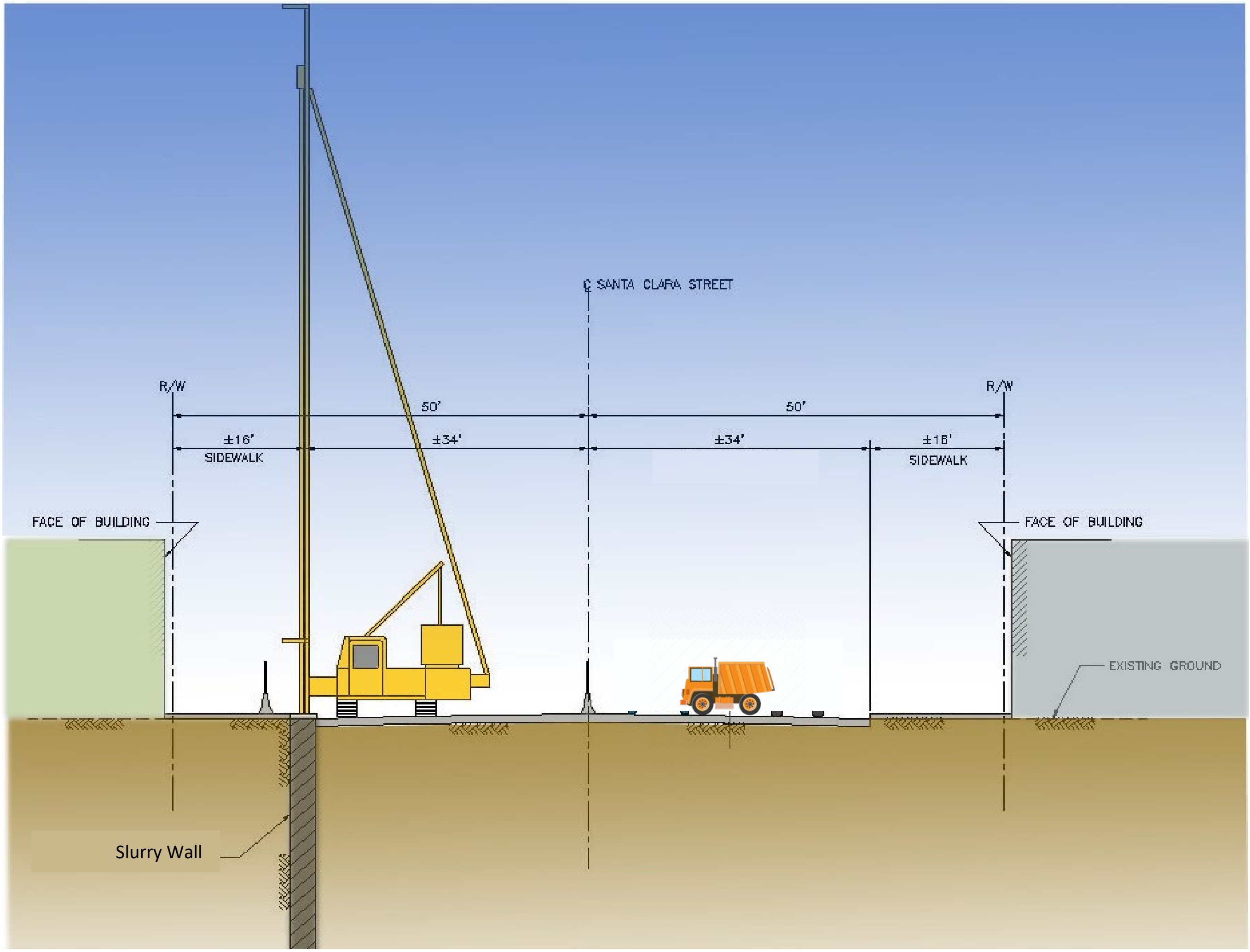
Appendix B Linear Schedule

Updated - 10 Dec 08
Optimized Base Case

Appendix C Twin Bore/Cut-and-Cover DTSJ Station Construction

Twin-Bore Cut-and-Cover Station Construction

Step 1: Support of Excavation (SOE) Wall Installation



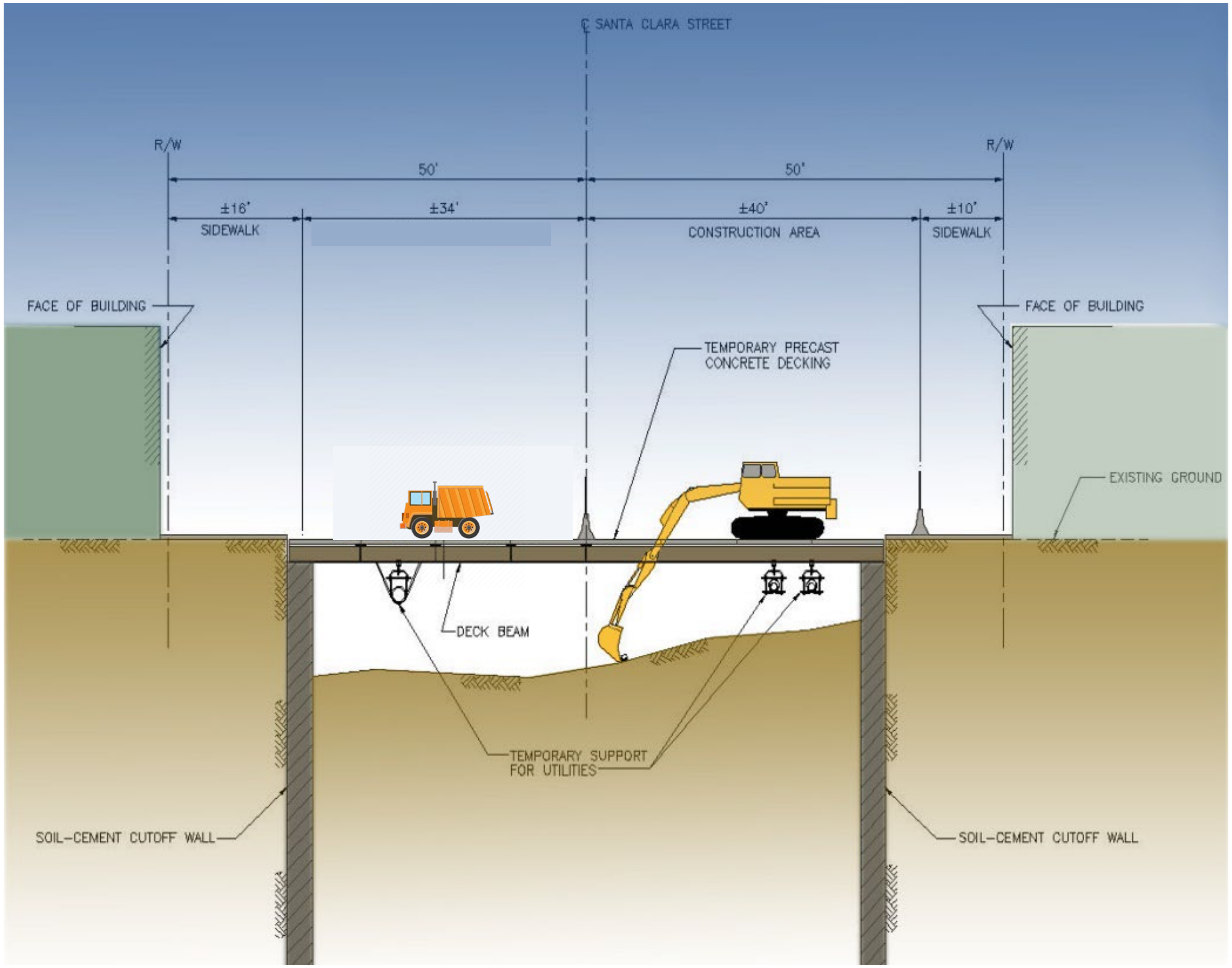
Solutions that move you

Twin-Bore Cut-and-Cover Station Construction

Reinforced Concrete Slurry Walls

Twin-Bore Cut-and-Cover Station Construction

Step 2: Excavation, Decking & Temp Utility Support

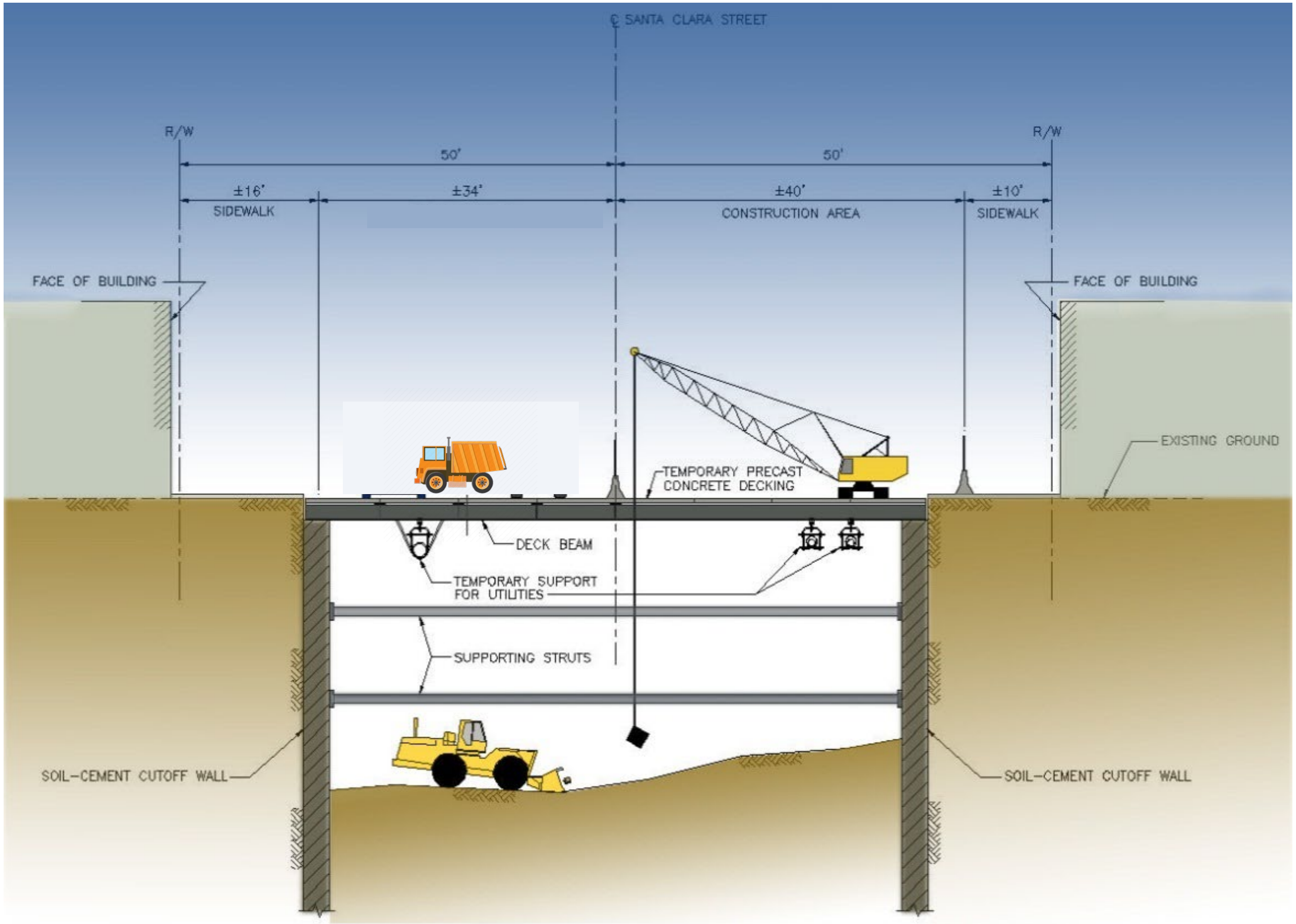


Solutions that move you

Twin-Bore Cut-and-Cover Station Construction

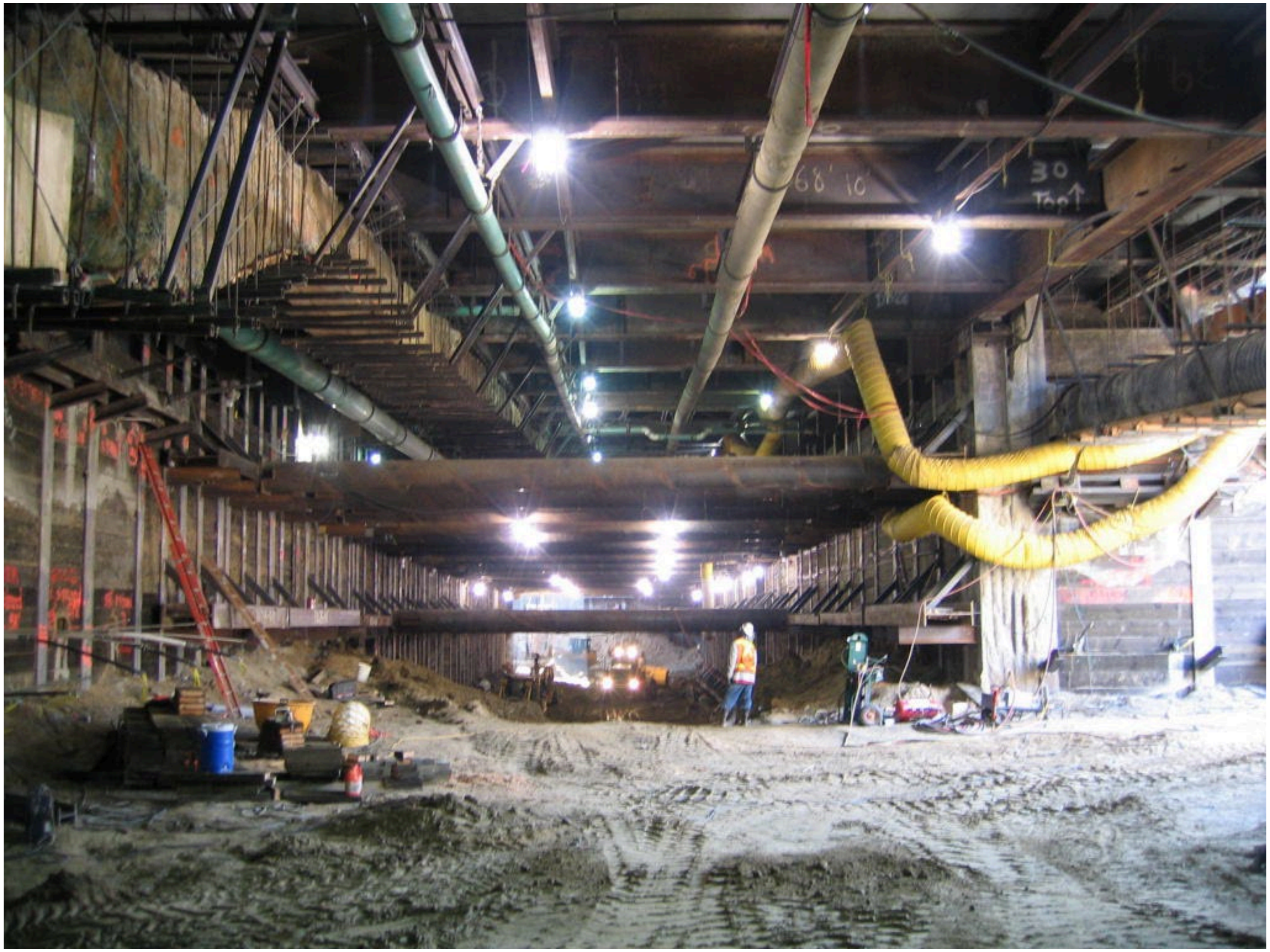
Twin-Bore Cut-and-Cover Station Construction

Step 3: Continue Excavation & Add Internal Bracing



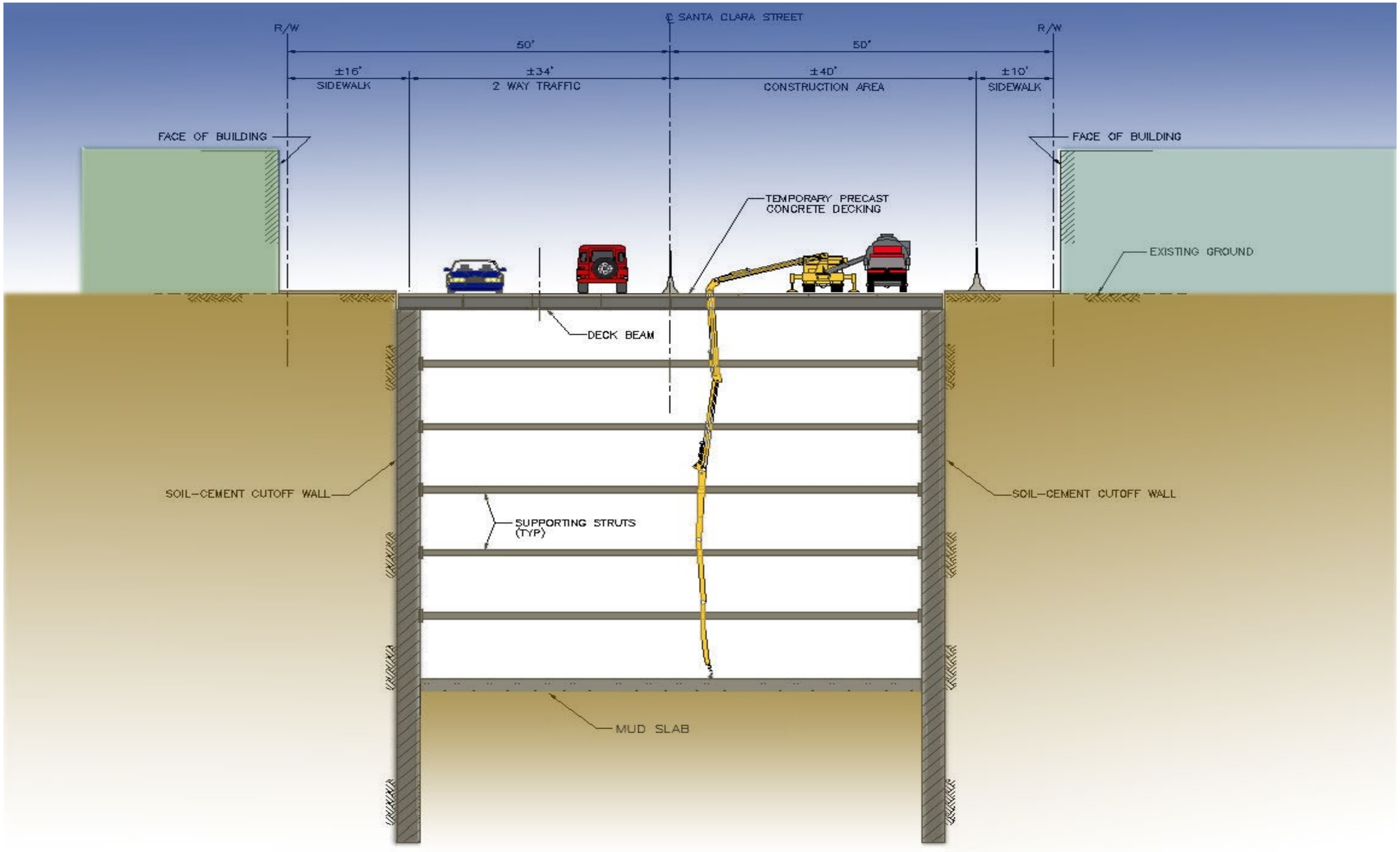
Solutions that move you

Twin-Bore Cut-and-Cover Station Construction



Twin-Bore Cut-and-Cover Station Construction

Step 4: Excavation & Decking Complete, Traffic Reinstated, Tunneling into Excavation

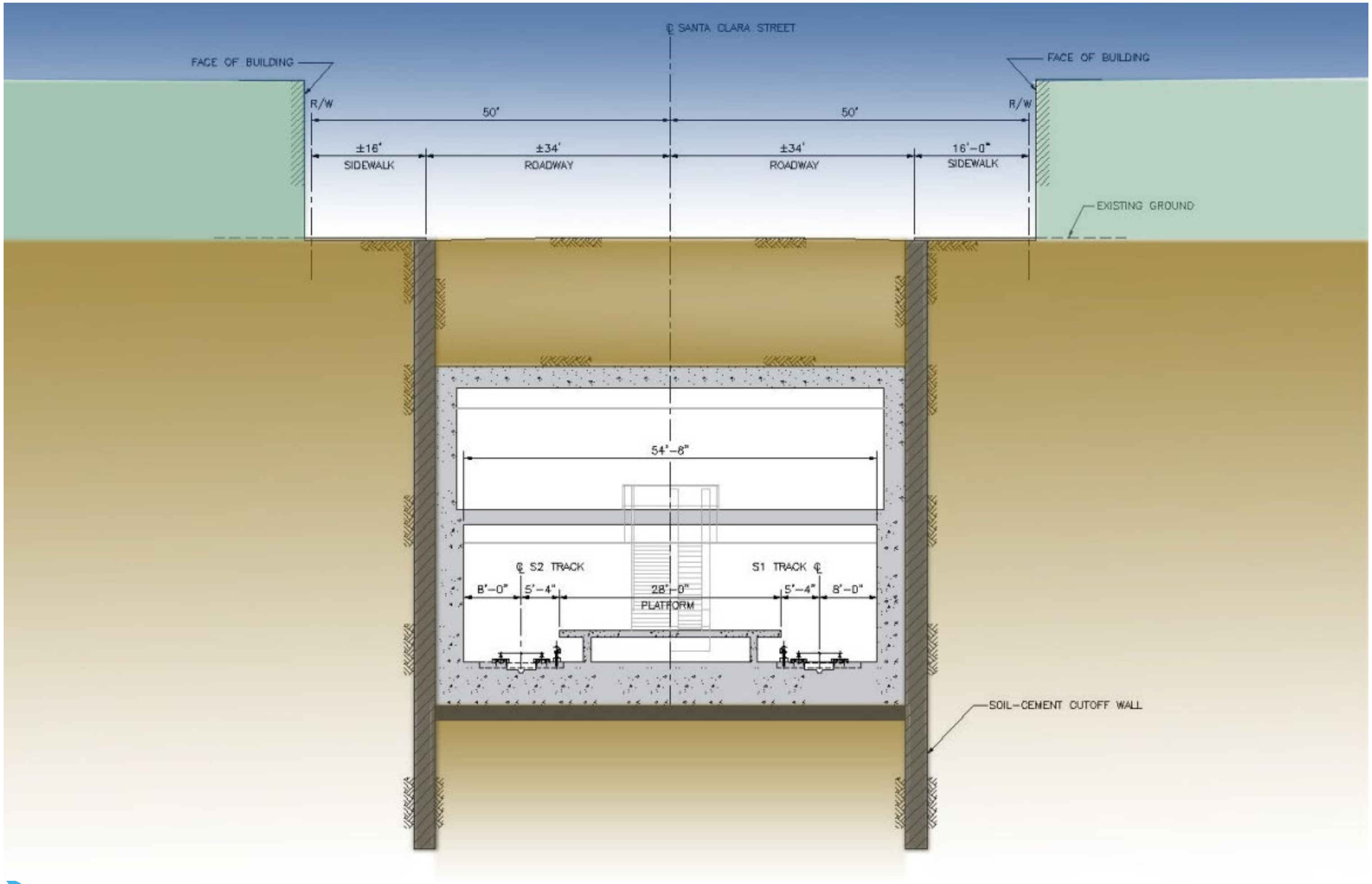


Solutions that move you

Twin-Bore Cut-and-Cover Station Construction

Twin-Bore Cut-and-Cover Station Construction

Step 5: Construct Structure & Restore Street



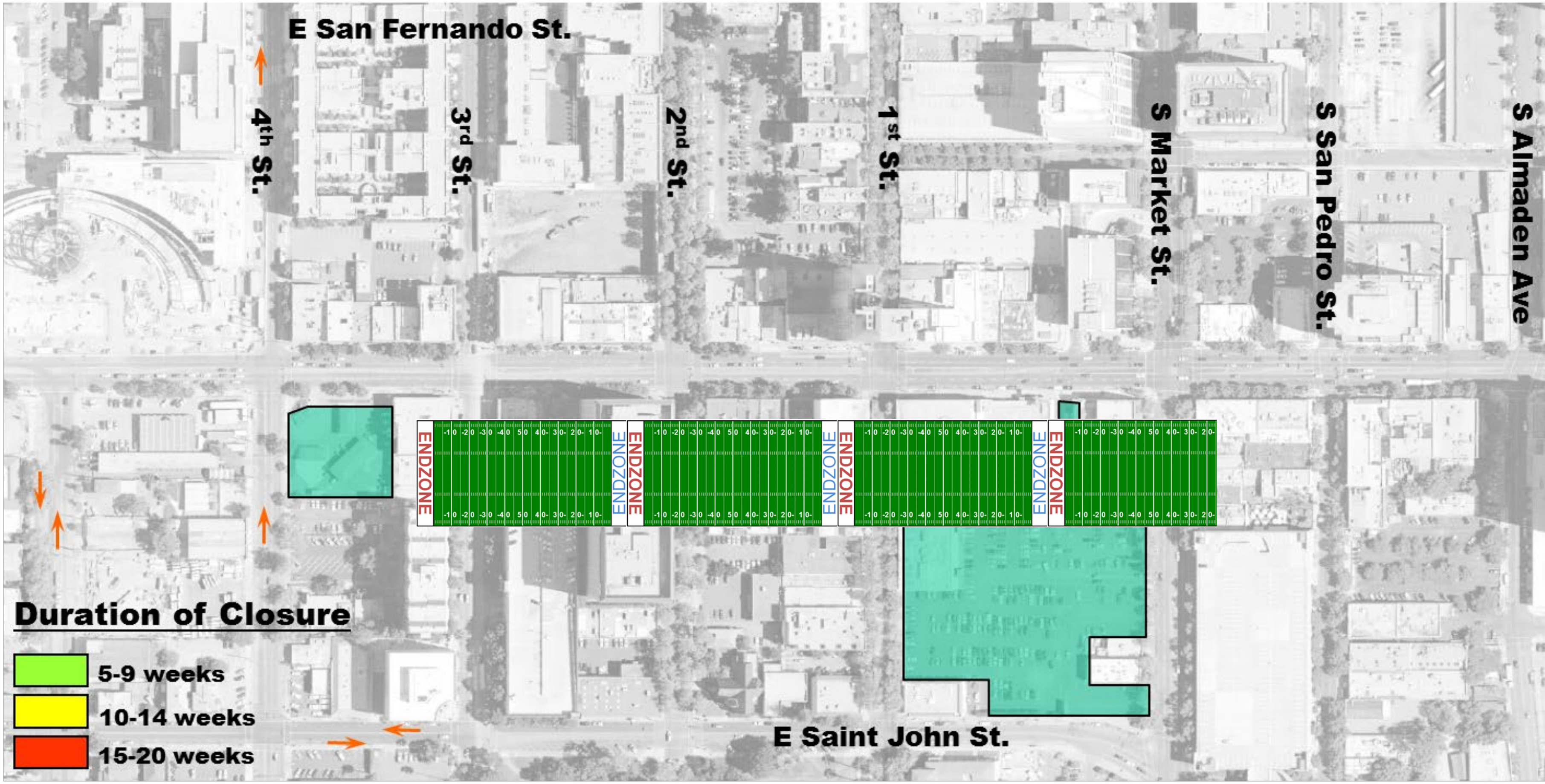
Downtown San Jose Station
Twin-Bore Roadway Construction Impacts

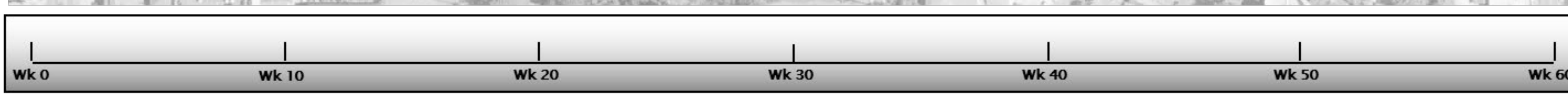
Activity	Duration	Adverse Effects on Roadways
Advanced Utility Relocations	16–24 months	Temporary lane closures and some street closures along Santa Clara Street – one block, or one block and one intersection, or two blocks and one intersection at a time – for periods of up to 3 months at a time.
Support of Excavation Wall Installation	12–18 months	Temporary street closures along Santa Clara Street – one block or one block and one intersection, or two blocks and one intersection at a time – for periods of up to 3 months at a time. Light Rail Transit will require bus bridges at 1st and 2nd Street intersections for up to 3 months at each intersection.
Decking Installation	1–6 months	Temporary street closures along Santa Clara Street – one block or one block and one intersection, or two blocks and one intersection at a time – for approximately 2 weeks to 1 month at a time.
Station Box Excavation	10–18 months	Intermittent lane closures along Santa Clara Street.
Tunnel Boring Machine Removal	2–4 weeks	Intermittent lane closures on each end of the station – up to 4 weeks four times.
Station Structure Construction	18–30 months	Intermittent lane closures along Santa Clara and up to 2-month street closure of Market Street.
Decking Remove, Backfill and Street Restoration (includes Street Resurfacing, Landscape, Sidewalk, Signals, Lighting)	18–24 months	Temporary one-block or one block and one intersection street closures of 1 to 2 months, with intermittent lane closures along Santa Clara Street and the effected cross street.

Source: VTA 2016. Table 5-2 in Draft SEIS/SEIR.
Note: Station construction is projected to last less than six years.

Construction Sequencing for Downtown San Jose Station & Crossover

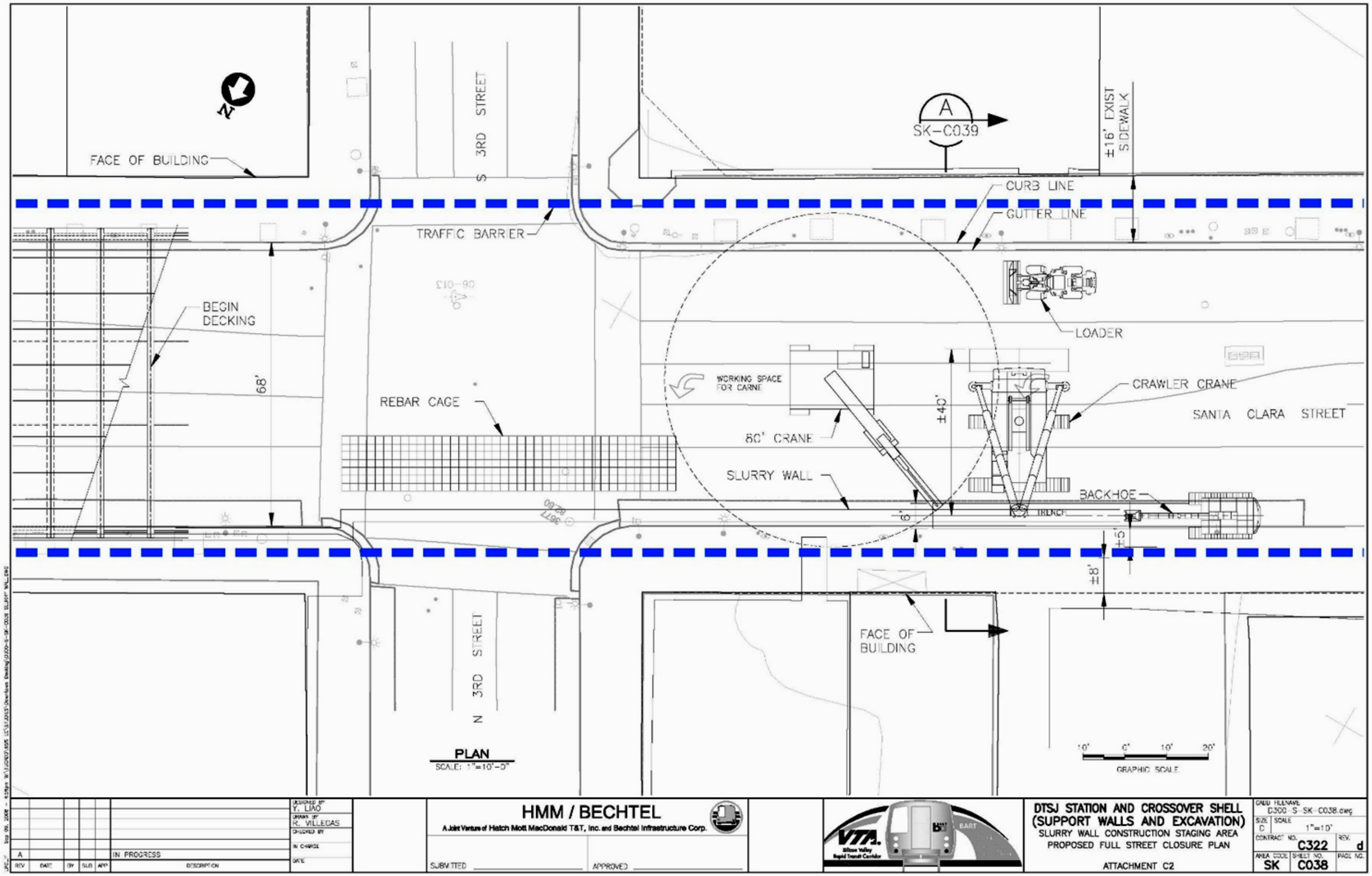
Downtown Construction Phasing Plan: "Block by Block" Approach



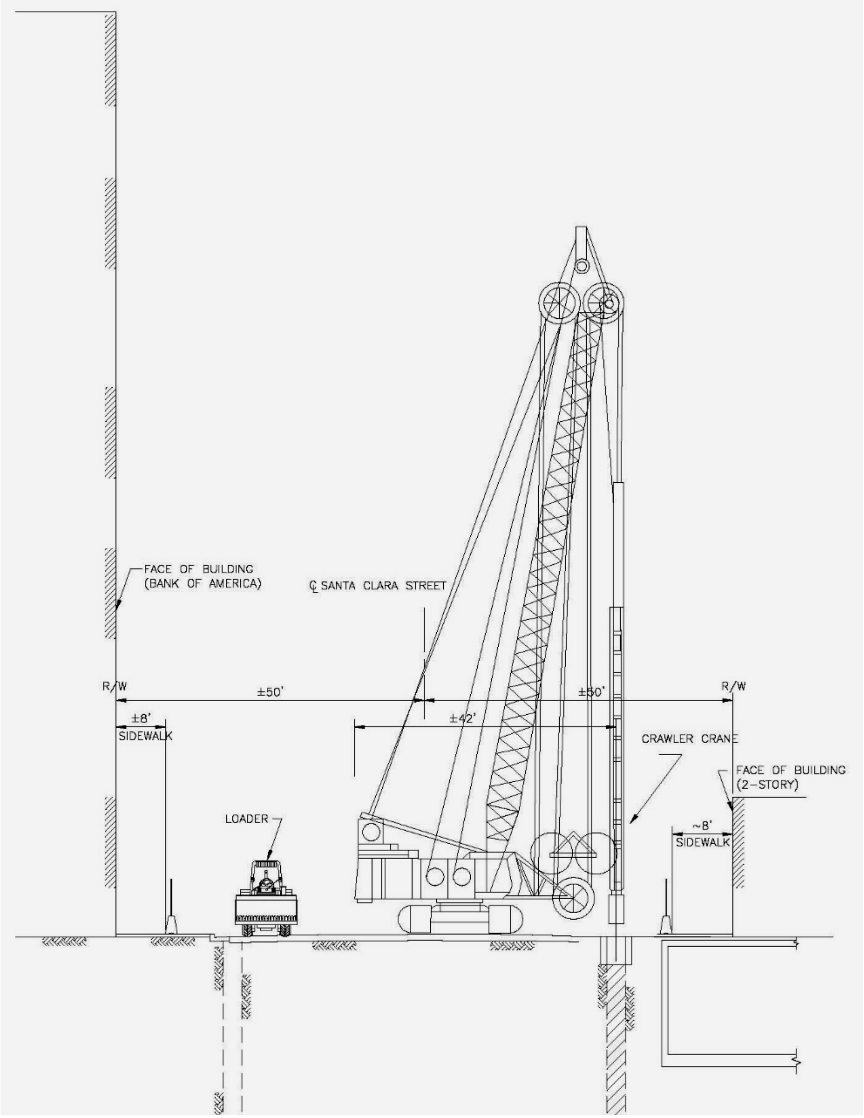


3.77 Football Fields (end zones included)

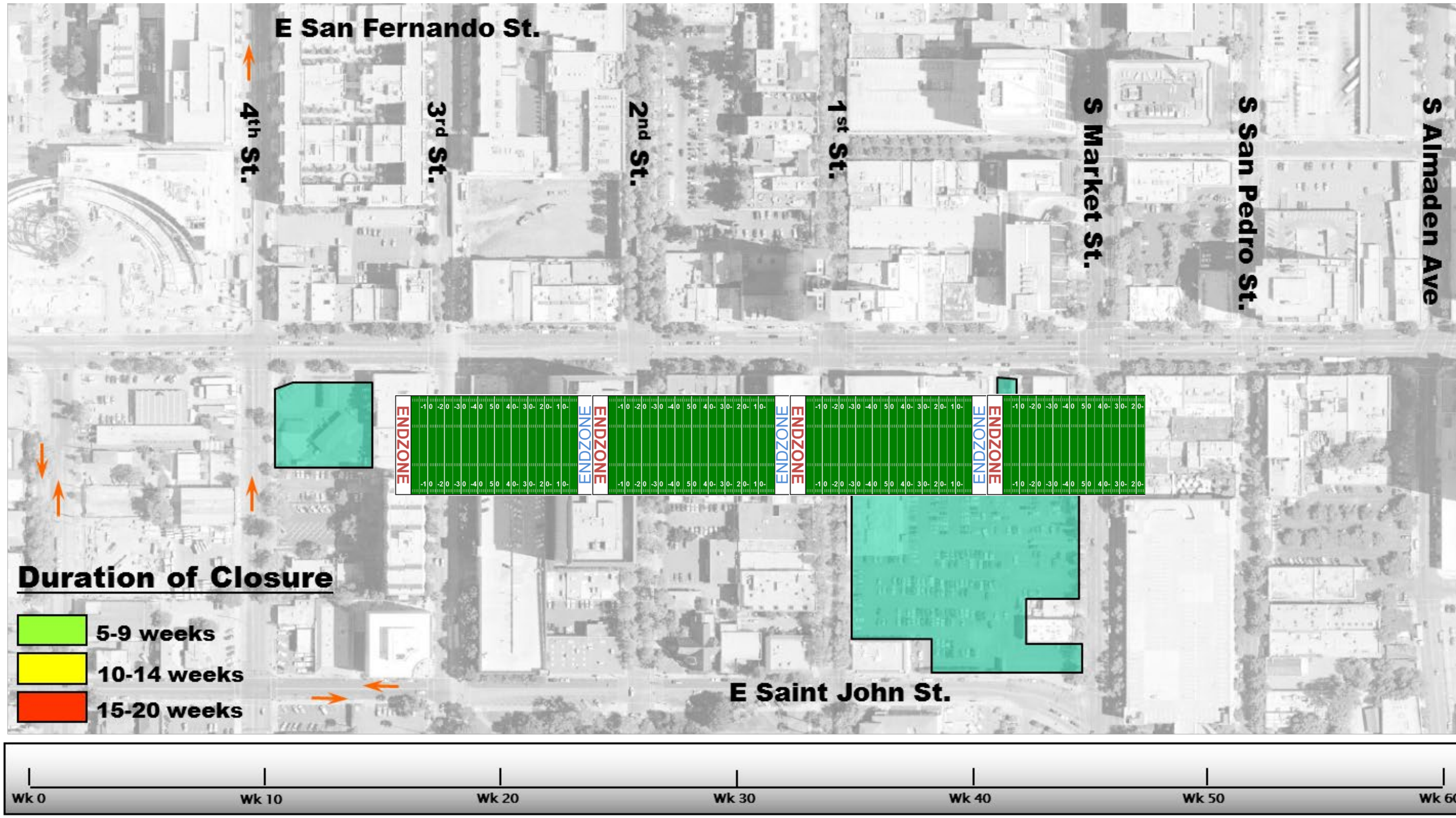
Block by Block Approach:
Typical Slurry Wall Work Area



Slurry Wall Work Area Elevation



Downtown Construction Phasing Plan



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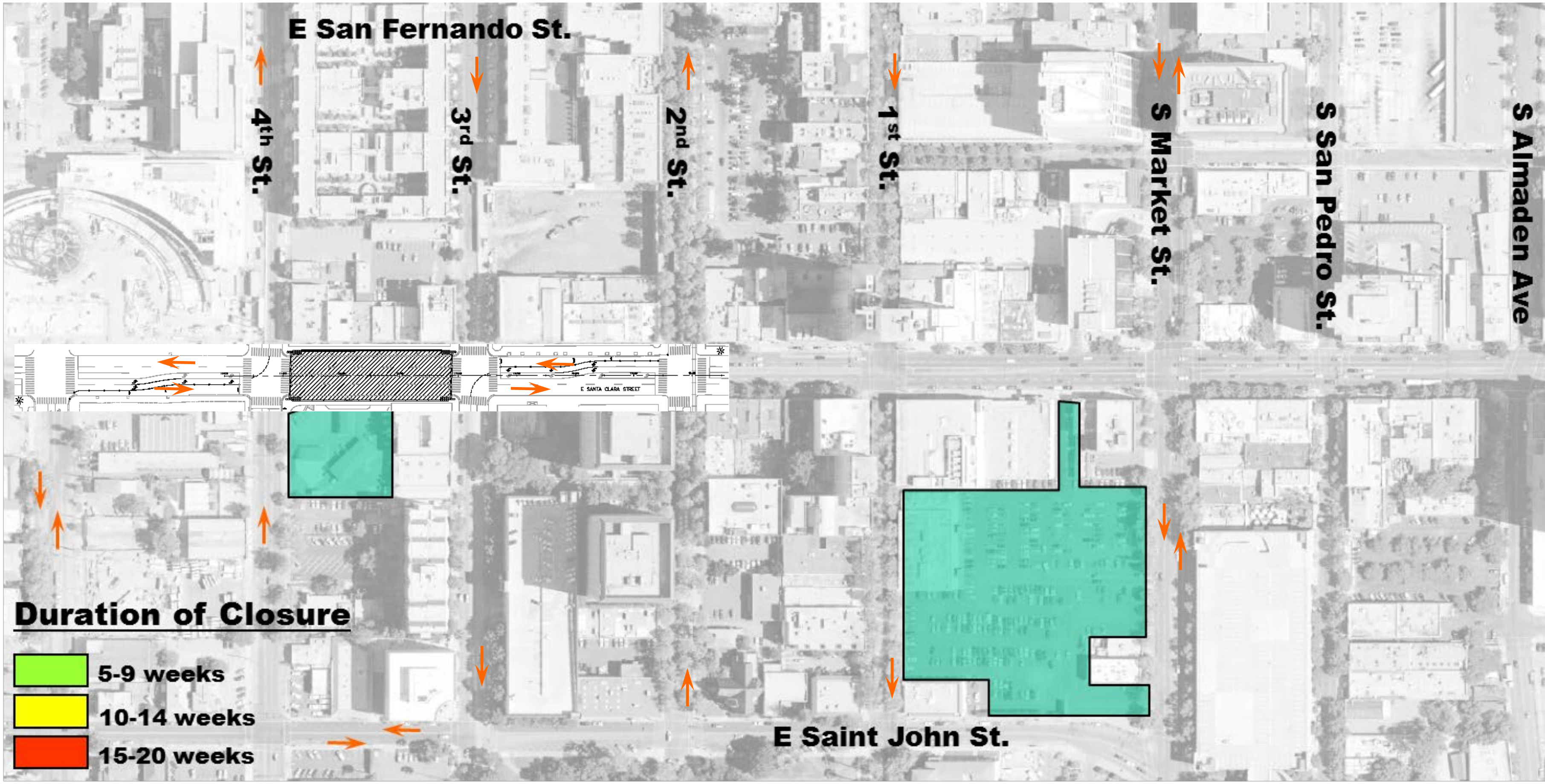
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Duration of Closure
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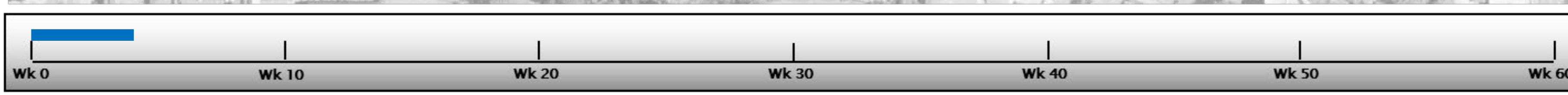
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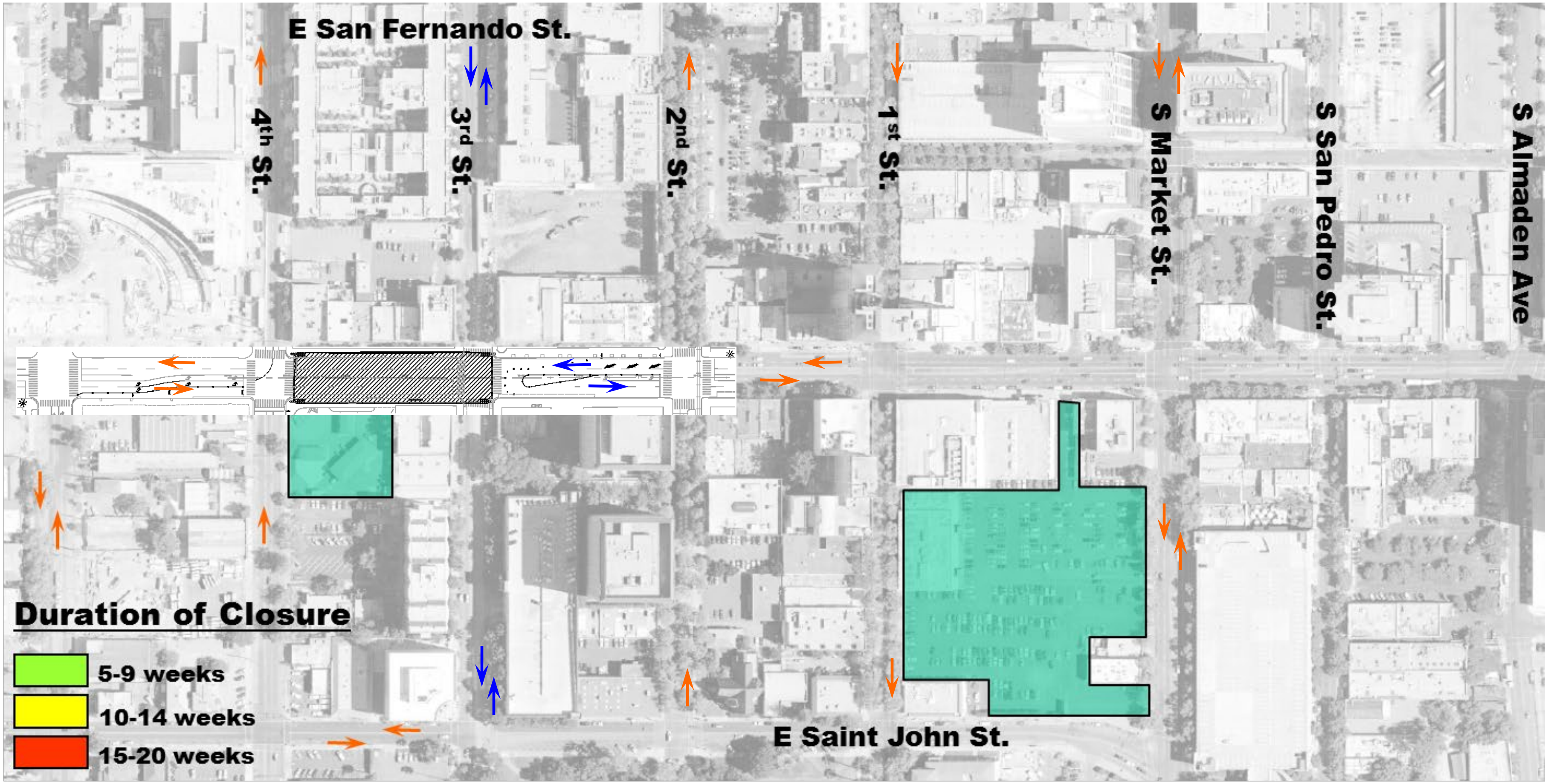

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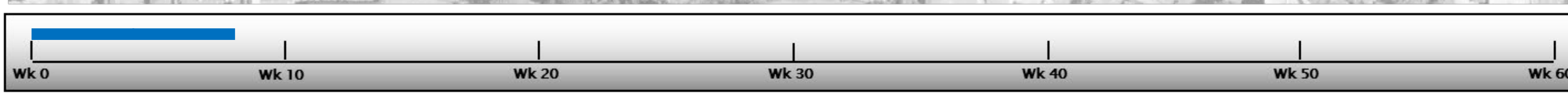

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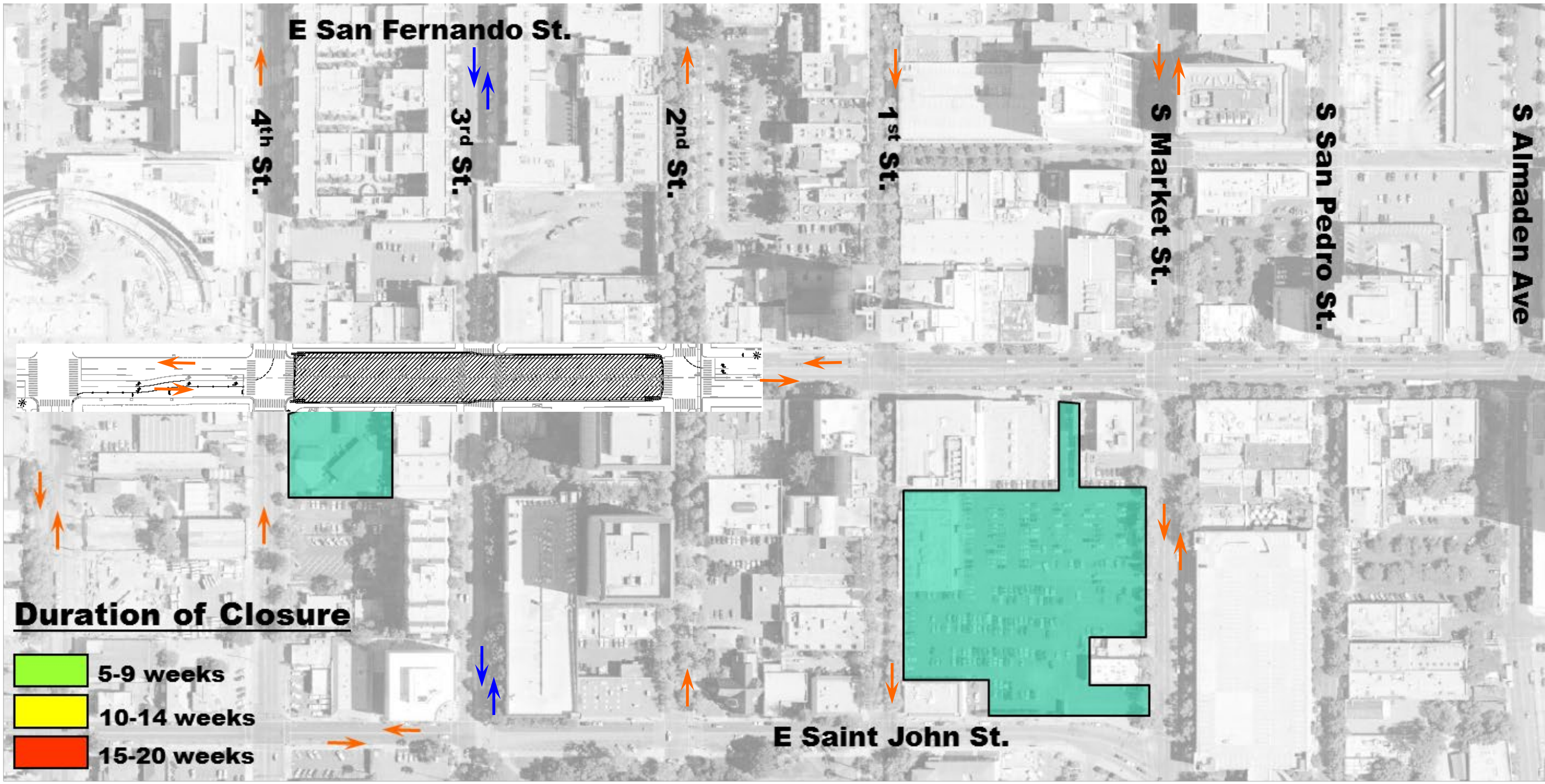

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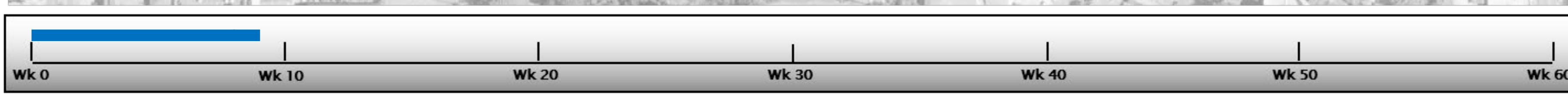

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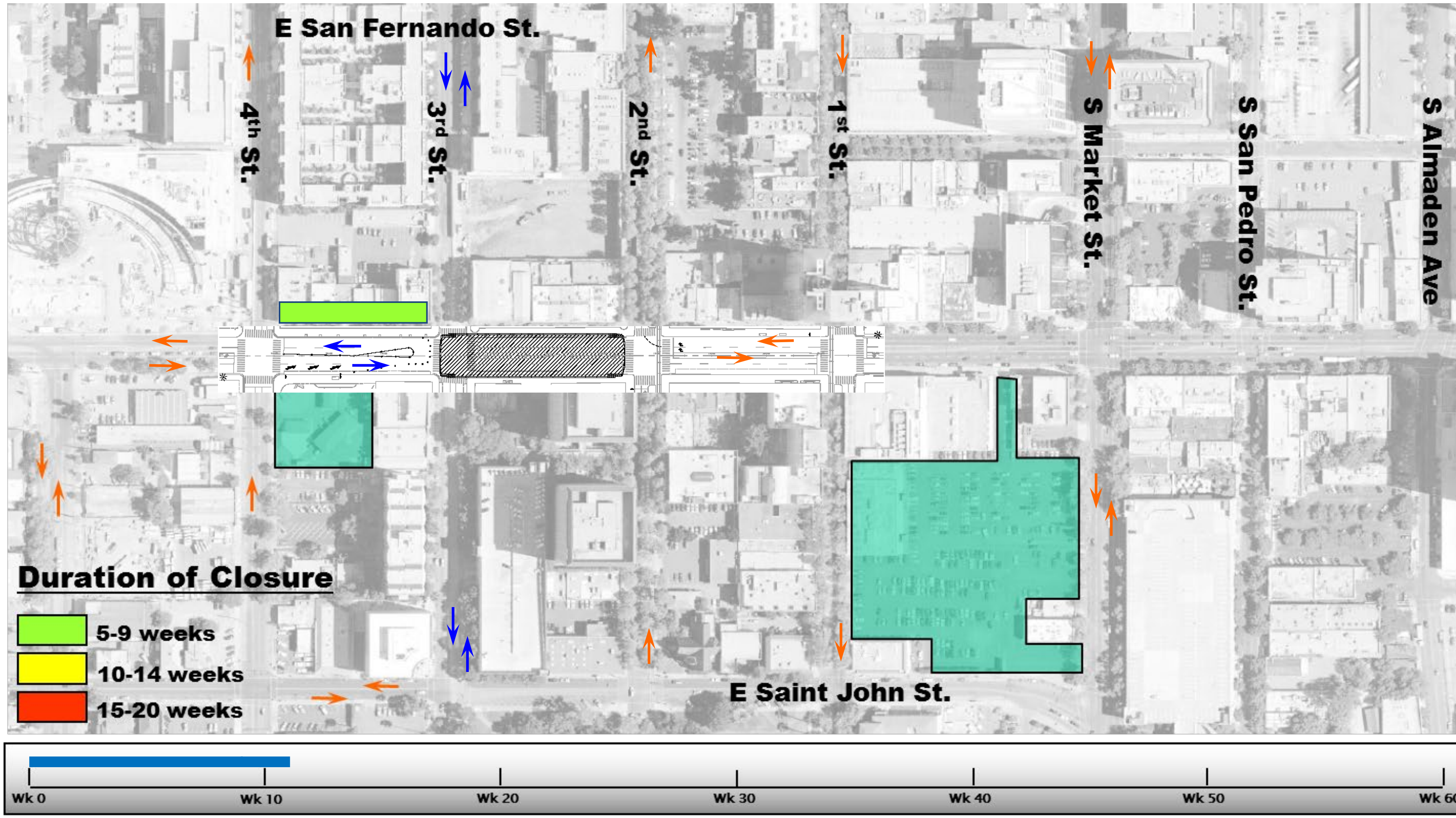
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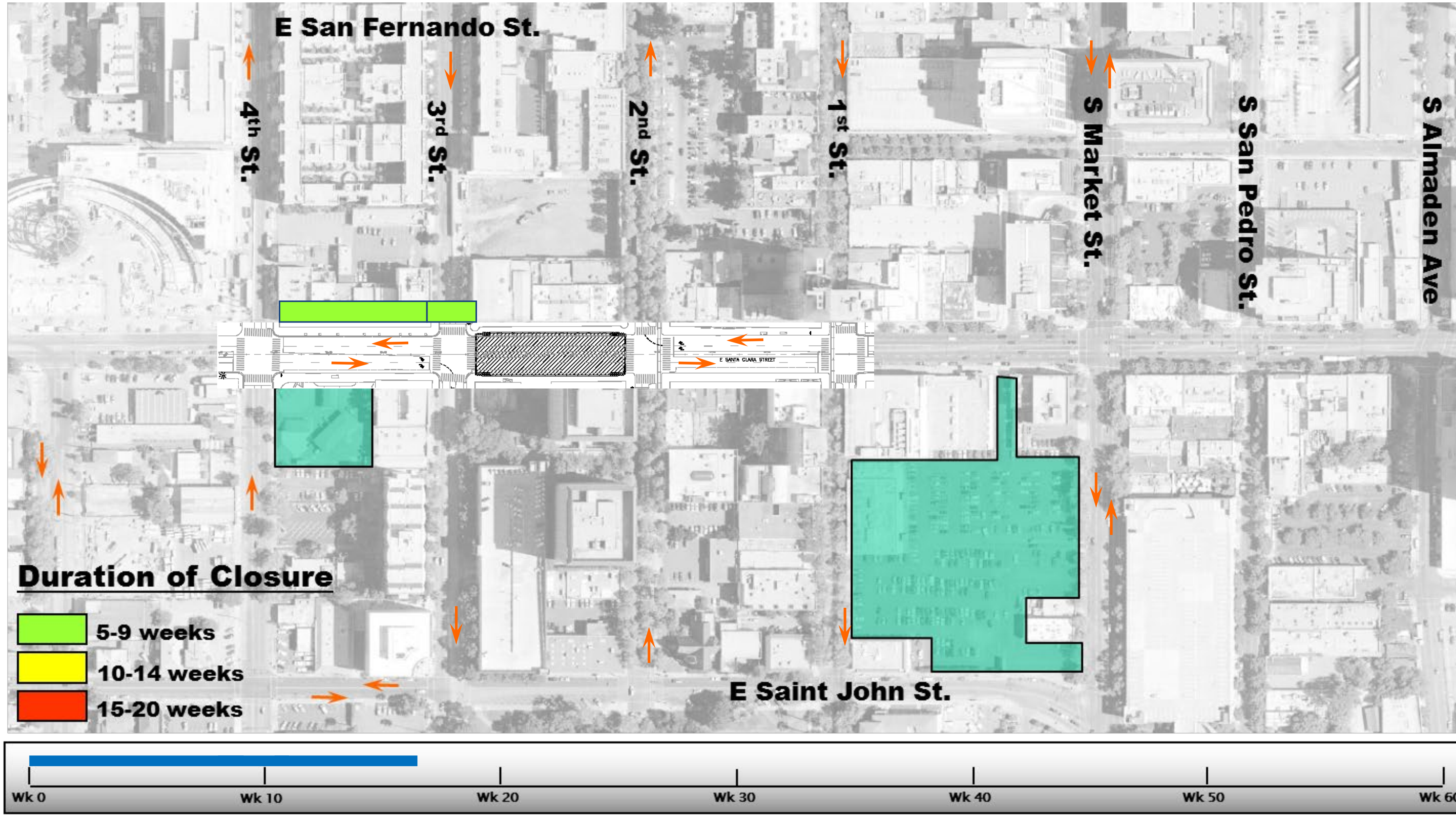
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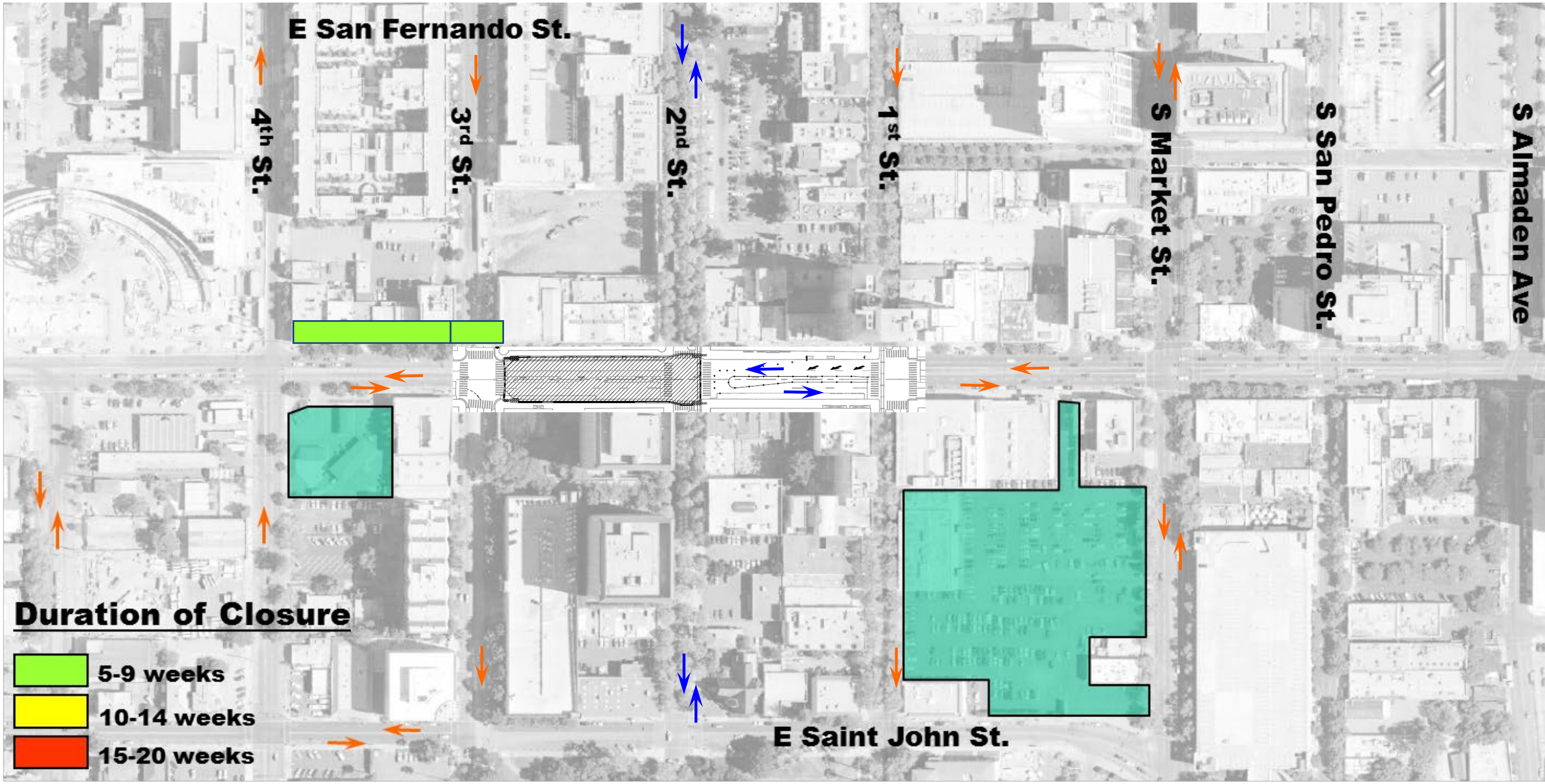

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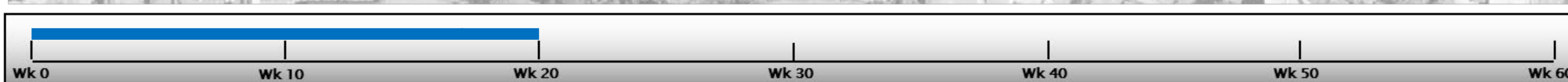

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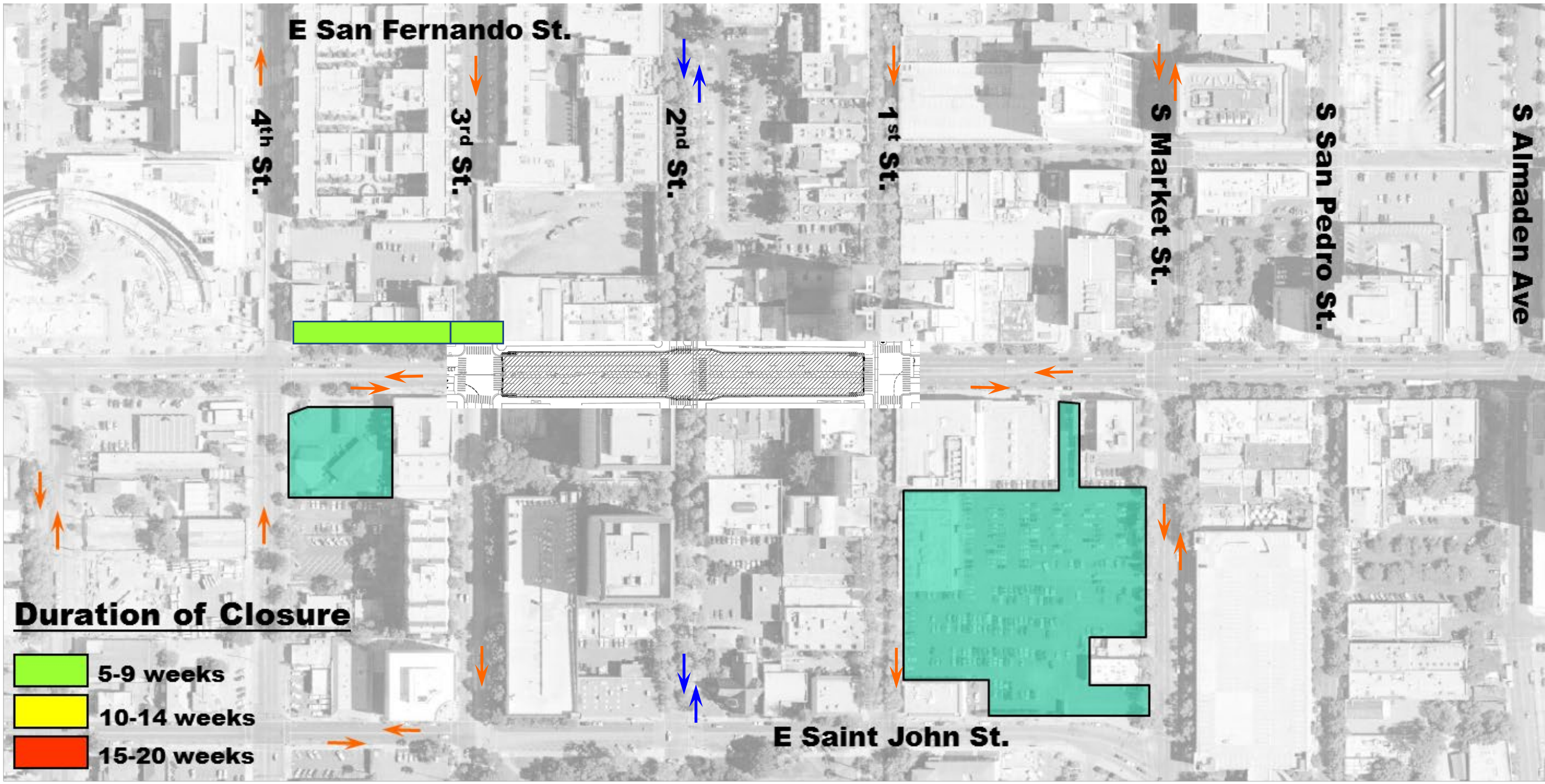

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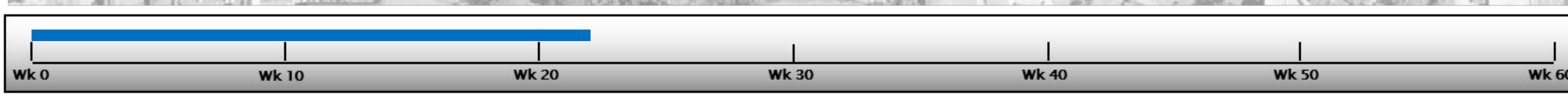

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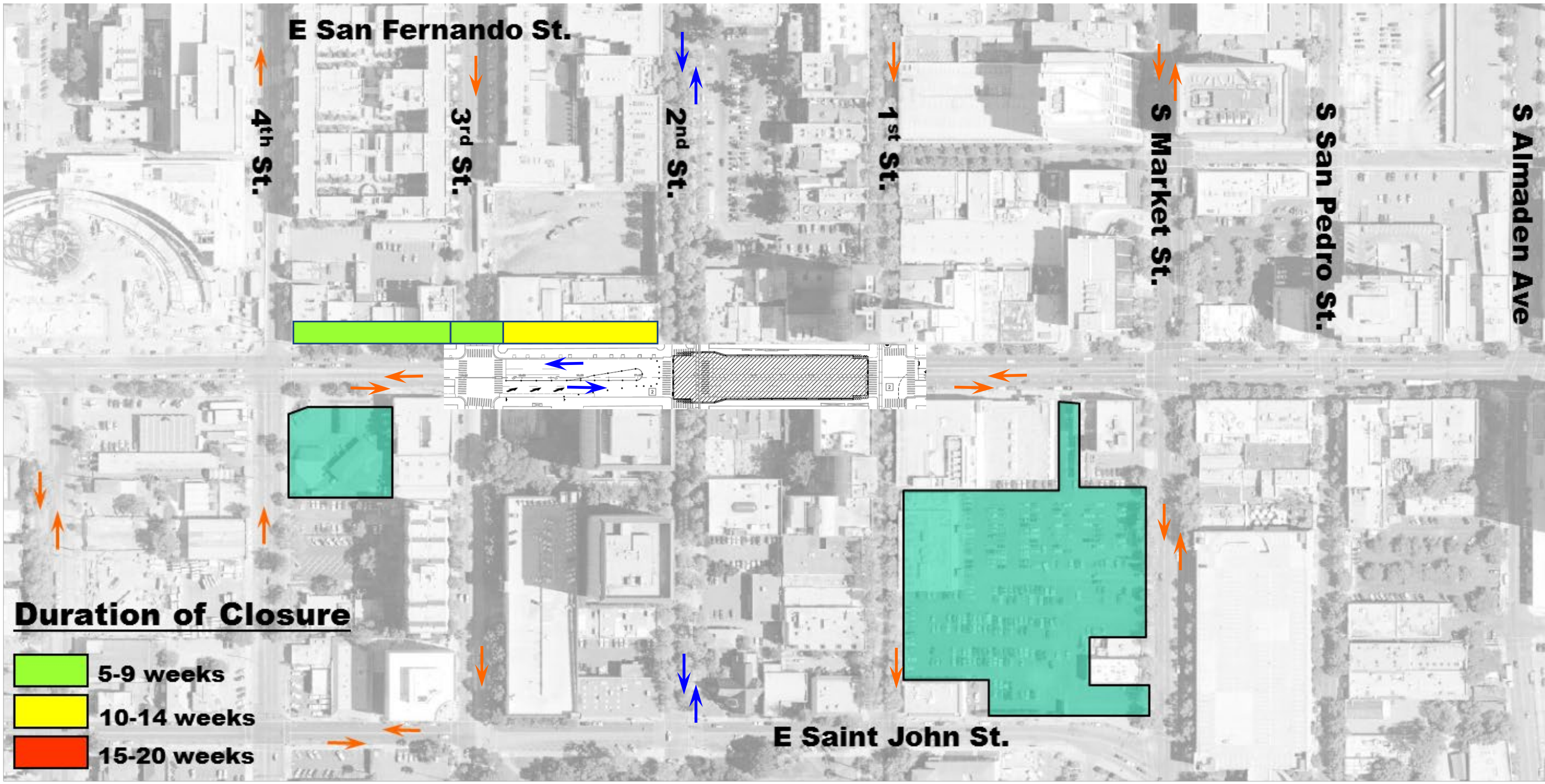

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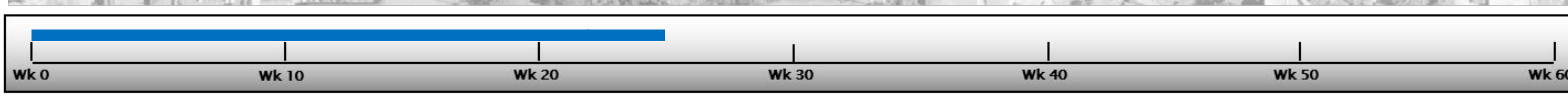

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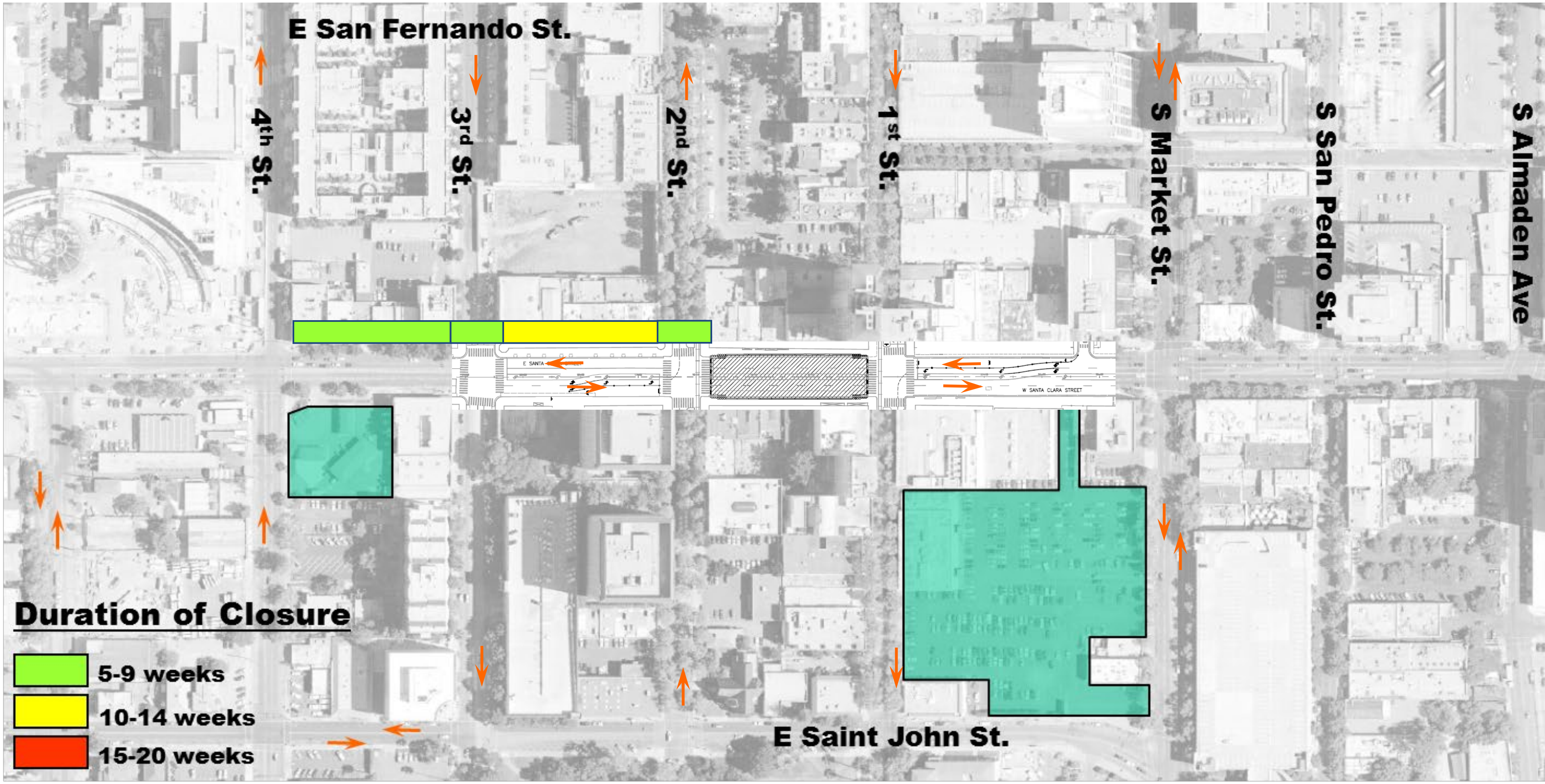

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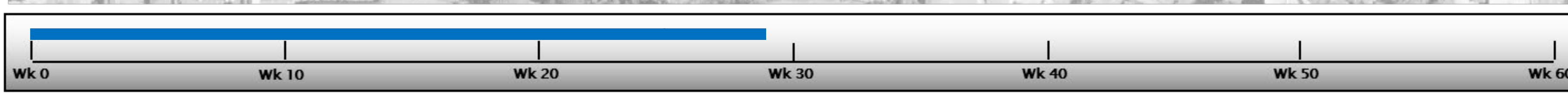

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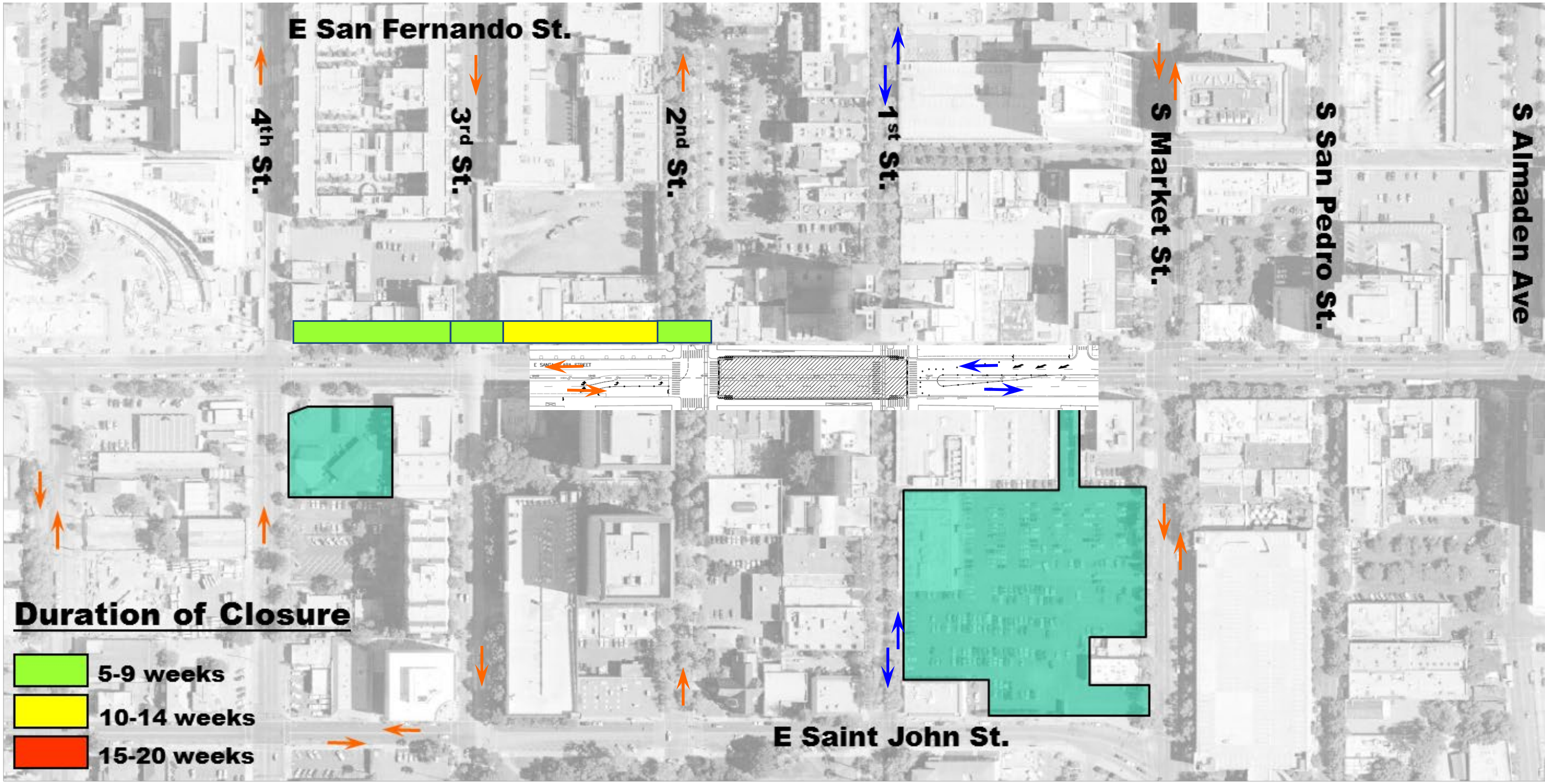

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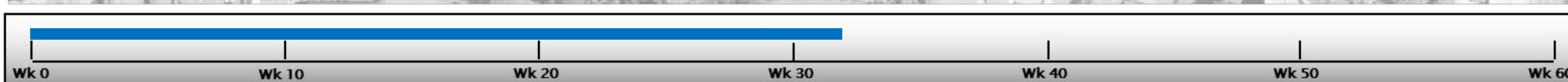

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Phase 11


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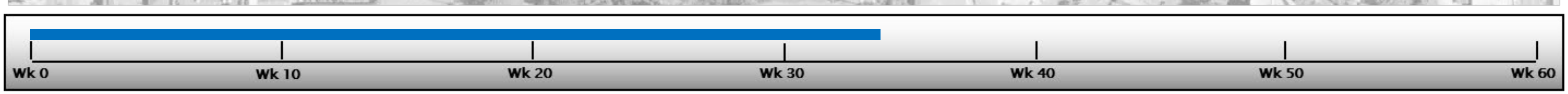
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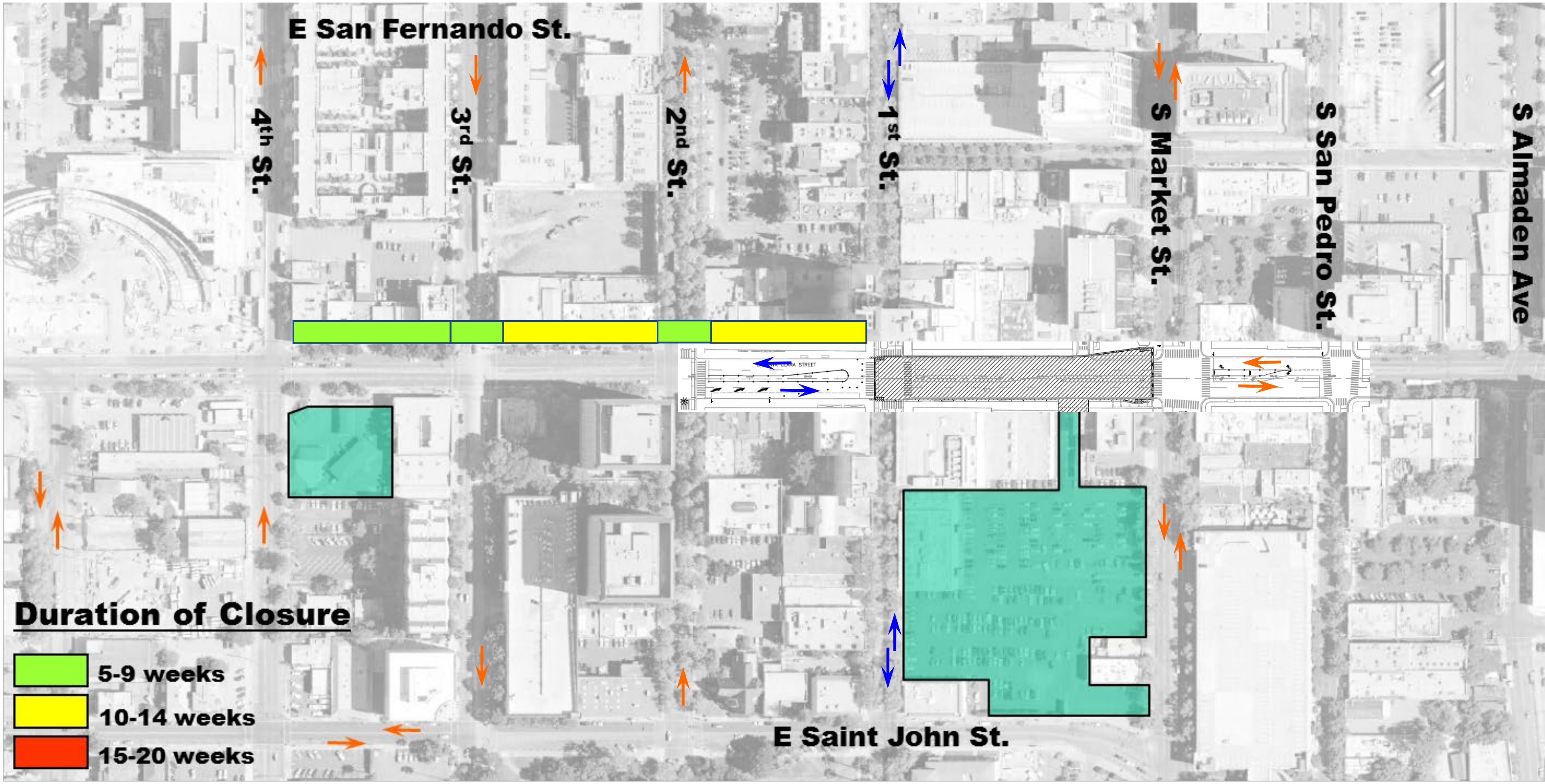
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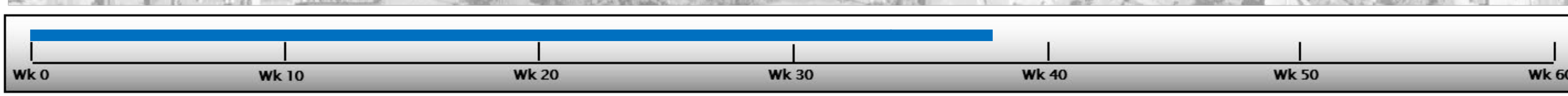
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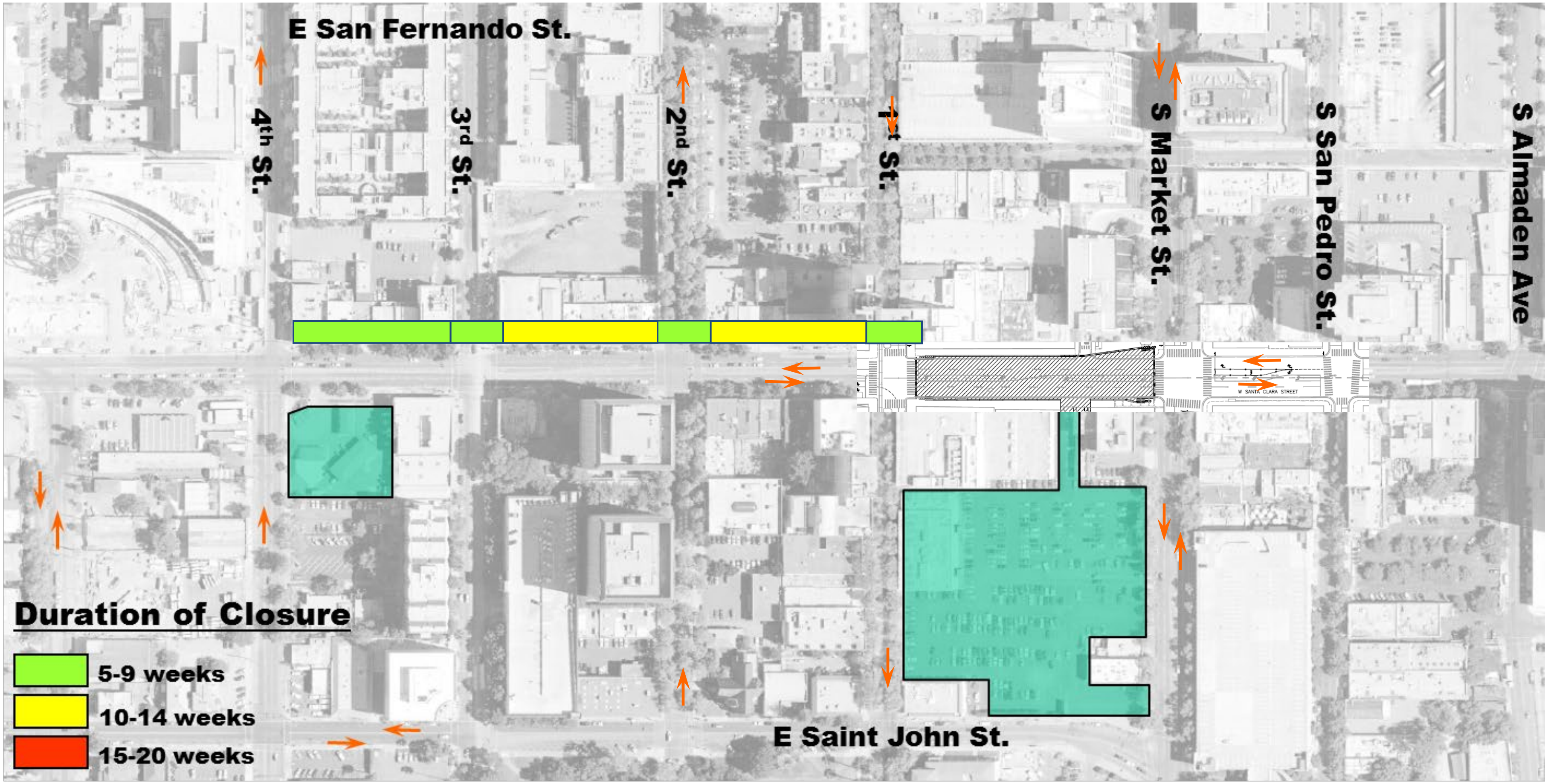
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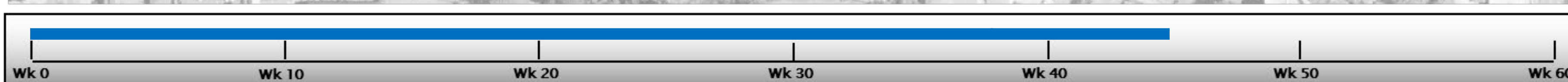
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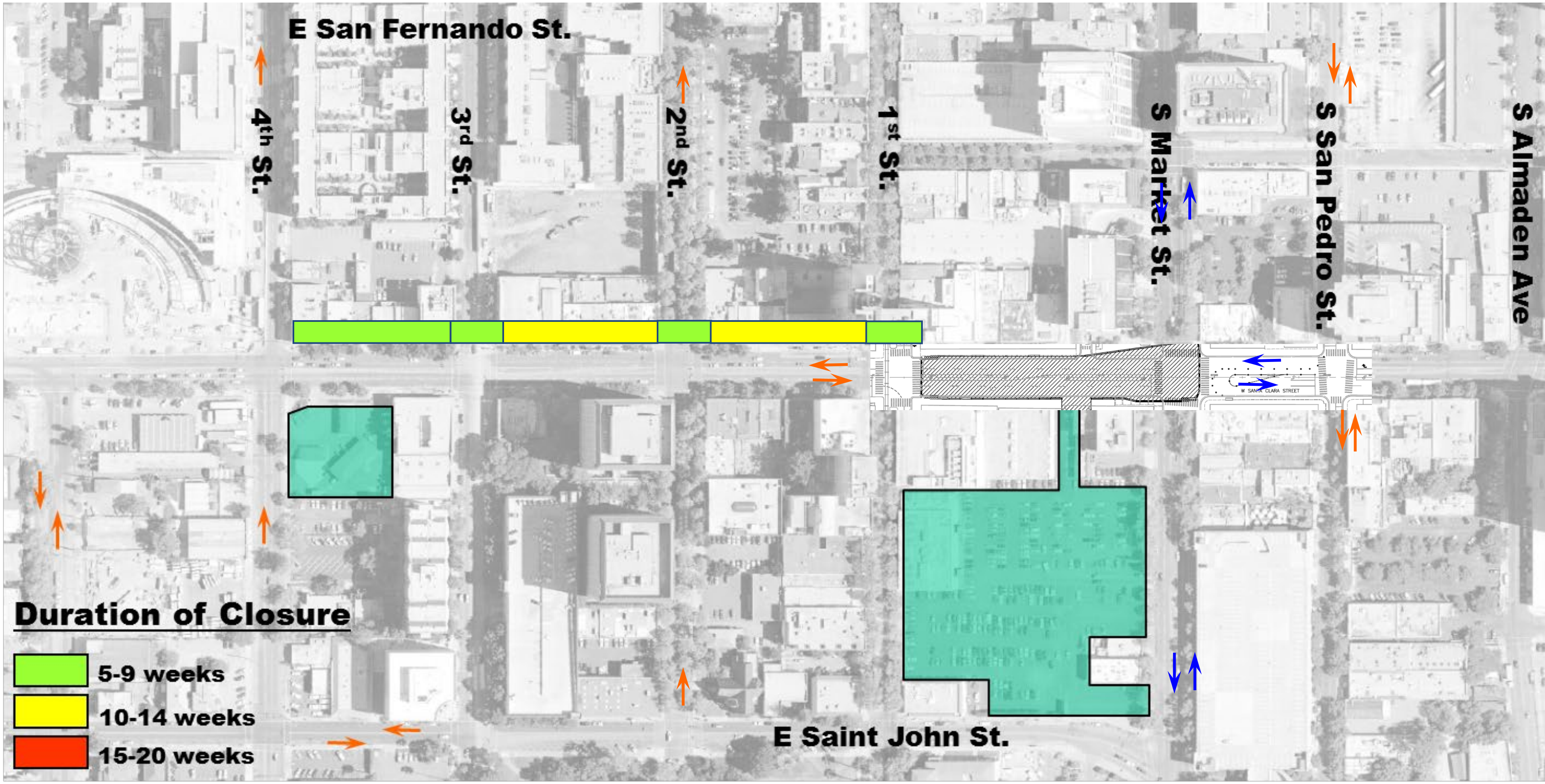
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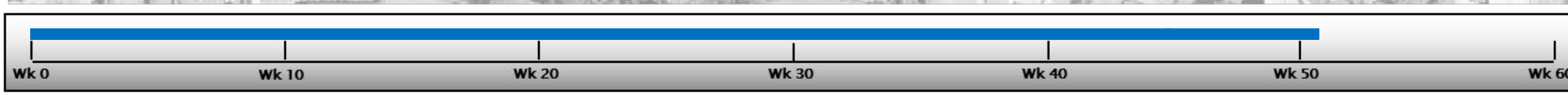
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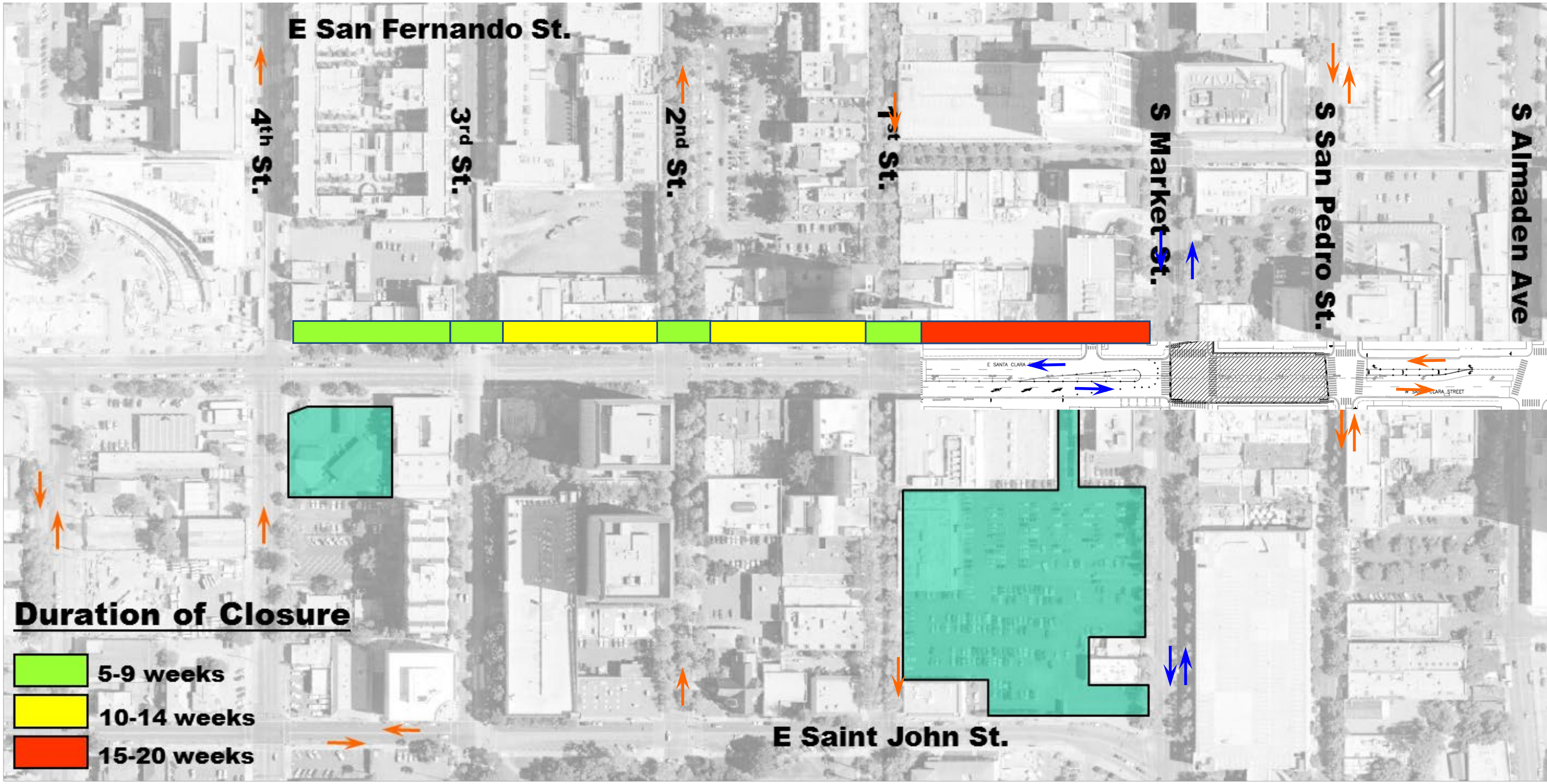

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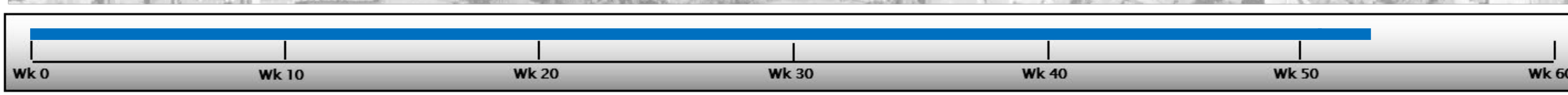

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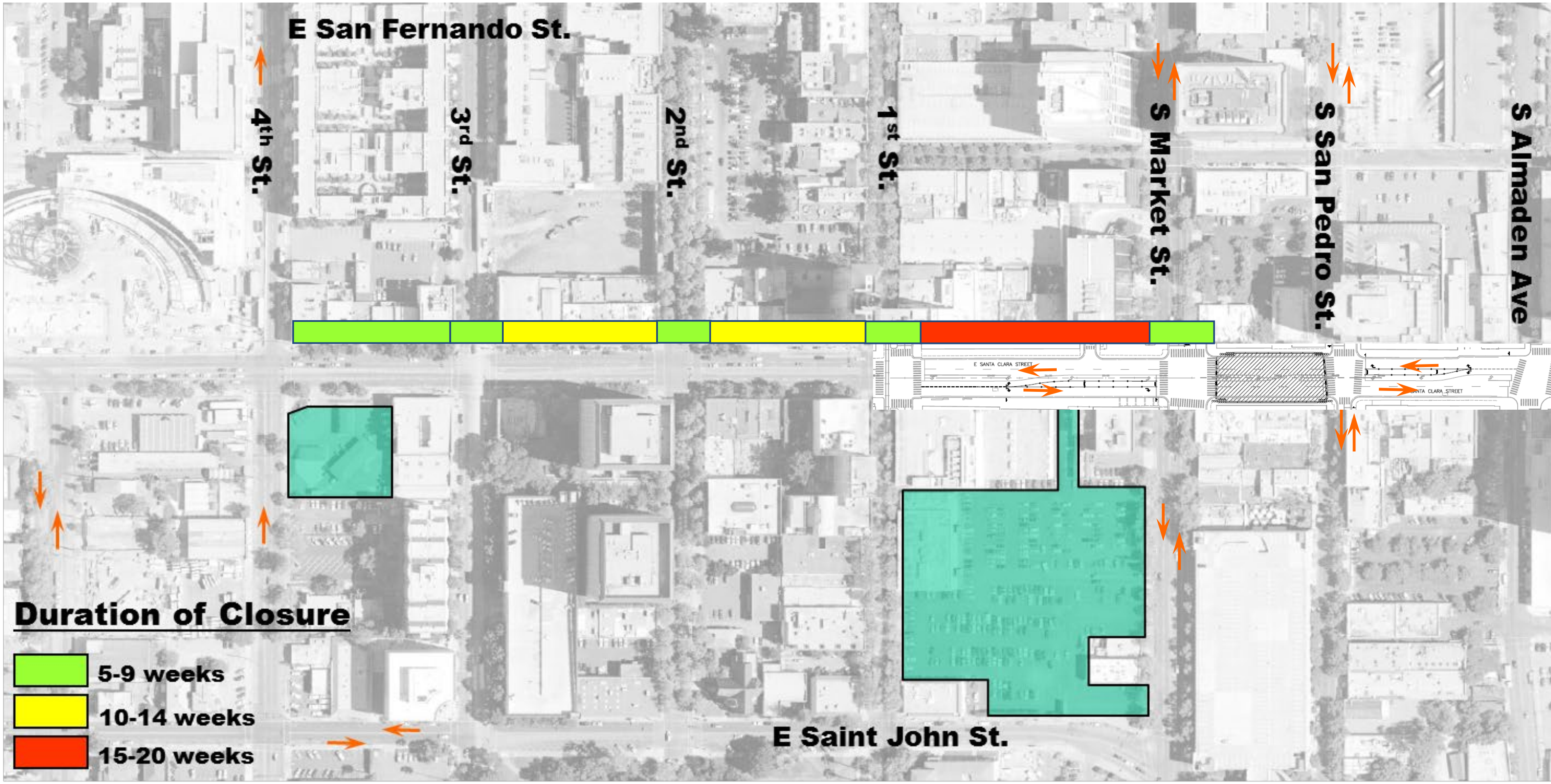

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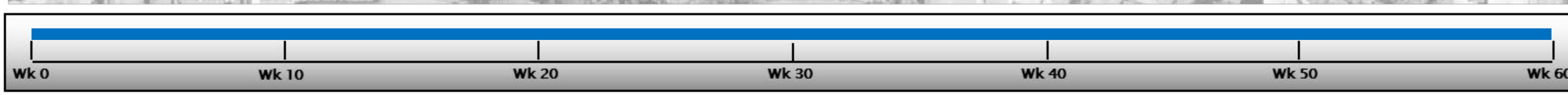

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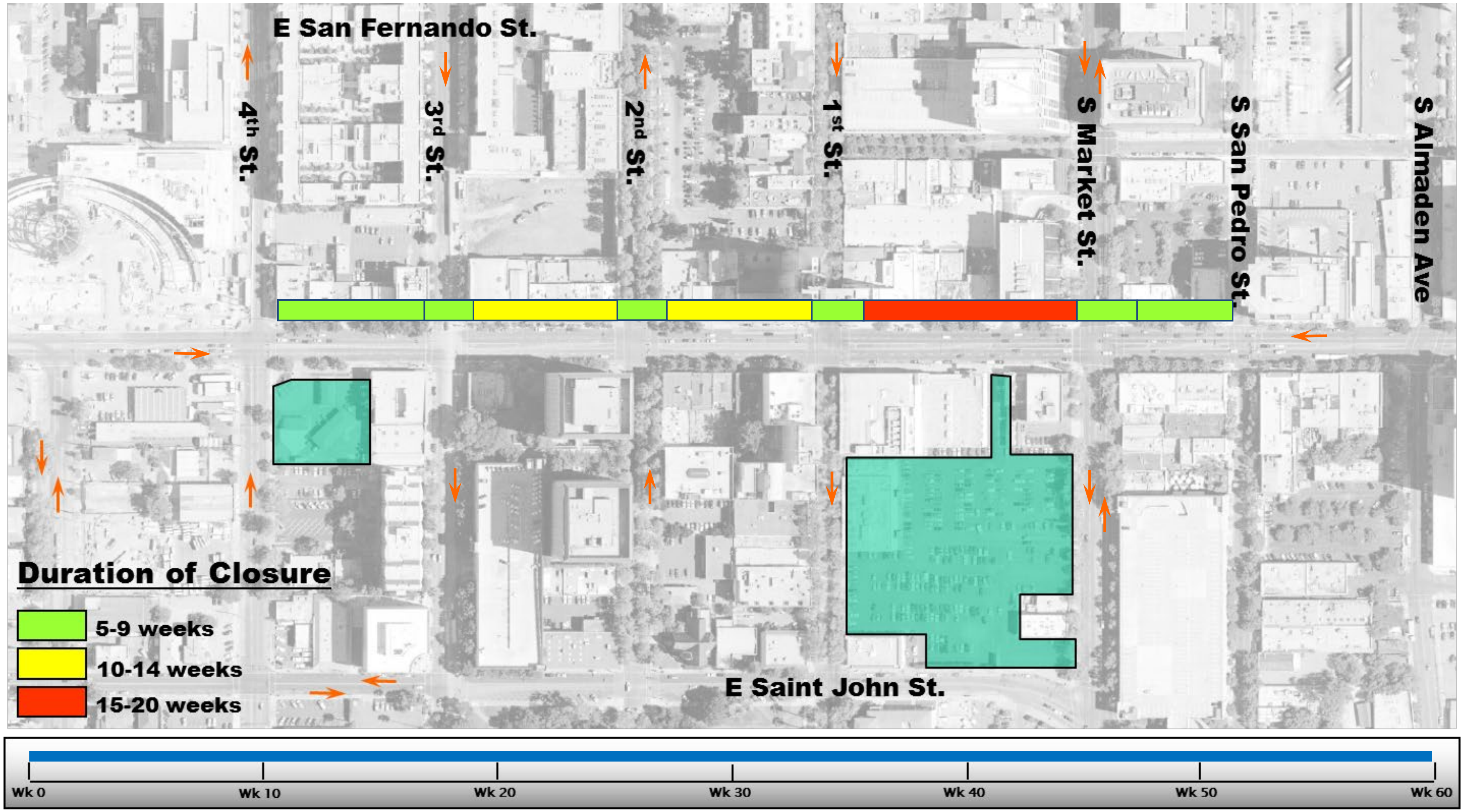


TECHNICAL MEMORANDUM

To: VTA BART Silicon Valley (BSV) Phase II Project Team

CC: Robert JF Goodfellow, PE

From: James J. Brady, PE

Date: 8 August 2025

Subject: **VTA BSV Phase 2 Extension Project - Twin Bore Risk Analysis Update 2025**

Executive Summary

This memorandum summarizes our review of the current state of the risk profile for a Twin Bore Option to construct BSV Phase 2. Our review encompassed the original efforts on the Twin Bore option culminating in a 65% Design in 2008, the updates performed for the comparative analysis (vs. Single Bore) performed in 2016-2017, and the most recent efforts by the Mott MacDonald-Wong (MMW) Engineering team to update the cost estimate and schedule in 2024 (VTA's BART Silicon Valley Phase II Extension Project – Twin Bore Estimate Update Rev. A, August 22, 2024, by MMW.

The 2024 update by MMW did more than update the costs of the previously uncompleted 2008 design to 2024 dollars, it also evaluated and estimated the impact of known changes in the project's regulatory requirements, and construction standards that have occurred to the program in the ensuing years. An example of this was the revision of the 2008 cut-and-cover stations to have non-continuous concourses and relocating their back-of-house rooms in the concourse area to a basement area adjacent to the stations. Another significant physical change involves the relocation of the Diridon Station from the Diridon South alignment (2008) to the Diridon North alignment (2024) which now requires jacking a concrete box beneath active Caltrain tracks. Another significant source of change incorporated in the 2024 update are the regulatory changes which included addressing changes to the environmental clearance process. Other contractual changes that differed from the Single Bore model were also evaluated in the update and included basing all the construction contracts on a Design-Bid-Build (DBB) model and contractually procuring the project as three independent DBB heavy civil contracts for the twin bore tunnels and stations.

While no formal workshops were held with the Twin Bore (TB) project update team to assess the updated risk profile for the Twin Bore approach in 2024-2025, the discussion presented in their report of the update process itself allowed us to describe risks to the cost and scheduling effort that were able to be consolidated into an updated risk register. The resulting top ten risks to the Twin Bore approach are:

1. Project cost and schedule risk due to adjacent stakeholders' reactions due to construction impacts from the Twin Bore station excavations
2. Risks to project due to greater than anticipated time to update the 2008 design to achieve seismic code compliance
3. Risk of additional cost growth (beyond Class 4 ranges) from the 2024 estimate due to lack of design completeness (latest TB estimate is Class 4 which can range from -15% to +50%).
4. Risk of damage to the Caltrain electrified tracks at Diridon station occurs during the jacked-box operations due to TB station geometry reconfiguration (changing to Diridon North configuration).
5. Cross-passage construction, unable to proceed in parallel to TBM tunneling delays project completion due to installation delays resulting from worse than predicted ground conditions
6. Cut and cover station boxes expand beyond the area defined in the base estimate due to late changes in spacing requirements
7. Construction costs and schedule impacted due to surface-applied ground treatment for cross-passages being more than anticipated in base estimate
8. Risk of cost, schedule and reputational damage from surface street interruption due to street decking of E Santa Clara St. for San Jose Downtown Station exceeding planned durations.
9. Additional construction costs due to extensive monitoring and instrumentation of existing buildings required beyond that established in preconstruction specifications/design.
10. Risk of schedule delays due to limited number of TBM Manufacturers capable of producing 2 ea. 17-'10"' ID. and 2 ea. 18'-10" ID EPB machines (4 TBM's) within a short timeframe.

Conclusion

Strategic Implications

These Top 10 Twin Bore Risks should serve as a foundation for any ongoing planning, stakeholder engagement, and mitigation strategies for the Twin Bore approach. Proactive management of design finalization, supplier coordination, and community impact will be crucial for maintaining the project viability of the Twin Bore approach should VTA elect to continue advancing this option.

Key Findings:

- **Project Cost & Schedule Risks**
    - Construction impacts at station sites may provoke stakeholder backlash, affecting project timelines and budget.
    - Design updates needed for seismic compliance could exceed anticipated effort.
    - The Class 4 design estimate risks significant cost growth beyond projected ranges (-15% to +50%).
- **Construction Constraints**
    - Reconfigured geometry at Diridon station may damage Caltrain electrified tracks during jacked-box operations.
    - Delays in tunneling due to poor ground conditions will stall cross-passage construction.
    - Late changes in station box sizing may lead to expanded cut-and-cover zones and higher costs.
- **Operational & External Challenges**
    - Surface ground treatment requirements for cross-passages may be underestimated, impacting both cost and schedule.
    - Extended street decking at E Santa Clara St. may result in public disruption and reputational damage.
    - Extra building instrumentation and monitoring are needed exceeding the current design scope.
    - Limited global TBM manufacturing capacity threatens schedule adherence (for 4 TBM's).

From the 2025 Top 10 list, and similar to the Twin Bore risks identified in 2017, there is very significant risk from the open-cut station excavations in the Twin Bore approach (Risks #1 and #8) that continues to rise to the top of the Twin Bore risk profile. From our vantage, we further caution that the threat of the delays incurred while updating the 2008 Design (Risk #2) are probably underestimated. The reality is that after 17 years, that design must be considered sub-30% in 2025. The MMW did a good job identifying this risk and addressing the most significant and noticeable changes to that design, however, the full impact of all the required changes won't be confronted until a design team is engaged in the update task. To advance the Twin Bore approach we advise that a comprehensive review of the redesign/contract delivery process be performed and that the design team focus on reducing the risks in the 2025 Top Ten list presented herein.

Attachment C

Technical Study Commissioned by Santa Clara Valley Transportation Authority (VTA)

Twin-Bore Versus Single, Large-Bore Tunnel Configuration Technical Review

December 3rd, 2024

Twin-Bore Versus Single, Large-Bore Tunnel Configuration Technical Review

Technical Study Commissioned by Santa Clara Valley Transit Authority (VTA)

TABLE OF CONTENTS

1. Executive Summary

VTA requested a technical review of the twin-bore tunnel configuration versus a single, large-bore tunnel configuration. The review focused on three key areas: (1) current market trends in the adoption of twin-bore versus single, large-bore configurations, (2) an evaluation of the differences between VTA's BSVII Program and the Barcelona Metro System, the model project initially used as a reference for BSVII, and (3) the potential impacts of reverting to a twin-bore configuration.

Globally, the current industry trend in the development of underground metro systems using machine-excavated tunnels in soft or relatively soft ground conditions has increasingly favored the consideration of single, large-bore configuration. This shift has been driven by two key factors: (1) advancements in single, large-bore tunneling methodologies and the development of tunnel boring machines (TBMs) capable of handling significantly larger diameters, and (2) the operational and construction benefits of integrating station facilities within the larger-bore, minimizing surface disruptions associated with constructing separate underground stations.

Emerging studies and modern metro system design considerations suggest that single, large-bore tunnels may offer some cost advantage over twin-bore systems. This cost advantage is not because the twin-bore tunnels themselves may be cheaper to construct than a comparable single, large-bore tunnel but because twin-bore systems require additional external facilities, such as ventilation shafts, emergency access points, and large, separate stations. These facilities, which would otherwise be partially incorporated into a single, large-bore tunnel, contribute to the relatively higher overall costs of twin-bore systems.

The primary advantages of twin-bore tunnel systems continue to include that they can be constructed at shallower depths and the significantly lower volume of excavation required, less than half that of single, large-bore tunnels. However, when factoring in the costs of stations and other necessary facilities associated with twin-bore systems, the net effect is that the single, large-bore systems have shown to be competitive to twin-bore systems.

Performing a high-level constructability review of a twin-bore tunnel system station configuration for BSVII confirms the greater surface impacts of a twin-bore/cut-and-cover configuration compared to the single, large-bore approach. Analysis of these greater impacts also confirms that changing the basic tunnel configuration on BSVII will likely increase program costs, result in greater impacts to the community, and delay the project.

Arguably, transit projects in the U.S. typically cost significantly more than comparable projects in other parts of the world, including in Europe and for the Barcelona Metro. These cost disparities are less likely to result from differences in tunnel configuration and more likely due to factors such as: (1) European metro systems tend to use shorter trains at faster intervals, allowing for the construction of more compact facilities than U.S. systems, (2) the environmental permitting process in the U.S. is longer and more complex than in other parts of the world, and (3) third-party stakeholder input for the design of systems in the U.S. tends to have a much greater impact on overall cost.

2. Scope of Study

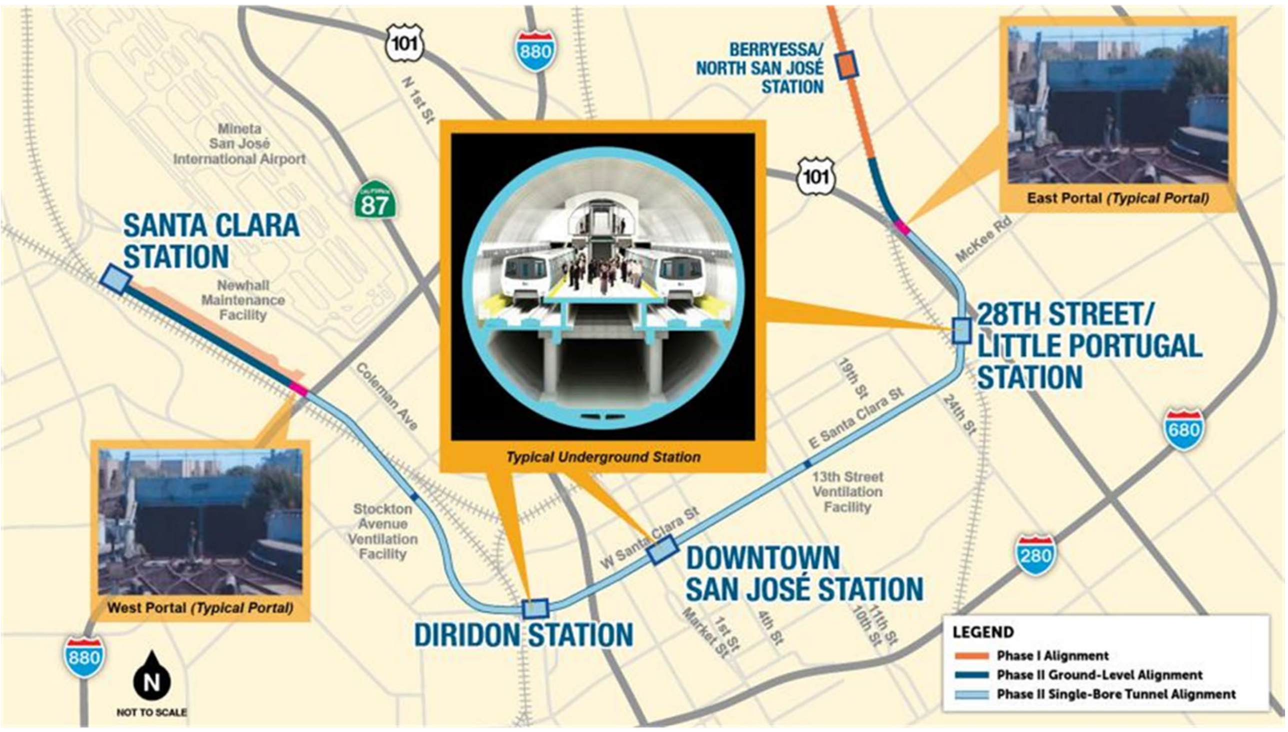
Bechtel and subject matter experts (SMEs) under the purview of Bechtel will:

1. Provide a summary of current industry market trends associated with selection of twin-bore versus single, large-bore tunneling configurations for major transit projects;
2. Discuss fundamental differences between the Barcelona Metro's single, large-bore system and the BSVII single, large-bore system;
3. Perform a high-level constructability review of a twin-bore configuration applied to the current project alignment stations. Address major potential program impacts, including right-of-way, utility relocations, cut-and-cover, and assess potential impacts related to changing to a twin-bore tunnel configuration; and
4. Prepare a comparative list of pros and cons related to twin-bore and single, large-bore configurations.

Qualifications and Limitations for the scope of this technical review:

1. Did not prepare any new cost estimates or schedules/analysis for the BSVII Program or on a twin-bore design;
2. Did not provide any comments or present any views on existing cost estimates, estimating processes, ongoing negotiations, forecast schedules, nor opine on the accuracy or conclusions provided in previous comparative studies evaluating the twin-bore design versus a single, large-bore configuration;
3. Did not comment or opine on areas outside of potential impacts to the BSVII Program from a constructability perspective, including but not limited to: Engineering/Design, Risk, Quality, Safety & Health, Operability of the System, Commercial, etc.;
4. Assumed that the archived 65% twin-bore design of 2008 (in which Bechtel participated) cannot be re-used, except as a conceptual guideline or general basis for the beginning of a new re-design; and
5. Assumed that any twin-bore design alternatives would have a conventional twin-bore BART Metro station configuration requiring open cut-and-cover construction methodology.
6. Bechtel has not considered a hybrid model of single, large and twin-bore configurations as part of this report.

VTA's BART Silicon Valley Phase II Extension (BSVII) Project alignment and stations.



3. Introduction

In May 2024, VTA approached Bechtel and requested that they provide a technical review of the twin-bore tunnel configuration versus a single, large-bore BSVII tunnel configuration to help address discussions in the public related to the costs of the current single, large-bore tunnel design of the BSVII Program. In response to VTA's request, Bechtel employed internal subject matter experts (SMEs) as well as tunneling SME's working with Bechtel on the BSVII Program.

While not strictly limited to a direct comparison of single versus twin-bore configurations, this review attempts to indirectly address recent discussions in the public sector arguing that the twin-bore configuration would have been, and still may be, a more cost-effective approach to delivering the Program. However, in discussing the relative costs between the two tunneling approaches, it must be noted that this report did not engage in or perform any estimating or direct cost analysis of either tunnel configuration for the BSVII Program. Rather, it depended on the professional experience of the authors, and recent market trends in the tunneling industry related to the development of projects using either large bore single or twin-bore tunnel configurations.

The question of which approach, twin-bore or single, large-bore, may be more cost-effective cannot be discussed without first understanding the basic differences between the two configurations. These differences in turn inform the understanding of the costs, impacts, and effects on the BSVII Program due to a change from the current approach.

As a point of reference for the discussion in this report, small bore tunnel diameters for twin-bore tunnels refer to tunnels with an excavated diameter in the range of 18 to 24 feet. Similarly, single, large-bore tunnels referenced in this technical review have an excavated diameter greater than 24 feet.

Additionally, this study used historical technical information available from the 65% design completed by Hatch Mott MacDonald/Bechtel (HMM/Bechtel) for VTA archived in 2008 for illustrative purposes, only with a focus on the impacts associated with station construction for a twin-bore configuration (see Section 7).

4. Background

As mentioned in Section 3, Bechtel, in joint venture partnership, collaborated with Hatch Mott MacDonald to complete a 65% design of a twin-bore, conventional cut-and-cover station approach for the BSVII Program. The 65% design was formally archived by VTA in 2008 instead of the single, large-bore tunnel approach. The APTA Peer Review of November 2022 covered the selection of the single, large-bore tunnel over a twin-bore configuration, concluding that the construction of the single, large-bore system generated fewer impacts to the community and that the twin-bore approach offered no clear cost advantages.

There was no information available to the authors of this report relating to cost analysis to support statements by APTA that would indicate a relative advantage of either single or twin-bore configurations. However, based on the collective professional experience of the authors contributing to this report, it can be generally said that prior to 2008, there may have been a slight cost advantage to a conventional twin-bore tunnel system compared to a single, large-bore system. Regardless, any cost advantage the twin-bore may have had over a single, large-bore is now negligible at best, as the technology and methodology of single, large-bore tunneling has evolved in the last two decades, The cost advantage that a twin-bore configuration may have had in 2008 is reasonable to justify, given that large-bore tunnel diameters of that era were relatively few, and the technology available to design TBMs and the methodology to construct large-bore tunnels were far less developed than they are today. In today's construction environment, those advances in technology and methodology have neutralized any cost advantage that twin-bore systems may have historically held.

Stating that there is no longer a generic cost differentiator between a typical single, large-bore, and a twin-bore configuration, one must consider that the cost evaluation performed in 2008 would have compared a smaller tunnel diameter than the current nominal 54-foot diameter BSVII design. As will be briefly discussed in Section 6, the original BSVII single, large-bore design considered a nominal diameter of 48 feet. Additionally, when considering a cost evaluation of either system of tunnel configuration, the costs of the station and ventilation facilities need to be factored into the decision.

The reasons for the increase in BSVII's single, large-bore tunnel diameter from 48 feet to 54 feet are not part of this discussion but are mentioned herein only to note that the current tunnel design has evolved and resulted in a larger tunnel than was conceptually envisioned.

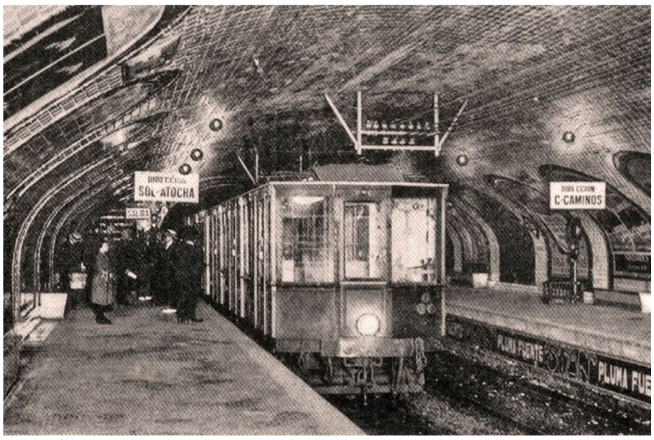
5. Evolution of Underground Metro Tunneling Systems

Metro rail tunnels in the U.S. and Northern Europe (e.g., the UK and Germany) were traditionally constructed using two parallel tunnels of equal diameter, commonly referred to as twin-bore systems. In this configuration, each tunnel typically is large enough for only a single trackway with physical access between the two separate tunnels provided by smaller excavated access tunnels known as adits. The adoption of the twin-bore configuration in early metro projects was largely influenced by the tunneling excavation limitations of the time, whether using TBMs or by conventional excavation machinery and manual methods.

The earliest metro system, the London Underground, adopted a twin-bore configuration due to the limitations of manual tunneling methods at the time. Increasing the tunnel diameter made construction more complex, expensive, and unsafe. Mining larger-bore tunnels capable of accommodating twin tracks within a single tunnel was simply not feasible compared to constructing multiple smaller-bore tunnels. For these early metro systems, mined stations typically featured a cross section with a three-tube configuration: the side tubes accommodated the tracks and the platforms, while the central tube provided access between the surface and platforms via inclined adits.

Single, large-bore tunnels began appearing in metro systems during the early phases of the Paris Metro. However, these were relatively shallow structures constructed using open cut-and-cover methods, not mined. Other metro systems, such as those in Madrid and Barcelona, adopted a similar single, large-bore tunnel configuration containing two separate tracks with side platforms at the stations. In contrast to the cut-and-cover tunnels of the early Paris Metro, the single, large-bore tunnels in Madrid and Barcelona were mined. These mined tunnels were designed to be approximately 26 to 30 feet wide to accommodate both tracks and a sidewalk. Stations in these systems required excavating caverns, approximately 60 feet wide, with multiple cross passages connecting both platforms.

Image of the Historic Madrid Metro.



Many metro systems have since adopted either the twin-bore or single, large-bore tunnel configuration, with ventilation systems and passenger egress facilities tailored to meet the specific needs of each system. Early metro systems featured relatively short distances between stations, and emergency egress from the tunnels was typically provided via station platforms. However, as station spacing increased, additional emergency egress provisions became necessary. In twin-bore tunnels, cross passages are installed between the two tunnels, allowing for evacuation from the incident tunnel into the adjacent tunnel. The maximum allowable spacing between cross passages is regulated by NFPA 130, which mandates a distance not exceeding 800 feet. In single, large-bore tunnels, emergency egress shafts are added when the distance between stations exceeds 2,500 feet.

Following the early use of drill-and-blast or manually excavated methods, the introduction of TBMs in tunnel construction began with modest tunnel diameters, typically sufficient for a single-track tunnel with internal tunnel diameters under 22 feet, due to limitations in TBM technology and tunnelling methodology. However, advancements in TBM technology and tunneling methodology enabled the development of larger tunnel diameters, exceeding 30 feet, capable of accommodating two tracks within a single tunnel. Continuous advances have further expanded TBM capabilities, allowing for even larger excavation diameters—up to 40 feet internally—suitable for two-lane road tunnels. These increased diameters have made single, large-bore configurations feasible, accommodating either stacked or side-by-side track configurations. Both configurations eliminate the need to excavate mined cross passages and emergency egress shafts, as these functions are integrated within the single, large-bore tunnel using internal dividers.

Figure 1. Metro Barcelona Line 9. Typical cross section at station platform.

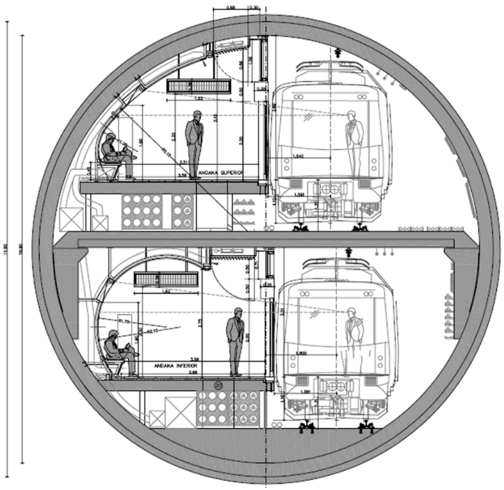
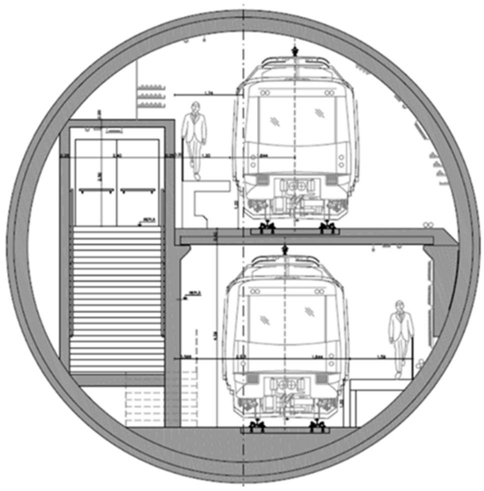


Figure 2. Metro Barcelona Line 9. Typical mainline cross section at cross passage.



Mined excavation of either cross passages or connection passages between tunnels, such as in the twin-bore configuration, poses several technical challenges. The primary difficulty lies in the constrained workspace, as the main tunnel excavation is ongoing, requiring simultaneous support of the tunnel heading with material and muck removal. Typically, cross passage excavation requires ground stabilizing treatment of the surrounding strata be applied first, especially in areas below the groundwater table. Ground stabilization activities are also impeded by the limited workspace and the prioritization of the principal tunnel excavation. Additionally, the TBM's tunnel lining may require strengthening from the inner side to be opened safely. Performing these concurrent activities while the primary activity of the TBM advancing the main tunnel heading is inefficient and adds risk and potential schedule impacts. In contrast, single, large-bore configurations enable more concurrent activities to be executed efficiently.

As TBM diameters in the range of 40 to 45 feet became state-of-the-art, the concept for Barcelona Metro Line 9 was developed, utilizing an excavated nominal tunnel diameter of 41 feet. The Line 9 concept adopted a very large tunnel diameter (Figure 1 and 2), such that different cross sections would be able to accommodate two vertically stacked, independent fire compartments, each containing a single-track. This configuration promoted that in the event of a fire in one compartment, the fire would not spread to the other, thereby preserving an emergency egress path to the non-incident compartment. Each compartment accommodates, at a minimum, a track and an emergency egress walkway. Further to this, each compartment may accommodate where required:

- Sidings and tail tracks at each level.
- Cross connections for pedestrians between both levels (cross passages) allowing one of the compartments to be used as escape route when a fire incident occurs in the other compartment. A pressurized compartment connects both levels with an emergency egress stair, fulfilling the same function as a cross passage between different tubes.
- Rail connections between the upper and the lower track (crossovers). In case of fire, an interlocked emergency gate will isolate the upper fire compartment from the lower fire compartment.
- Station platforms as well as pedestrian connections at the platform ends between the upper and the lower platform, allowing one station platform to be used as escape route for the other one. In this case, the guideway emergency walkway for each level ends at the corresponding platform. Once the upper and lower-level tracks are at opposite sides of the tunnel, the upper track can be lowered and/or the lower track can be lifted until both tracks share the same level. This is particularly useful for crossovers and tunnel portals.
- Traction Power substations.
- Transition sections from stacked tracks to same level tracks, e.g. at the tunnel portals, but also applicable to crossovers if a fast and compact connection is required.

The innovative tunnel configuration of Barcelona Metro Line 9 significantly reduces the surface footprint of the emerging vertical elements to a single shaft approximately 100–110 feet in diameter at the stations, with all other infrastructure integrated into the single, large-bore tunnel. Additionally, connecting the shaft to the TBM-excavated tunnels via one or more adits (used for passenger access and ventilation) provides the flexibility to position the shaft at the most convenient location relative to the station. This flexibility helps to avoid or mitigate impacts on sensitive surface facilities, such as roads, utilities, and properties. These design considerations result in cost and schedule advantages.

The BSVII Project exhibits several significant differences with respect to the Barcelona Metro Line 9 project:

- **Train Length:** The BSVII Project is approximately 700 feet, while the Barcelona Metro Line 9 trains are slightly under 300 feet.
- **Operational Headway:** The BSVII Project is approximately 10 minutes, compared to only 1.5 minutes on Barcelona Metro Line 9.
- **Distance Between Stations:** In Barcelona Metro Line 9, the distance between stations typically ranges from 2,000 to 3,000 feet, whereas the BSVII Project has an average station spacing approximately four times longer.
- **Train Width:** BART trains are significantly wider, measuring 10.5 feet compared to less than 9 feet for the Barcelona Metro Line 9 trains.
- **Rail Gauge:** The BART system utilizes a wider rail gauge than Barcelona Metro Line 9.
- **Power Source:** Barcelona Metro Line 9 trains are powered by a rigid overhead catenary system, whereas BART trains are powered by a third rail (Figures 1 and 2).
- **Crossover Frequency:** The BSVII Project features one crossover every 5 miles, compared to Barcelona Metro Line 9, which has a crossover approximately every 1.2 miles.
- **Crossover Design:** Barcelona Line 9 crossovers incorporate vertical transition elements with associated complexity and length, while the BSVII Project employs a more traditional level crossover configuration and shorter lengths.
- **Station Configuration:** Due to smaller platform requirements, Barcelona Metro Line 9 uses a vertically stacked track configuration with smaller side platforms, allowing passengers to access the station directly at each level.
- **Platform Design:** BSVII stations feature side-by-side tracks with a shared center platform, designed to accommodate longer trains and larger passenger volumes, requiring a wider center platform.

BSVII trains require a larger tunnel width than Barcelona Line 9 trains because the two systems operate differently (Figure 3 and 4). The Barcelona system runs shorter trains at more frequent intervals, which reduces the required station platform space. While both systems are capable of carrying the same number of riders, the Barcelona system's use of shorter trains at higher frequencies allows for shorter platforms and smaller stations.

Figure 3. BSVII Metro single, large-bore tunnel schematic.

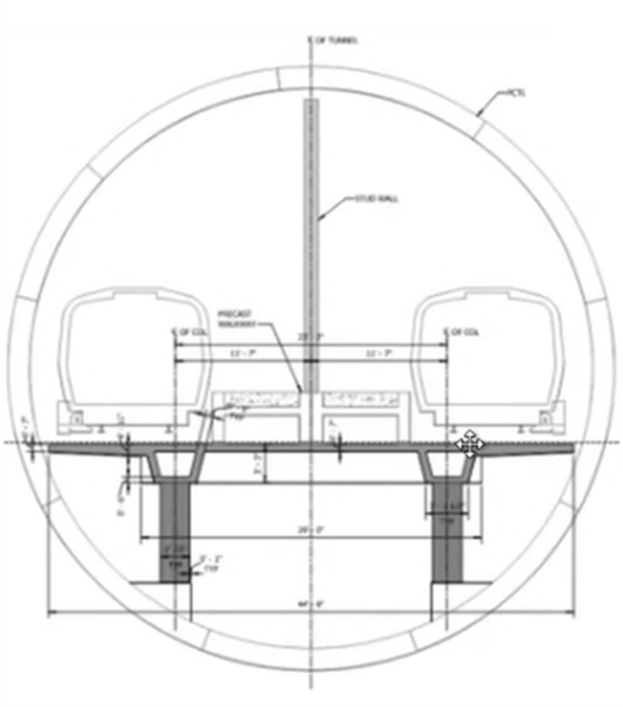
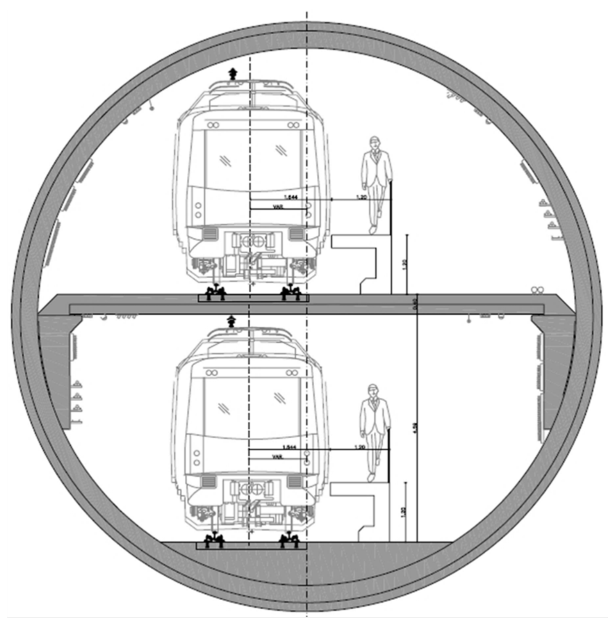


Figure 4. Barcelona Line 9 mainline cross section at cross passage.



6. Single, Large-Bore Versus Twin-Bore Tunnel Costs

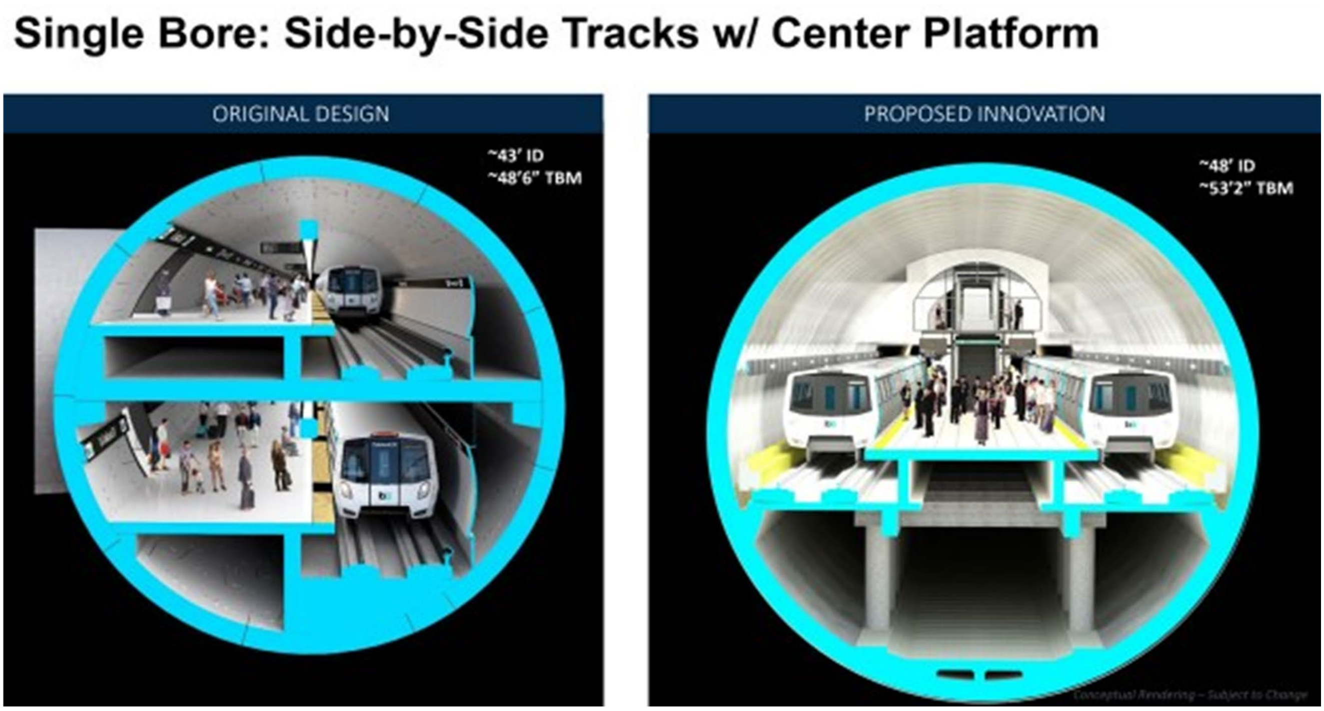
This technical review does not attempt to address the generally accepted fact that construction costs of mega-projects in the U.S. are significantly higher than in Europe and other parts of the world. This technical review also does not attempt to review previous cost estimates conducted for or by VTA related to either the twin-bore or single, large-bore tunnel configurations. Furthermore, this technical study did not review any existing cost estimates for the BSVII Program, nor was it commissioned to perform a new comparative estimate. Much has already been written comparing the costs of both configurations, and there is already ample discussion and opinion in the public sector related to the cost benefits of either approach as related to the BSVII Program.

Even without discussion of the BSVII Project, as noted in Section 4, it is generally accepted that several decades ago, the twin-bore configuration was considered less expensive to construct than a single, large-bore configuration offering comparable service levels. Advances in tunneling technology during this period made machine-bored tunnels with diameters under 24 feet increasingly cost-effective compared to traditional drill-and-blast excavation methods. Similarly, in the last few decades, continuous advancements in TBM technology and tunneling methodologies have rendered tunnels larger than 24 feet in diameter more cost-effective. A notable example is the Scarborough Metro in Toronto, Canada, where an existing conventional twin-bore/cut-and-cover station system is being extended using the single, large-bore tunnel approach.

Based on the authors' professional experience and limited proprietary data available to them, advancements in large-bore tunneling technology over the past 20 years have reduced costs to the extent that single, large-bore tunnel systems may now be slightly less expensive to construct than traditional twin-bore systems for equivalent service widths. This cost advantage becomes more pronounced when considering the additional expense of constructing separate and extensive station facilities required for twin-bore systems. Moreover, there is evidence that suggests that operations and maintenance costs for twin-bore tunnel configurations may exceed those of single, large-bore tunnels, further enhancing the life-cycle cost attractiveness of the single, large-bore approach.

While there is likely no longer a significant cost difference between generic single large-bore and twin-bore tunnel designs, system specific operation and third party requirement costs remain a critical cost differentiator between the two systems. In the original BSVII single, large-bore tunnel concept, which proposed a nominal 48 foot diameter, the tracks were stacked vertically. However, as the design evolved to a side-by-side track configuration, the tunnel diameter increased to the current nominal 54 feet, significantly increasing the construction cost of the tunnel (Figure 5). Although the reasons for this diameter increase are beyond the scope of this discussion, it is noted here only to inform the reader that the current tunnel design has undergone substantial evolution, resulting in a larger tunnel than initially envisioned during the conceptual design and configuration selection process.

Figure 5. BSVII original (left) and current (right) single, large-bore tunnel design.



7. Impacts Associated with Changing from the Current Single, Large-Bore to a Twin-Bore Configuration

Although there is understandable concern regarding the significantly escalating costs of the current single, large-bore BSVII Program, the implications of deviating from the current single, large-bore/integrated station design are substantial and must also be carefully evaluated. Regardless of the reasons for the cost escalation, these potential impacts cannot be ignored. While many of these implications fall outside the quantitative scope of this study, they can be addressed qualitatively to enable the reader to extrapolate potential effects on both schedule and cost.

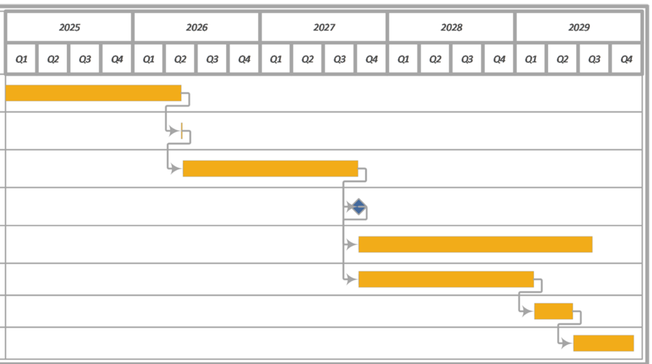
The following considerations are pertinent when evaluating a shift (or return) to a twin-bore configuration with cut-and-cover station design. It is important to note that this list is not exhaustive but highlights key factors requiring assessment:

- The BSVII 65% twin-bore design, completed for VTA and archived in 2008, was not considered in the current environmental permit:
  - **Environmental Permit Amendment:** The impacts of the earlier twin-bore design, or any new twin-bore design, differ significantly from those outlined in the current Environmental Impact Report (EIR) and would require an amendment to the existing permit. Processing an environmental permit amendment of this magnitude could take 12 to 24 months.
  - **Preliminary Engineering:** Before submitting an amendment application, extensive preliminary engineering must be conducted to identify the new set of impacts and support the amendment process. This engineering phase could take 6 to 12 months and must be completed prior to the application submittal.
  - **Community Input:** Prior to the development and submission of an environmental permit amendment, VTA must gather extensive community input. Surface impacts associated with the twin-bore/open-cut station configurations are significantly greater than those for the single, large-bore/integrated station format. This community engagement effort could be conducted in conjunction with and partially in parallel with the preliminary engineering phase.
  - **Utility and Right-of-Way Conflicts:** New utility and right-of-way conflicts must be identified, and mitigations need to be engineered or developed. While this engineering effort can begin in parallel with the amendment process, procuring new rights-of-way and addressing utility conflicts could require an additional 12 to 24 months following the Record of Decision (ROD).
  - **Progression to 60% Design:** After obtaining approval for the environmental permit amendment, engineering will need to advance to the 60% design level to qualify for federal participation in the revised program design. This design and engineering effort could take 12 to 18 months to complete.

As proposed by the authors of this report (above) and based on current industry trends and advances in large-bore tunneling technology, the single, large-bore configuration, under normal applications and for equivalent levels of service, is not inherently more expensive than the twin-bore configuration. Even when accounting for increases in the minimum tunnel diameter made to accommodate specific operational requirements unique to the BART system, it can be reasonably concluded that the single, large-bore configuration remains cost-competitive with the twin-bore configuration. It should be noted, in any comparison between the single, large-bore and twin-bore configurations in relation to the BSVII Program, the issues summarized in this section must be carefully considered. Reverting to a twin-bore configuration would likely result in schedule and cost impacts to the Project which would override any cost savings achieved (Figure 6).

Figure 6. Implications of Transitioning to a Twin-Bore Design: Timeline and Regulatory Challenges.

ID	Task Name	Start	Finish	Duration
1	Preliminary Engineering	1/1/2025	5/19/2026	72w
2	Community Outreach and Input	5/20/2026	5/22/2026	.6w
3	Application for Amended Permit	5/25/2026	10/8/2027	72w
4	Record of Decision	10/11/2027	10/11/2027	0w
5	ROW Puchase	10/11/2027	8/10/2029	96w
6	Engineering to 60%	10/11/2027	2/23/2029	72w
7	Develop Bid Package	2/26/2029	6/15/2029	16w
8	Competitive Bidding	6/18/2029	12/7/2029	25w



8. Constructability Overview of Stations for the Twin-Bore Tunnel Configuration

The physical configuration and associated construction impacts of the single, large-bore tunnel design have already been extensively presented to the community and are incorporated into the existing environmental permit. The BSVII Program has incorporated those physical impacts into the project scope and remains in compliance with the existing environmental permit's ROD. As such, the scope of this report is not to revisit those impacts and perform a quantified comparative evaluation of the twin-bore configuration versus the current single, large-bore approach.

Any comparison that may have been conducted by VTA during the selection process leading to the adoption of the current single, large-bore tunnel configuration was not available to the authors of this report. Even if such a comparative analysis were accessible, conducting a point-by-point evaluation of constructability impacts for each approach is beyond the scope of this report.

Considering this, without undertaking a lengthy point-by-point, quantified comparison of the impacts associated with single, large-bore and twin-bore tunnel configurations, it is still beneficial to provide a high-level overview of the construction process associated with a typical BART-standard metro station as it would appear on the BSVII Program. This overview focuses on conventional cut-and-cover construction methods and is based on the HMM/Bechtel 65% design, completed and archived in 2008.

8.1 Cut-and-Cover Station Construction Impacts Along Alignment

It is anticipated that at peak construction, work related to construction of temporary and permanent Project elements will be performed simultaneously within the Project Limits of Disturbance (LOD) along the entire length of the Project alignment.

The majority of construction work will take place underground, with minimal surface-level impacts except at the tunnel launch portal, designated construction staging areas, underground station surface work zones, and along local streets and roadways. Construction activities will generate noise and vehicle traffic from the movement of craft personnel, transportation of construction materials (both temporary and permanent), and the operation of heavy construction equipment. It is anticipated that construction materials will be staged at remote locations and delivered to active work sites as needed.

Additionally, regional streets and roadways will experience impacts from the off haul of construction waste and excess excavation materials, which will be transported by truck from the work areas to staging locations and subsequently to appropriate disposal sites.

Surface construction activities will occur at each work and staging area of the Project and will include tasks such as demolition, construction of temporary facilities, and implementation of mitigation measures to address noise, vibration, light pollution, dust, and excavation. These activities will require hauling materials to and from the site.

Construction activities related to and within the Project LOD will take place in a densely developed residential and commercial urban environment, presenting unique challenges. These include working within mixed-use communities with limited temporary ROW availability, proximity to existing high-rise structures, and operating in areas with a mix of commercial, residential, and public transportation facilities. These challenges are compounded by the reliance on already congested local roads and highways.

Except for utility relocation work associated with the Project, surface construction activities will principally occur at specific staging and tunnel portal work areas engaged in supporting underground operations, construction of the underground track guideway, and cut-and-cover underground stations. These construction activities will involve extensive use of surface construction equipment and will affect public roadways locally and their use, necessitating the proactive management of surface traffic and the implementation of maintenance of traffic (MOT) engineered measures.

In addition to MOT measures, mitigation measures will be required at staging areas and work sites along the alignment to address air quality, noise, and light impacts. These measures may include the construction of temporary visual and noise barriers, as well as restrictions on work hours for specific activities, to minimize unacceptable impacts on the surrounding community.

8.2 Urban Environment Cut-and-Cover Station Surface Impacts

The proposed underground stations will be constructed using the cut-and-cover method, in which a deep trench is excavated from the surface to house the station structure. This trench is subsequently backfilled during the later stages of the station's construction. The work planned at each underground station will be executed in stages, applying methodologies specific to each location to minimize construction impacts within and around the work zone and reduce negative effects on the surrounding community.

The stations local work zone's LOD will include the permanent station footprint as well as temporary construction easements from adjoining properties. Due to the limited availability of temporary ROW at and adjacent to the station sites, some staging and construction support facilities will likely need to be located offsite, with materials and craft transported to and from the station work zones as needed.

Station construction presents several challenges related to managing congestion, ensuring limited access, and implementing mitigation measures to minimize construction impacts on the community. Engineered mitigations will be required to prevent adverse effects on existing buildings and infrastructure, with additional measures in place to address noise, air quality, light pollution, and vibration. These efforts aim to avoid broader negative impacts on the surrounding community and region.

Transportation of materials and personnel to and from the construction site will utilize conventional surface vehicles, with movements managed through specific MOT measures to mitigate disruptions to the community. Staging of construction materials and craft parking will be provided at offsite locations.

The stations will be constructed in three to five main stages of cut-and-cover construction. Depending on the density of existing development and traffic patterns, portions of the station footprint may be temporarily decked or plated to maintain vehicle and pedestrian traffic above the excavation. This approach allows station construction to progress underneath the decking in parallel with normal surface operations.

8.2.1 Urban Station Locations in Existing Roadways

Stations in high density areas where the proposed station box is located within the existing roadway present distinct challenges during construction. The proposed Downtown San Jose station, as depicted in the archived 2008 65% design, is representative of this type of station (see Figures 7 and 8). Due to the physical proximity of active roadways to the proposed station box, cut-and-cover excavation will require a construction methodology capable of maintaining vehicle and pedestrian traffic concurrently with station construction. This is typically accommodated using a phased MOT program and the use of temporarily road decking.

MOT will involve temporary lane closures and adjustments to traffic patterns along the project alignment and adjacent roadways. Both partial and full short-term road closures are anticipated, with full closures primarily scheduled during weekends, night shifts, or other periods of reduced traffic volume to minimize disruption.

Phased traffic shifts across multiple construction stages will allow the proposed station structure to be built while maintaining full access to roadways and adjacent properties. Temporary road decking, consisting of steel beams and precast concrete slabs, will enable uninterrupted vehicular traffic and pedestrian movement overhead while excavation progresses below. The decking will include removable panels to facilitate the lowering of equipment and materials into the excavation with minimal traffic disruption.

Access to the station excavation during decked configuration will be maintained via an open vertical access shaft situated within work zone and off-set from the road alignment. Where feasible, station entrance locations will be used as access points during construction. Following establishment of decking, the concrete station structure will be constructed within the excavated space, backfilled up to street level, and the surface restored. Exterior station entrances would be constructed after completion of the main structure.

The specific sequence of station construction in relation to the TBM advance rate will be developed in a future phase. Where feasible, station box excavation would be completed prior to TBM arrival, enabling the TBM to skid through the station box on a temporary base slab.

To accommodate TBM reception, transit, and re-launch through the station boxes, adequate internal space must be maintained with Support of Excavation (SOE) system. The selection of the SOE must take this aspect into consideration.

Since the proposed station boxes are located beneath the public ROW, numerous existing utilities are likely to be encountered within the excavation footprint. Utilities in conflict with the excavation must be relocated or supported in place above the station construction activities.

Considerations for the SOE system includes limited construction space and the presence of utility crossings, which may require protection in place or relocation, potentially creating barriers and increasing the complexity of certain SOE systems. Dewatering-induced settlement may impact existing structures, presenting elevated risks associated with the non-watertight options. Applicable SOE systems for consideration include slurry walls, secant pile walls, and soldier piles with lagging.

Figure 7. Typical Plan View of a Station from Archived 2008 65% Design.

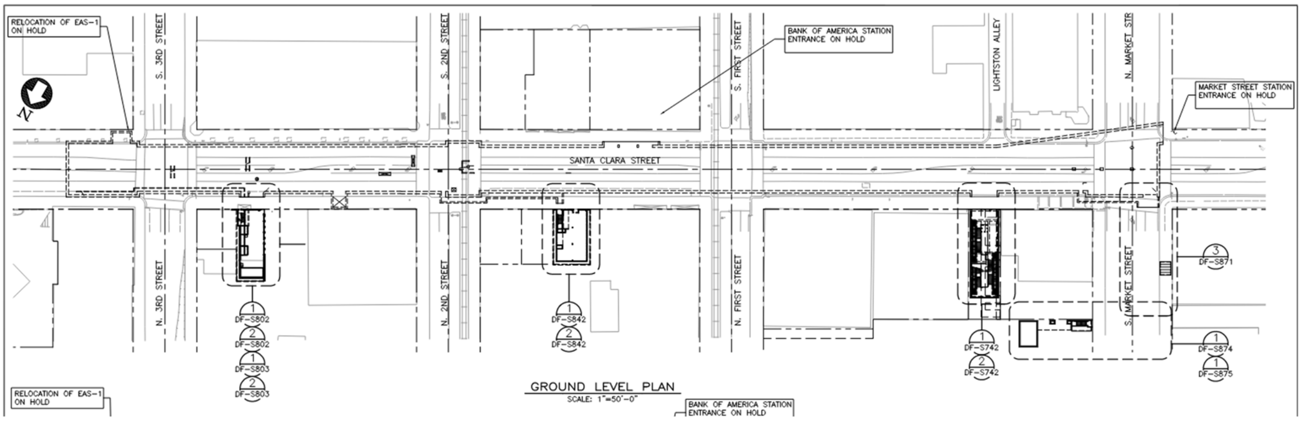
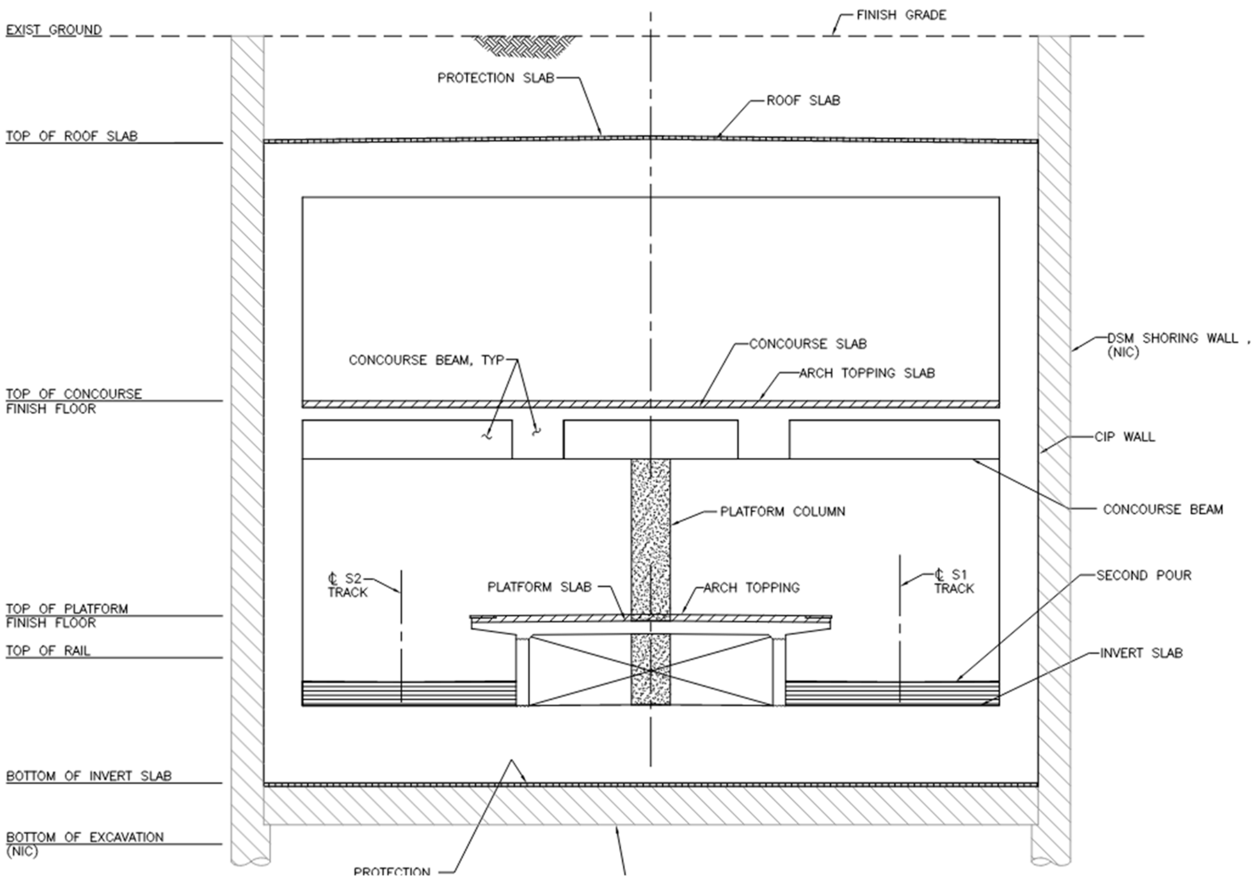


Figure 8. Typical Station Cross Section from Archived 2008 65% Design.



8.3.2 Urban Station Locations Not in Existing Roadway

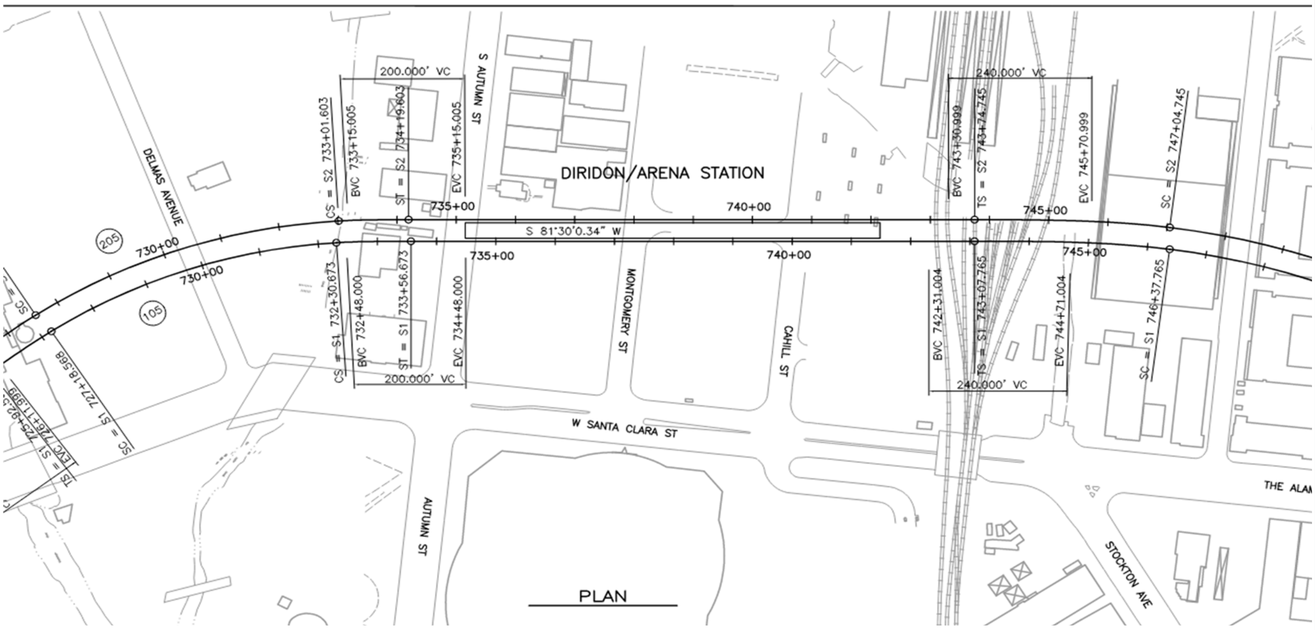
Stations in medium-density areas, where the proposed station box is not located within an existing roadway, allow for a more traditional open excavation methodology during construction. The proposed Diridon station, as depicted in the archived 2008 65% design, is representative of this type of station (see Figure 9).

The underground station is to be excavated using cut-and-cover methodology. The station site is located in an existing at-grade parking lot with multiple points of entry to the property. The proposed limits of construction will provide adequate space for on-site construction operations while maintaining existing traffic and road configuration. The station box excavation will remain open during construction, and the use of temporary decking is not anticipated.

Excavation of the station box is anticipated to be completed prior to the arrival of the TBM, allowing the TBM to skid through the station box on a temporary base slab. The exact sequence of station construction, as it relates to the TBM advance rate, will be developed in a future phase.

To accommodate the reception, transit, and re-launch of the TBM through the station box, adequate internal space must be maintained, supported by an appropriate SOE system. The selection of the SOE system must account for this aspect and consider its potential impacts on existing infrastructure during construction. Given that the station location is outside the road ROW, existing utilities crossing the excavation footprint are anticipated to be minimal. However, dewatering-induced settlement could impact existing structures, which elevates the risks associated with non-watertight SOE options. Applicable SOE systems for consideration include slurry walls, secant pile walls, and soldier piles with lagging.

Figure 9. Typical Plan View from Archived 2008 65% Design.



8.3 Underground Station Dimensions and Surface Area Twin-Bore to Single, Large-Bore Relative Differences

Based on the referenced 65% design, a typical twin-bore station box with a platform length of 700 feet requires a cut-and-cover open excavation approximately 850 feet in length and 80 feet in width. This results in a deep excavation surface area of approximately 76,000 sf for a typical twin-bore cut-and-cover station.

In contrast, a contemporary single, large-bore tunnel station configuration, such as that used in the Barcelona Metro Line 9, involves a surface excavation footprint limited to a single shaft approximately 110 feet in diameter, offset from the tunnel alignment. This results in a deep excavation surface area of approximately 10,000 sf.

While both methodologies require the establishment of a temporary work zone at the proposed station site, the single, large-bore configuration provides flexibility in shaft placement. The shaft can be located at the most convenient position around the station, connected via adits, thereby mitigating impacts on sensitive surface facilities such as roads, utilities, and adjacent properties—constraints that are more challenging to address with a traditional twin-bore station's open-cut configuration.

9. Pros and Cons of Each Configuration

Section below outlines general variables, not to be interpreted as BSVII Project specific, as some of these pros and cons would be subject to applicability based on project development phase.

9.1 Twin-Bore Tunnel Pros:

- **Conventional Station Design:** Stations can be designed and constructed using more conventional layouts that conform with standards already widely accepted by VTA and BART.
- **Shallower Stations:** Stations can be constructed at shallower depths, reducing the need for extensive mechanical infrastructure, such as escalators and elevators, compared to single, large-bore systems.
- **Established Practice in the U.S.:** Twin-bore systems are more commonly used in the U.S., resulting in a larger pool of experienced contractors and a more competitive procurement environment.
- **Shallower Excavation Depth:** Twin-bore tunnels require less cover (typically a minimum of one tunnel diameter), enabling construction at shallower depths.
- **Reduced Surface Settlement:** Smaller bore tunnels typically result in less surface settlement compared to large-bore tunneling.
- **Cost-Effective TBMs:** Smaller diameter TBMs are less expensive than large-bore machines and have shorter procurement lead times.
- **Availability of Refurbished TBMs:** Smaller TBMs are widely used globally, making the procurement of refurbished TBM systems a viable and cost-effective alternative to purchasing new TBMs.
- **Schedule Mitigation:** Twin-bore tunneling using multiple TBMs reduces the risk of schedule delays due to machine failure. If one TBM is unexpectedly halted, the second TBM can continue working, providing opportunities for schedule recovery.
- **Construction Advancement Potential:** Smaller bore TBMs can tunnel faster than large-bore machines and deploying multiple smaller TBMs can potentially complete the system faster or at least as quickly as a single large-bore TBM.
- **Adaptability to Geological Conditions:** Smaller bore TBMs can more easily adapt to varying geological conditions compared to large-bore TBMs, which may also reduce overall surface settlement risks.
- **Reduced Excavation Volume:** Twin-bore systems require less than half the excavated volume compared to single, large-bore systems, significantly decreasing the amount of material that needs to be off-hauled.

9.2 Twin-Bore Tunnel Cons:

- **Tunnel Depth:** Twin-bore tunnels are typically shallower and more likely to be in close proximity to building foundations on both sides of the street.
- **Tunnel Alignment:** Twin-bore requires a wider ROW and prevents configuring the system underneath existing roadways, impacting existing structures.
- **Cross Passages for Evacuation:** Twin-bore tunnels require cross passages for evacuation at intervals of no more than 800 feet. Constructing these mined cross passages introduces weak points in the tunnel lining (e.g., potential for leakage) and must be executed using specialized mining techniques. This poses significant challenges in densely developed urban areas with high groundwater tables.
- **Sequence of Cross Passage Construction:** Cross passages in small-diameter tunnels, such as single-track railway tunnels, needs to be constructed after tunnel boring is complete and the TBM's trailing logistics equipment has been removed. Twin-bore tunneling requires numerous cross passages and sumps, which increase both cost and construction time. These activities can be particularly challenging in soft ground conditions.
- **Station and Crossover Construction:** Twin-bore configurations necessitate either mined caverns or large cut-and-cover excavations for station and crossover construction to connect both tracks. Mined station caverns are especially difficult to construct in soft soils with high groundwater tables. Consequently, cut-and-cover methods are often preferred, although they result in greater surface-level impacts.

9.3 Single, Large-Bore Tunnel Pros:

- **Integrated Station Facilities:** Can incorporate station facilities for passenger movement and egress within the finished tunnel section, as demonstrated by the Barcelona Metro system. This significantly reduces the surface footprint of stations.
- **Flexibility in Excavation Locations:** Provide greater flexibility in determining the location of cut-and-cover excavations for station access. This allows for smaller openings and more options to minimize disruptions, particularly in sensitive areas.
- **Reduced Surface ROW Requirements:** Require less ROW for surface facilities, minimizing construction impacts along the alignment.
- **Cost-Effective Station Design:** By integrating station facilities within the tunnel, single, large-bore systems eliminate the need for larger, separate conventional stations, resulting in more cost-effective station construction.
- **Optimized Ventilation Design:** Plenums and trackways can be separated by internal structural dividers, reducing the need for separate intermediate ventilation facilities between stations. This optimizes space and reduces infrastructure requirements.
- **Enhanced Emergency Ventilation:** Can accommodate emergency ventilation by removing smoke from the fire area through vents and plenums that are separate from the affected tracks.
- **Reduced Cross Passages:** Reduce the number of cross passages required for evacuation, simplifying construction and lowering associated costs.

9.4 Single, Large-Bore Tunnel Cons:

- **Critical Dependency on Single TBM:** A breakdown or stoppage of the large-bore TBM, regardless of the cause, could result in the entire Project coming to a halt, creating a critical dependency on the single TBM for project progress.
- **Impracticality of Using Multiple Large-Bore TBMs:** Operating two large-bore TBMs to improve the construction schedule is not practical due to the lack of adequate site space required to support the large-scale infrastructure necessary for multiple large-bore operations.
- **Schedule Risk and Dependency:** A single, large-bore tunnel configuration relies on a single TBM, introducing significant schedule risks associated with potential mechanical breakdowns or unknown conditions that could impede operation. Maintenance and interventions for large-bore TBMs may also be more involved and time-consuming compared to smaller TBMs.
- **Larger and Costlier Launching Facilities:** Large-bore TBMs require significantly larger and more expensive launching facilities compared to small-bore TBMs. Small-bore TBMs, in contrast, require less excavation for cover, simpler support of excavation, and less complex dewatering systems.
- **Higher Temporary Power Supply Costs and Lead Times:** Large-bore TBMs require more expensive and complex temporary power supply systems, which also have longer procurement lead times compared to those needed for small-bore TBMs.
- **Higher Procurement Costs and Lead Times:** More expensive and has a longer lead time to procure than two small-bore TBMs.
- **Higher Complexity in Operation and Ground Conditioning:** Operating a large-bore TBM requires more advanced ground conditioning techniques, making the process more complex than with small-bore TBMs. This complexity increases the risk of subsidence compared to smaller TBMs.
- **Challenging Maintenance Requirements:** Maintenance, particularly cutterhead maintenance, in a large-bore TBMs is more complex and time-consuming than in a small-bore TBM. Hyperbaric interventions on the cutterhead occur at higher pressures due to the greater tunnel depth, and cutting tool consumption is higher, necessitating more frequent interventions.
- **Higher Excavation Volumes:** The excavation volume of a large-bore TBM is considerably greater than that of a standard single, large-bore TBM or a twin-bore tunnel configuration. For example, the excavation volume of the nominal 41 foot diameter TBM used in Barcelona is 66% larger than that of a standard large-bore TBM for metro systems and 54% larger than that of a twin-bore metro configuration. Over a 5-mile tunnel, this translates to approximately 477,400 CY of additional excavation volume.

10. Conclusions

Lacking access to historical cost data to support the selection between the twin-bore and single, large-bore configurations for the BSVII Program, a direct comparison between the Barcelona Metro single, large-bore system and a conventional twin-bore metro tunnel configuration, one cannot say that that twin-bore construction is inherently cheaper than single, large-bore construction. In fact, market trends and advancements in large-bore TBM technology and excavation methodologies suggest that single, large-bore configurations are likely to be cost-competitive with twin-bore approaches.

However, in making general statements about the relative cost-effectiveness of each tunnel configuration, one must consider factors that have escalated the cost of BSVII's single, large-bore design beyond a straightforward "apples-to-apples" comparison with a twin-bore approach, including:

- There was a shift from a stacked configuration to a side-by-side configuration and subsequent effect on the increased single, large-bore tunnel diameter and cost.
- Fundamental differences in operational requirements between the Barcelona Metro system (shorter European-style metro trains operating at faster intervals) and the BART system, which necessitate larger BSVII stations and platforms, thereby driving up capital costs.
- The reduced surface disruption to communities of single, large-bore system configurations.
- The additional costs of constructing large cut-and-cover stations required for twin-bore configurations.

Section 7 of this report provides a high-level overview of the impacts associated with cut-and-cover station construction. Although this construction method is commonly used in the U.S. and is similar to approaches seen in Southern California, one does not need to do a detailed analysis of the impacts of each approach to see that the single, large-bore configuration significantly reduces community impacts during construction. Given that constructing a single twin-bore cut-and-cover station typically takes four to five years, and a large program like BSVII requires an overall construction timeline of 10 to 15 years, the cumulative impacts to communities from constructing multiple stations are substantial. From a cursory study of the information available in the public sector, the reduced community impacts of the Barcelona-style configuration were a primary factor in selecting the single, large-bore approach for the BSVII Program.

In any discussion of the single, large-bore configuration and twin-bore configurations for BSVII, reverting to a twin-bore design would necessitate significant time to amend the current environmental permit, update and refresh the design of the tunnels and stations, and initiate a new program-wide utility and ROW effort. Such a change would likely cancel out any potential cost savings and would also delay the forecasted revenue service date.

Appendix

11. Appendix

11.1 Appendix: Acknowledgment of Technical Authors' Expertise and Contributions

We extend our sincere recognition and appreciation to the technical authors for their invaluable contributions to this technical study. Their expertise and analysis have been instrumental in verifying the accuracy and quality of this document.

- Jorge Martinez, BSVII Director, Construction Management, Bechtel
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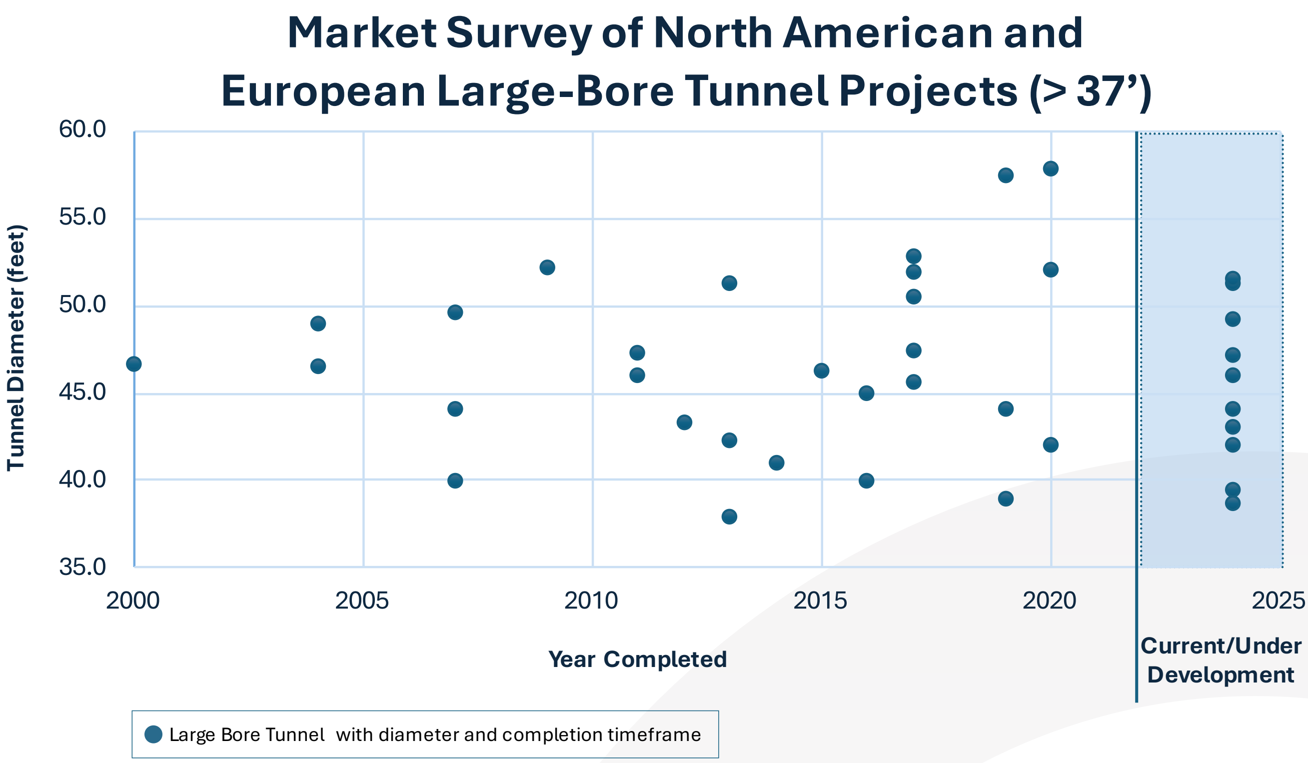
- Steven Curtis, P.E., Operations Manager, Bechtel
- Ken Buchanan, P.E., Project Engineer, Bechtel
- Nick Groeniger, Proposal Manager, Bechtel

11.2 Appendix: Market Survey of North American and European Large-Bore Tunnel Projects

A dataset of North American and European large-bore tunnel projects that are completed or are under development, is provided below.



11.3 Appendix: Publicly Accessible Reference Studies

A list of relevant publicly available studies is provided below for reference:

Study	Date Published
APTA Peer Review BART Silicon Valley Phase II Extension Tunneling Approach	2022
Integrated Cost & Schedule Life-Cycle Comparative Risk Analysis of Single-Bore Vs. Twin-Bore Tunneling	2018
VTA BSVII Tunneling Methodology Background	2017
VTA BSVII Single-Bore Tunnel Technical Studies Executive Summary Report	2016

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WORKING DRAFT

MEMORANDUM

To: Tom McGuire, Scott Johnson

From: Nasri Munfah, GZ Consultants

Cc: Ronak Naik, Monica Born, Ritika Kundu, Louis Falco, Margaret McBride, Harald Leiendecker, V.E Gall

Subject: GZ Feedback on the Twin-Bore Estimate Update, Sep 25, 2024 MMW Report

Date: June 1, 2025

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1 EXECUTIVE SUMMARY

Gall Zeidler Consultants was tasked with reviewing and evaluating the "Twin-Bore Estimate Update Revision B, dated September 25, 2024", prepared by the Mott MacDonald Wong Engineering Team (MMW). The report presents MMW's cost estimate and evaluation of constructing a twin-bore tunnel using TBM tunneling for the tunnels and the cut & cover construction method for the underground stations.

It should be noted that the report does not compare the Twin-Bore vs the Large Single-Bore concepts nor does it provide advantages/disadvantages of either of the two methods, or address risk assessment of either method. The report simply modifies the Twin-Bore concept to accommodate certain changes in the modified design criteria and provides a Rough Order of Magnitude (ROM) cost estimate in 2024 dollars using Class 4 cost estimate according to AACE, then escalating the cost to Year of Expenditure (YOE) based on an assumed contract packaging and its associated construction schedules.

The revised estimate of the Twin-Bore concept uses the FTA work breakdown structure SCC categories 10 to 50 and excluded from the update SCC categories 60 – 100. The estimated construction cost of SCC categories 10 to 50 in YOE dollars is $8.872B. This is higher than the 2008 Twin-Bore cost estimate escalated to YOE.

The main drivers of the cost increase are:

- Increasing the twin tunnel diameter from 17’-10” internal diameter (ID) to 19’-0” (ID) along with increasing the external diameter and the TBM diameter.
- Establishing “smoke reservoir” areas in the underground stations at the track level to accommodate “instantaneous” fire growth rate.
- Providing underground spaces adjoining to the station headhouses for Back-of-the-House rooms (BOH) to replace the spaces occupied by the “smoke reservoirs”.
- Using the northern alignment for Diridon Station requiring extending the station under Caltrain tracks.
- Using jacked boxes technique to extend Diridon Station under Caltrain tracks
- Reintroducing the two additional mid-tunnel ventilation plants at 13th Street and at Stockton Street
- Increasing the number of cross passages between the twin tunnels from 27 to 33
- Using a large footprint of the Downtown Station with 5 entrances
- Using Design-Bid-Build (DBB) delivery method for all construction packages
- Delay the start of construction until 2029 and having long construction durations of three civil packages
- The construction sequencing of the DTSJ station which includes closing street blocks of Santa Clara Street and a significant disruption to the traffic on Santa Clara Street and cross streets
- Maintaining the same station amenities, configurations, services, provisions as developed for the Large Single-Bore Concept
- Maintaining the same configuration of Newhall Yard as in the present design

We believe the assumptions used are conservative resulting in a potentially overstated cost estimate.

The report presents construction sequencing of the DTSJ station requiring the closure of Santa Clara Street in segments for extended period of time. We believe that this construction sequencing is not warranted. We have developed construction sequencing for the Downtown Station with the mid-size Single-Bore tunnel that will always maintain the traffic on Santa Clara operational as one lane in each direction. The restricted traffic operation is limited to 38 to 42 weeks. This approach was used on numerous projects throughout the US including the Central Subway in San Francisco, the Regional Connector and the Purple Line in Los Angeles, and the Second Avenue Subway in New York.

In our March 2025 Cost Saving Proposals report, we recommended a mid-size Single-Bore tunnel (34’-6” internal diameter) to house two tracks, and the use of the cut & cover construction method for the underground stations. This proposed approach is being evaluated under Level 3 Cost Saving Task Force. It will reduce the excavation volume, raise the alignment profile, optimize the station configurations, eliminate the cross passages, eliminate the cut and cover construction for the cross-over, eliminate the need of Diridon Station to cross under Caltrain tracks, minimize the impact during the DTSJ station construction, reduces the overall construction schedule, and minimize the cost. In our opinion, this proposal of a mid-size Single-Bore with cut & cover stations is the most cost-effective solution for the project.

To optimize costs of the Twin-Bore while maintaining efficiency, alternative solutions of the proposed Twin-Bore concept should be considered. These include re-evaluating the tunnel size and the stations configuration, potentially modifying construction packages and delivery methods, eliminating the smoke reservoirs, re-evaluating BOH rooms placement, using the southern alignment of the Diridon Station and addressing the ventilation system without the additional mid-tunnel ventilation plants if possible. By refining the design and construction methodologies, significant cost savings can be achieved without compromising safety and operational effectiveness, ensuring that the chosen tunneling method is technically feasible and financially sustainable.

In our opinion, in order to address public comments and the elected officials' concerns about the Single-Bore vs the Twin-Bore, a comparative evaluation of the Large Single-Bore with the Twin-Bore and/or any other potential cost saving alternative be performed. The comparison should address cost, schedule, advantages/disadvantages, risks, construction impacts, and affordability.

2 INTRODUCTION

Gall Zeidler Consultants was tasked with reviewing and evaluating the "Twin-Bore Estimate Update Revision B, dated September 25, 2024", prepared by the Mott MacDonald Wong Engineering Team (MMW). The report presents MMW's cost update and evaluation of constructing a Twin-Bore tunnel using TBM tunneling and cut and cover construction method for the underground stations. The report does not compare the twin-bore vs the Single-Bore nor does it evaluate advantages/disadvantages or risks associated with either method. Our scope of work is to evaluate MMW report and provide our comments, observations, and opinion. We did not perform comparative evaluation, nor detailed cost estimate or schedule comparison as they are outside our scope of work. Our evaluation focused on the assumptions used, the tunnel and station configurations, the proposed construction methods and procurement strategies, the proposed construction schedule, and provided a cursory review of the construction cost estimate and contingencies.

In addition, we reviewed the proposed construction staging and sequencing for San Jose Downtown Station as presented in the report and provided our comments.

Our conclusions and recommendations are provided in the end of this memo report.

3 ASSUMPTIONS/MODIFICATIONS USED IN THE MMW'S TWIN-BORE ESTIMATE UPDATE REPORT

The following main assumptions and modifications of the 2008 Twin-Bore concept were included in this evaluation:

1. The twin tunnel internal diameter increased from 17'-10" to 19'-0" to accommodate the crossing of the Silver Creek fault zone.
2. Establishing "smoke reservoirs" above the tracks in the station to address the instantaneous fire heat release rate
3. Relocating the back-of-the-house (BOH) spaces from the mezzanine/concourse areas, where the smoke reservoirs are established to underground spaces adjacent to the station headhouses
4. Using the northern alignment of the Diridon station requiring crossing under the Caltrain tracks using jacked box technique
5. Re-introducing the two mid-tunnel ventilation plants
6. Using 28' wide center platforms in the stations rather than the 22' wide center platform as it is presently being used in the Single-Bore Concept.

7. Using a large footprint of DTSJ station to accommodate the cross-over west of the station, the underground station ventilation plant, and 5 entrances
8. The delivery method of all contracts is assumed to be design-bid-build
9. Three major civil contracts to be used: 1) East Tunnels with cross passages, 13th Street Ventilation plant, and 28th street Station; 2) West Tunnels with cross passages, Stockton Street ventilation plant, and Diridon Station; and 3) DTSJ station as an independent package.
10. Increasing the number of cross passages from 27 to 33 cross passages
11. TBM tunnel construction will be using 4 TBM (two for the East Tunnels and two for the West Tunnels) with an average advance rate of 32ft/day.
12. Award of construction contracts will be in year 2029, and revenue services is estimated to be by year 2037
13. Constructing DTSJ station requiring full closure of Santa Clara Street and adjoining intersections in segments
14. Utility relocation based on the PMT's 2020 design of the Twin-Bore considering relocating or replacing utilities.
15. Newhall maintenance facility and Santa Clara Station, and the system work remain the same as is in the present design.

The following are our comments on the assumptions:

1. Increasing tunnel diameter due to crossing of the Silver Creek fault zone:
   The Silver Creek fault is recently modified from being dormant to potentially active. The potential slippage of the fault is very low, but its magnitude could be high. Increasing the tunnel diameter from 17'-10" to 19'-0", an increase of 14" will not protect the tunnel from shearing in case of the fault slippage. Our recommendation has always been to treat the Silver Creek fault slippage by risk management and repair if the slippage occurs rather than by increasing the size of the tunnel. Increasing the size of the tunnel will not prevent its severe damage and will not reduce its potential repair time.

2. Establishing "smoke reservoirs":
   The use of underground space to create smoke reservoirs is not needed for the following reasons:
   - Instantaneous fire growth is unrealistic. Fire growth rate can be either calculated or physically tested even under arson scenarios. The smoke growth and dispersion are dependent on the location of the start of the fire, the composition of the vehicle materials, the used accelerant, the ventilation system, etc. These can be determined by analyses or by testing.
   - The mezzanine can be made into safe haven by providing positive air pressure in the mezzanine, similar to that in the single-bore concept, allowing passengers to evacuate to the mezzanine in case of a fire. The stairs/escalators between the platform and the mezzanine can be provided with smoke canopies to prevent the smoke from migrating to the mezzanine. This is similar to Chinatown Station in San Francisco.

3. Relocating the back-of-the-house (BOH) spaces to underground spaces below the station headhouses:
   The use of smoke reservoirs is not needed as discussed above, therefore the BOH spaces can remain in the mezzanine/concourse. In addition, for Diridon and 28th Street Stations, significant above ground surface spaces are available to house BOH spaces.

For the DTSJ Station the present parking lot behind the headhouse provide ample space for BOH rooms.

4. Using the northern alignment of the Diridon station requiring crossing under the Caltrain tracks using jacked box technique:
   We suggest using the southern alignment of Diridon Station to avoid crossing Caltrain tracks and avoiding the jack box construction for crossing tracks. Jack box technique is high risk technique especially in this configuration and the ground conditions. In addition, crossing of the tracks falls on the project critical path impacting its overall duration. In addition, if the jacked boxes encountered difficulties or stopped, the west tunnels will be further delayed. In addition, passing the TBM through the jack boxes will require the jack boxes to be larger than needed further increasing its construction difficulties and risks. The southern alignment is included in the EIS and should be used.

5. Re-introducing the two mid-tunnel ventilation plants:
   We understand that the mid-tunnel ventilation plants are provided to accommodate shorter push-pull ventilation zones for fan efficiencies and to address NFPA 130 requirement of a single train in a single ventilation zone. We recommend re-evaluating the needs of the two mid-tunnel ventilation plants by using other methods of ventilation systems such as the addition of booster fans, the use of the Secardo Nozzle method, increasing the horsepower of the station fans, etc. Regarding the single train in a single ventilation zone requirement, this has been addressed in various countries by using train control and risk management rather than additional facilities.

6. Using 28’ wide platforms in the stations rather than the 22’ wide center platform as it is presently being used in the Single-Bore Concept:
   Assuming that 22’ wide center platforms are suitable for passenger load and emergency evacuation in the Single-Bore Concept, they should be suitable for the Twin-Bore Concept. Reducing the width of the platform will reduce the overall width of the stations and their cost, and will allow the stations to be constructed within the public ROW.

7. Using a large footprint of DTSJ station to accommodate the cross-over west of the station, the underground station ventilation plant, and 5 entrances.
   The present Single-Bore design of DTSJ station provides for one main entrance. Considering that if the required capacity of the present design can be accommodated by a single entrance, the need for 5 entrances may not be warranted. Also, the platform width as discussed above can be reduced if desired. Finally, the ventilation plant configuration and the ventilation duct, can be optimized to reduce the station footprint.

8. The delivery method of all contracts is assumed to be design-bid-build:
   The delivery method of DBB will require long duration to update the design and issue the construction contract documents for potential bidders. This will delay the start of the construction and along the initiation of the TBM procurement. In addition, most recent heavy civil tunnelling contracts are being issued using alternative delivery methods such as DB, CMGC, PDB, etc. Contractors prefer alternative delivery methods for which they can provide input in the design to meet their means and methods. Considering that the design of the Twin-Bore concept that was done in year 2008 is about 80 to 85% complete, Design-Build tender documents can be prepared and issued fairly quick. This approach will reduce the schedule by at least a year for awards and potentially by two years for construction completion. Not considering funding issues and the delay of FFGA, contract awards can be done in 2026, and construction NTP can be in 2027.

While the DB contractor is completing the design the TBMs can be ordered and fabricated.

9. Three major civil contracts to be used:
We concur that three major civil contracts can be used to deliver the project. However, it is recommended that further evaluation of the number of the contracts and their scoping should be made to potentially increase competition, optimize skill sets, and yield faster construction completion. For example, separating the TBM tunnels from the cut & cover station contracts would provide smaller contract sizes and more competition for the cut & cover stations; having civil only contract and station finishes contracts will optimize contractors' skill sets and reduce markup cost; providing early construction of utility relocation, early contracts for the West and East portals may accelerate the schedule; etc.
10. Increasing the number of cross passages from 27 to 33 cross passages:
Increasing the number of cross passages from 27 to 33 is unwarranted. Based on NFPA130, cross passage spacing is 800 ft. We understand that BART design criteria require closer spacing. An evaluation should be made using a risk-based approach to assess the optimum spacing of the cross passages and meeting the industry standards. Regardless, if the 2008 design met NFPA 130 and the BART design criteria with 27 cross passages, a re-evaluation of increasing the number of the cross passages should be considered.

11. TBM tunnel construction will be using 4 TBM (two for the West Tunnels and two for the East Tunnels) with an advance rate of 32ft/day:
Although we concur with using 4 TBMs (two for each heavy civil tunnel contract) to reduce the construction schedule, the average advance rate of 32ft per day is low for the size of the TBM. The average advance rates of similar TBMs in similar grounds are in the 50 to 60 ft per day using 24hrs per day 6 days per week work schedule. For this evaluation and to be conservative, we suggest using 45 to 50 ft per day. It will expedite the construction schedule and the associated cost.

12. Award of construction contract will be in 2029, and revenue services is estimated to be by 2037:
Not considering the funding gap and the status of FFGA, awarding the three civil construction contracts can be done sooner especially if the contracts are issued as DB or CMGC. As stated above, the 2008 design is 80% to 85% complete, therefore, refinement and preparation of the tender documents can be completed in a few months and the bids can be issued in 2026 for an award in 2027, saving about 2 years of the schedule. This will reduce the schedule, reduce the escalation cost, and reduce the overall project cost. In addition, and assuming the construction durations of the contracts as depicted in the report, revenue service can be achieved by 2035 rather than 2037.

13. Constructing DTSJ station requiring full closure of Santa Clara Street and adjoining intersections in segments:
The construction of DTSJ Station does not require full closure of Santa Clara Street while installing the support of excavation walls and the street decking. As shown in the illustrations in MMW report appendix C steps 1 through 4, the installation of the slurry walls, decking, excavation, and concreting can be done while maintaining the street traffic open taking half the street at a time. Furthermore, in our proposed construction of DTSJ Station using the cut & cover method, we provided a step-by-step construction sequencing showing the traffic pattern on Santa Clara Street during construction. The

proposed sequencing restricted traffic on Santa Clara street to one lane in each direction during the support of excavation and street decking installation for a period of 38 to 42 weeks. Please refer to Section 7.1 of this report. Although using DTSJ station configuration of the twin bore will increase the duration of the restricted traffic, it will not require full closure as depicted in MMW report.

14. Utility relocation based on the PMT's 2020 design of the Twin-Bore considering relocating or replacing utilities:
    Many of the utilities on Santa Clara Street can be supported in place using street decking beams as depicted by MMW report Appendix C graphically and in photos. This will save significant utility relocation time and cost.

15. Newhall maintenance facility and Santa Clara Station, and the system work remain the same as is in the present design:
    We understand that as part of Cost Saving Task Force the Newhall maintenance facility size, number of trains stored and some of the facilities such as the heavy maintenance facility are being re-evaluated to reduce the cost. We also understand that some of the system elements such as the number of traction power substations are being reduced. We suggest similar reduction in the cost of the Newhall yard and the system work be implemented in this cost estimate update.

4 CONSTRUCTION SCHEDULE

The construction durations of the three main heavy civil contracts as shown in the schedule on figures 2.5 and 2.6 appear to be excessive. Each of the three contracts duration is 86 to 87 months with the construction duration of 69 to 75 months are excessive compared to other similar projects nationwide. In addition, as stated above, the starting date of contract awards in year 2029 is too far. Using alternative delivery methods such as design-build, the award date can be advanced, and the construction duration can be reduced. For example, the construction of the East Portal and the West Portal each taking 24 months is excessive considering that the West Portal is presently under construction. The TBM average advance rate of 32 ft per day is less than typical for this size TBM and the ground conditions, the construction of the cross passages sequentially can be expedited.

We analyzed the linear schedule shown in Appendix B and identified potential schedule acceleration and their associated cost reduction. We offer the following observations. The linear schedule divides the project into three segments.

- East Segment: East Portal to the Downtown San Jose Station through the Little Portugal/ 28th Street Station and the 13th Street Vent plant
- West Segment: West Portal to the Downtown San Jose Station through the Diridon Station, the jack boxes under the Caltrain tracks, and the Stockton Street Vent Plant
- Downtown San Jose (DTSJ) Station

As indicated in the report, each of the East Segment and the West Segment will have two TBMs excavating almost concurrently for a total of 4 TBMs. Although we did not assess other potential contract packaging plan, it is advisable that alternative packaging plan should be considered in order to accelerate the schedule and reduce cost.

4.1 East Segment – Heavy Civil Contract 1:

In the East Segment TBM for tunnel C will begin excavating, about 25th month, after the East Portal/Shaft is completed followed by the TBM for tunnel D. The excavation and lining of tunnel D is expected to end around the 42nd month with an average advance rate of 32 ft per day. Considering the size of the TBM and the ground condition, an average advance rate of 50 ft/day is possible, reducing the tunnel excavation schedule by three months. In addition, the duration of utility relocation and the East Portal Construction of 22 months seems to be excessive.

The present schedule also shows 16 cross passages to be constructed in this segment beginning after TBM D has completed its drive in the 42nd month. These cross passages have a duration of 26 months ending in 68th month with four (4) cross passages between the East Portal and Little Portugal/28th Street Station and twelve (12) cross passages between Little Portugal/28th Street Station and Downtown San Jose Station. The cross passages sequence indicates constructing them in a consecutive manner from both end of the tunnel drive rather than in a concurrent fashion with multiple headings once the TBM drives are completed. The average cross passages duration is approximately six 6 months comprising of 3 months ground improvement, 1 month excavation, and 2 months concreting. Using multiple locations of constructing the cross passages after the TBM drive is completed will reduce the duration of the cross passages' construction and the schedule. Using multiple headings in multiple locations for the cross passages' construction will allow a potential schedule saving of approximately 13 months. There is also the possibility of starting the cross passages construction earlier in the schedule when the TBM have been passed a sufficient and safe distance past the theoretical cross passage location which may provide further reduction of the construction schedule. Additionally, the construction of the invert slab and the sidewalks do not start until the completion of the construction of the cross passages; they can be overlapped to save time.

4.2 West Segment – Heavy Civil Contract 2:

The critical path of the West Segment passes through the Diridon Station Box Jacking work element. It is estimated that it will require 12 months to complete. This work interrupts the tunnel excavation for an anticipated period of 5 months. The interruption in the schedule may be longer if the jacking of the boxes is delayed. Such delay is on the critical path. On a recent project in New York to construct a rail underpass using jacked box technique, the shield was stuck, and the project has been abandoned for about 5 years.

Using the southern alignment of Diridon Station, eliminates the box jacking and decouple the TBM tunnelling from the station construction in the schedule. In addition, similar to the East Segment using an average advance rate of 32 ft per day is less than typical for this size TBM in this ground. An average advance rate of 50 ft per day can be achieved. This will reduce the schedule of this segment by 3.5 months.

The present schedule also shows 17 cross passages work in this segment to begin only after the second TBM has completed its drive in the 40th month. The cross passages are planned to be constructed in sequence from both ends resulting in having a duration of 30 months to complete ending in the 70th month. Four cross passages between the Downtown San Jose Station and Diridon Station will fall on the segment critical path and can only be performed after the jack boxes are installed impacting the overall project schedule. The average cross passage construction duration is approximately six months comprising of 3 months ground improvement, 1 month excavation, and 2 months concreting. Considering the length of the segment of about 12,750 ft, multiple cross passage construction can start simultaneously reducing the 30-month construction duration. With these modifications, there is a potential schedule savings in this segment of approximately 16 months. Furthermore, there is the possibility to start the cross-passage construction earlier in the schedule when the TBMs have passed a sufficient and safe distance past the cross-passage locations potentially providing further reduction of the construction schedule. Additionally, the construction of the invert slab and the sidewalks do not start until the completion of the construction on the cross passages; they can be overlapped to save time.

4.3 Downtown San Jose Station – Heavy Civil Contract 3:

In the present schedule, the Downtown San Jose Station (DTSJ) does not fall on the overall project critical path because the construction of the jacked boxes under Caltrain's tracks at the Diridon Station results in the Diridon Station falling on the critical path. However, if the southern alignment of the Diridon Station is used, the DTSJ station could fall on the overall project critical path.

The overall contract duration of the DTSJ is 87 months with 18 months of early lead items, submittals, etc. and the construction duration of 69 months. The utility relocation work is estimated to be 19 months, while the excavation of the Downtown San Jose Station has a total duration of 17 months and the duration of the concreting activities of 23 months.

In our opinion, the duration of the preconstruction activities of 18 months is excessive and can be done in 12 months since, unlike TBM tunnels, no special equipment would be needed for the station construction. Also, the duration of the utility relocation work of 19 months can be reduced to 12 months if the main utilities are supported by the decking beams as depicted in the Report. Other construction durations such as excavation, concrete work, finishes, system, etc. seem to be reasonable.

Based on the above, the DTSJ station contract duration can be reduced by 16 months, and the construction duration can be reduced by 7 months.

4.4 Track and System and System Integration Contract:

The track and system work fall on the overall project critical path. The present schedule shows that the track and system work and the system integration contract duration of 81 months. This includes 22 months of preconstruction, 44 months of construction and 15 months of testing and commissioning. Although these durations are reasonable, there are potential opportunities to accelerate the pre-construction activities allowing the start of the construction sooner. Also, testing and commissioning can be accelerated is individual systems are tested as they are installed. The overall system integration will be done upon the completion of the work. Based on the above, it is possible to reduce the preconstruction activities duration to 18 months and the testing and commissioning to 9 to 12 months. This will result in an overall schedule saving in the order of 7 to 10 months.

Based on the above comments, it is recommended that an overall review of the overall project critical path be performed. An early start of the construction and a reduction of the contract durations will result is cost saving and early revenue service.

5 CONSTRUCTION COST ESTIMATE

A comparison of costs between the single-bore and twin-bore tunnel configurations reveals significant discrepancies, particularly regarding the Guideway and Track Elements (SCC 10) and Stations (SCC 20). The estimated cost for the twin-bore option of SCC 10 to 50 totals $8.872 billion in YOE, while the single-bore option is estimated at $7.280 billion. The Guideway and Track Element (SCC10) is estimated to cost $3.425 billion for the twin-bore option compared to $2.900 billion for the single-bore option. Similarly, the largest cost disparity between the two configurations is found in the Stations (SCC 20). The twin-bore estimate for the stations is $3.045B, while the single-bore estimate is at $2.037B, a difference of over $1B. The Yard and Shops Category (SCC 30) should ideally remain the same for both configurations, yet there is an unexplained significant cost difference. The Yard and Shops in the twin-bore is estimated at $435M, while the for the Single-Bore is estimated at $352M. In addition, as part of the cost saving Task Force, the Newhall yard is being reduced in size and functions; however, it appears that these cost saving ideas are not implemented in the Twin-Bore estimate.

The Twin-Bore cost estimate appears to be overinflated, particularly with TBM allocation, cross-passage construction, station construction and BOH room expansion. These results invite questions of the validity of the cost estimate Update. Although we have not done independent cost estimate, the following observations are worth noting and should be addressed. They are all in 2024 dollars:

- Item 10.07 TBM tunnels cost of $1,873,618,432 is very high; it represents about $74,900/ft or $37,470/ft of track. This is higher than typical similar projects recently constructed in North America. The recently completed purple line with 9 miles of twin tunnels and 7 stations at a cost of $9.5B is an example of comparable transit system cost.
- Item 20.03 – The three underground stations are estimated to cost $1,565,900,000. This represents an average of $522M per station. This is high compared to other similar cut and cover subway stations. The station costs are estimated at $464M for 28th Street/Little Portugal station, $883M for DTSJ Station, $555M for Diridon Station and $164M for Santa Clara Station. These costs are overstated. The jacked boxes for the Diridon Station could be an influencer on its cost and should be adjusted if the southern alignment is chosen. In addition, the Santa Clara station being at grade with a simple headhouse should cost significantly less than the estimated $164M. DTSJ station cost of $883 is too high even with the large footprint and the 5 entrances. The proposed modifications to the construction method and the configuration of the DTSJ should yield significant reduction in its cost.
- Item 20.06 Parking at $130M; also, item 40.07 under Site Work adds another $114M for parking for a total cost of parking of $244M; this is very high cost for parking facilities totaling 1795 stalls. Considering that the Cost Saving Task Force replaced the parking structures with surface parking, similar adjustment should be made for the Twin-Bore concept cost estimate.
- Item 20.07 Elevators and escalators at a cost of $96,796,467 is high considering the stations are shallow requiring less escalators and shorter ones. And similar to the Single-Bore concept, the connection between the mezzanine and the platform can be provided by stairs only further reducing the cost.
- Item 30.03 Heavy maintenance facility at a cost of $182,242,500. We understand that under the Single-Bore Concept, the heavy maintenance facility will be deferred or

reduced/eliminated. If this is the case similar reduction should be applied for the Twin-Bore cost estimate.

- Item 40.02 Utility Relocation cost of $242M is high. Considering significant utility lines can be supported in place under the street decking, re-evaluation of this cost is warranted.
- Item 50.03 Substations at a cost of $200M for 5 substations (or $40M per substation) seems excessive. Also, we understand that as part of the cost saving for the Single-Bore concept the number of substations were reduced. Similar reductions should be applied to the Twin-Bore concept.
- Item 50.05 Communication is estimated at $343,137,587 seems to be high and should be re-evaluated.

In addition, we reviewed the allocated contingencies as shown in table 4-3 and determined that they are higher than needed base on the level of the Twin Bore design. Considering that the Twin-Bore design is at about 80% to 85% complete, the allocated contingencies on the major cost items such as Guideway and Track Elements, Stations, and System should be reduced. We suggest the following allocated contingency values, please note that some are higher than what is proposed by MMW:

SSC 10 Guideway & Track Elements

10.06 Guideway: Underground Cut & Cover ……….proposed 25% …….suggested 10%
10.07 Guideway: Underground Tunnel ……………..proposed 25% …….suggested 10%
10.09 Track: Direct Fixation…………………….……proposed 15% …….suggested 10%
10.11 Track: Ballasted ……………………………… proposed 15% …….suggested 10%
10.12 Track: Special (Switches, Turnouts) …………proposed 15% …….suggested 10%
10.13 Track: Vibration And Noise Dampening ……..proposed 15% …….suggested 10%

20 Stations, Stops, Terminals, Intermodal (Number)

20.01 At-Grade Station, Stop, Shelter, Mall, Terminal, Platform………..…proposed 20%
……………………………………………………………………………..…..suggested…15%
20.03 Underground Station, Stop, Shelter, Mall, Terminal Platform……… proposed 25%
…………………………………………………………………………...suggested…. 20%
20.06 Automobile Parking Multi-Story Structure………..…proposed 15% suggested 10%
20.07 Elevators, Escalators……………………………….. proposed 15% suggested 10%

30 Support Facilities: Yards, Shops, Admin. Bldgs

30.03 Heavy Maintenance Facility ………………….… proposed 20%……suggested 15%
30.05 Yard And Yard Track ……………………………..proposed 20%……suggested 15%

40 Sitework & Special Conditions

40.01 Demolition, Clearing, Earthwork………………proposed 15% …….suggested 10%
40.02 Site Utilities, Utility Relocation…………………proposed 15% ……suggested 20%
40.03 Haz. Mat'l, Contam'd Soil Removal/Mitigation, Ground Water Treatments
………………………………………………………proposed 15%....... suggested 25%
40.07 Automobile, Bus, Van Accessways Including Roads, Parking Lots
………………………………………………………proposed 20%....... suggested 15%

50 System

50.01 Train Control and Signals …………………proposed 15% ..…..suggested 15%
50.03 Traction Power Supply: Substations……..proposed 15%..…..suggested 10%
50.04 Traction Power Distribution: Catenary and Third Rail
……………………………………………………proposed 15% ..…..suggested 15%
50.05 Communications………………………….... proposed 15% ..…..suggested 15%
50.06 Fare Collection System and Equipment……proposed 15% …....suggested 10%
50.07 Central Control ……………………………… proposed 15% ..…..suggested 15%

6 CONSTRUCTION OF DOWNTOWN SAN JOSE (DTSJ) STATION – APPENDIX C

We reviewed the proposed construction staging for the Downtown Station and have the following comments:

- The construction sequence as shown in Appendix C Step 1 through 5 on pages 1 to 10 of Appendix C is the typical construction of cut & cover stations in urban areas. The support of excavation is usually installed half the street width at a time allowing restricted traffic during their installation, then street decking is installed, the utility lines are supported by the street decking and the excavation and concreting is done under the street decking while the traffic is restored fully on the street above. Upon completion of the construction, the decking is removed, and the street is restored again half the width of the street at a time always allowing traffic movement. This approach has been used on numerous projects throughout the world including projects in San Francisco, Los Angeles, Seattle, Toronto, Vancouver, and New York.
- An alternative solution would be to use the "top-down" construction technique. In this technique, after the installation of the support of excavation walls as described above, the top slab of the station is placed, and the street is restored above it allowing full restoration of the traffic. The station excavation, its concrete work, architectural, mechanical, electrical work, etc. are then done under the protection of the station top slab. This method was used recently for Yerba Buena/Moscone station construction in San Francisco.
- The illustrations shown on pages 13 to 34 are inappropriate and they seem intended to discourage the use of cut & cover station construction. Showing repeatedly of 3.77 football fields (including end zones) as illustration to the level of disruption is disingenuous and deceptive. The construction staging requiring full closure of Santa Clara Street as depicted in these illustrations is unwarranted.

6.1 Examples of Twin-Bore with Cut and Cover Stations

Twin-bore tunnels construction with cut-and-cover stations in urban setting is a feasible and proven. It has been successfully employed on several high-profile transit projects. Examples such as the LA Metro Purple Line Extension, the Regional Connector in Los Angeles, the 2nd Avenue Subway in New York, and the Broadway Subway in Vancouver illustrate how this approach can balance large-scale infrastructure development with the complexities of the urban settings. The integration of cut-and-cover station construction with traffic decking (Figure 1) offers a practical solution to minimizing disruption, maintaining traffic flow, and achieving project goals.

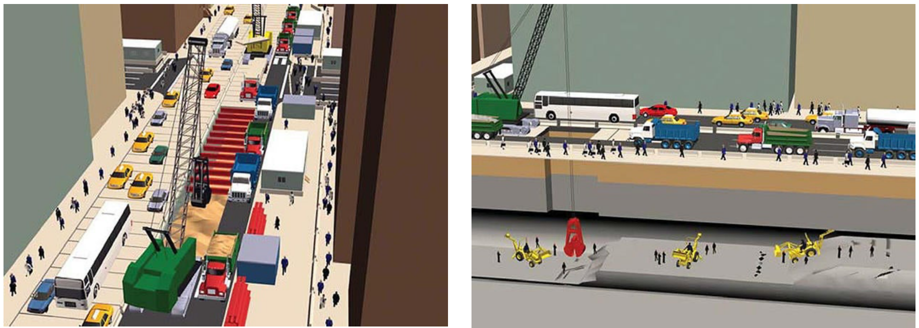

Figure 1 Illustration of cut and cover construction using the traffic decking in urban setting

The LA Metro Purple Line Extension exemplifies the use of this approach. Twin-bore tunnels were constructed beneath Wilshire Boulevard, while stations such as Wilshire/Fairfax and Wilshire/La Cienega were built using the cut-and-cover method. Temporary decking ensured the continuity of traffic along the corridor, reducing disruptions for commuters and businesses. See figure 2.

Figure 2 - Traffic Decking for the construction of Beverly Hill Station, LA Metro Purple line

The 96th Station for the 2nd Avenue Subway project (Figure 3) in New York City utilized cut-and-cover construction techniques with the use of traffic decking. This decking was essential for maintaining traffic flow and minimizing disruptions in the densely populated Upper East Side. Secant piles and slurry walls were used (Figures 4 and 5). Multiple slurry and secant rigs were employed to expedite the construction process. Once the excavation support was installed, the street decking was completed and the street was opened for traffic (Figure 6). The utility lines were supported under the decking beams and the excavation continued beneath the traffic decking (see figure 7).

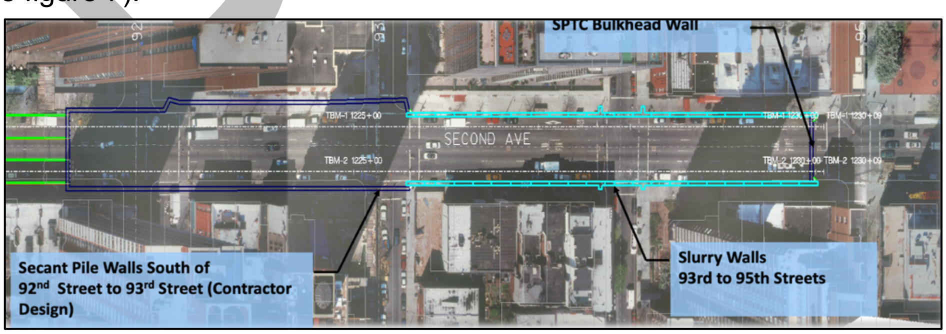

Figure 3 - 96th Street Station, 2nd Avenue Subway, New York

Figure 4 - 96th Street Station staging area, 2nd Avenue Subway, New York

Figure 5 - 96th Street Station slurry wall construction, 2nd Avenue Subway, New York

Figure 6 - 96th Street Station Street Decking, 2nd Avenue Subway, New York

Figure 7 - 96th Street Station excavation and support of utilities under the street decking, 2nd Avenue Subway, NY

The Broadway Subway project in Vancouver also demonstrates the successful integration of twin-bore tunnels with cut-and-cover station construction, employing sophisticated traffic decking strategies along the busy Broadway corridor (Figures 8 and 9)

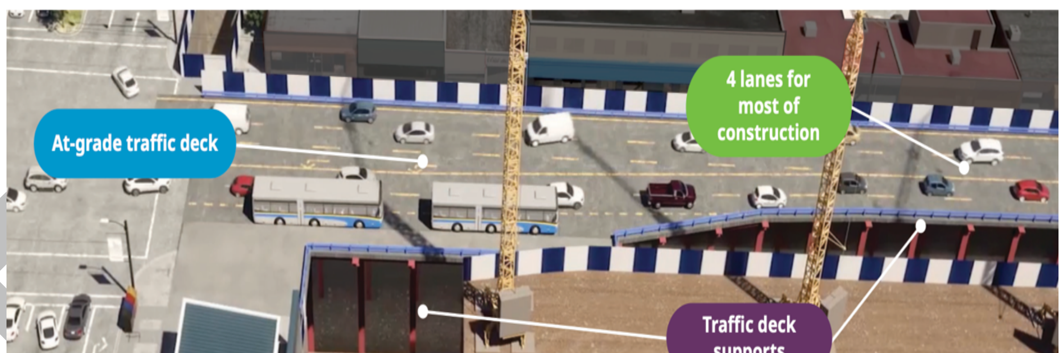

Figure 8 - Traffic Decking for Broadway Subway Project, Vancouver, CA

Figure 9 - Broadway subway construction near Yukon Street, Vancouver

While effective, the construction method of twin-bore tunnels and cut-and-cover stations has challenges that need meticulous planning. Key issues to be addressed include traffic control, utility support or relocations, noise and vibration, and stakeholders' coordination and interfacing. Collaborating with the municipal authorities, local businesses, and residents ensures alignment with community needs and helps maintain public support.

In summary, recent projects like the LA Metro Purple Line, the Regional Connector, the Broadway Line, and 2nd Avenue Subway showcase the effectiveness of this construction method in urban settings overcoming challenges through innovative techniques and stakeholder engagement, minimizing disruption to traffic, businesses, and communities.

7 ALTERNATIVE CONSTRUCTION METHODS

Three alternative construction methods have been proposed which will provide cost-effective alternatives:

1) Mid-size (34'-6" internal diameter tunnel) with Cut and Cover Station Construction
2) Mid-size (34'-6" internal diameter tunnel) with Sequential Excavation of DTSJ Station construction
3) The Hybrid Solution – presented previously in a separate report.

The Hybrid solution was presented previously and will be evaluated by the Project Team under Level 4 Cost Saving Task Force. It will not be presented here.

7.1 Mid-size Single-Bore tunnel with cut and cover stations

In this concept two mid-size Single-Bore tunnels each is 34'-6" inside diameter and each housing two tracks separated by a dividing wall to meet NFPA 130 requirements will be provided. See Figure 10.

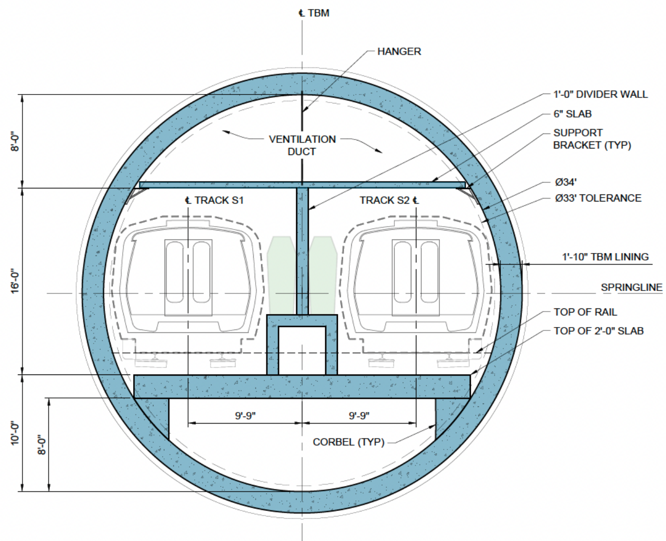

Figure 10 – Single-Bore Twin Track Mid-Size Tunnel

This tunnel configuration provides numerous advantages over the Large Single-Bore and the Twin-Bore:

1. 50% Smaller excavation volume than the Large Single-Bore
2. 47% less concrete than the Large Single-Bore
3. Although larger excavation volume and more concrete than the Twin-Bore, it eliminates the need for mid-tunnel ventilation plants and cross passages
4. Shallower alignment – shallower stations and shorter vertical circulation elements than the Large Single-Bore
5. Eliminates 33 cross passages required in the Twin-Bore
6. Eliminates the two mid-tunnel ventilation plants in the Twin-Bore
7. Eliminates the cut & cover construction of the cross-over in the Twin-Bore
8. Shorter stations foot print and smaller excavation than the Twin-Bore or the Single-Bore
9. Faster construction than the Single-Bore and less number of TBMs than the Twin-Bore
10. Limited impact on the downtown and less impact than the Twin-Bore
11. Safer construction than both concepts and meets NFPA 130 requirements better than either concept.

It is anticipated that two TBMs with an outside diameter in the range of 38.5ft (11.7m) will excavate the two tunnels one from the East Portal and one from the West Portal meeting at the Downtown Station. All underground stations will be constructed using the cut and cover method with side platforms. The alignment will follow the southern alignment of Diridon Station to avoid impacting Caltrain tracks. The two TBMs will terminate at the Downtown Station. This concept is being evaluated by Level 3 Cost Saving Task Force. Figure 11 illustrate the downtown station configuration.

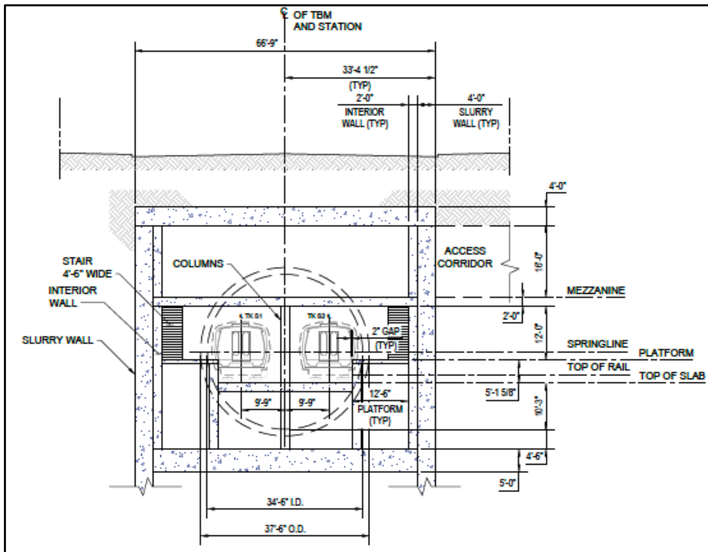

Figure 11 – Potential configuration of the DTSJ station

With this configuration the tunnel alignment will be raised to provide a cover over the tunnel of about 35 to 40 ft. This will raise the elevation of all stations, reduce the station excavation, minimize the vertical circulation elements and their lengths, and reduce travel time of the passengers under normal operating scenario and passengers' evacuation under a fire scenario. With today's technology of sophisticated tunnel boring machines, the required cover over the tunnel can be reduced to about one tunnel diameter. Although detailed analysis of the type of TBM required, with the variability of the ground and the high ground water pressure, it is suggested that multi-mode or variable density TBMs be used.

This proposed station configuration is optimal in which the station headhouse will remain as it is in the present design and the connection between the headhouse and the station mezzanine will be similar to the present design. The platforms will connect to the mezzanine with a number of stairs along the station wall to meet the passenger load. Using 2-unit stairs and 8 ft clear from the edge of the stair, each platform width will be 12'-6" wide. However, with minor adjustment to the track layouts as they enter the station, the platform width can be increased to 15'-3". The station box will be 66'-9" wide by 780' long. It will fully fit within Santa Clara Street ROW curbline to curbline with no impact on the sidewalks, and the vaults under the sidewalks. Under this configuration, the station excavation length under Santa Clara will be 780ft to accommodate the platforms length of 700 ft plus end of the platform facilities of 40 ft on each end. The station will be positioned between East of N. Market Street and West of N. Second Street. See Figure 12. The headhouse will be in the lot between N. Market Street and N. First Street. With this configuration no impact on the utilities or the traffic on Market Street and Second Street. Staging site will be located at the headhouse site and the parking lot behind it as planned in the present design concept.

Construction sequencing was developed to minimize impact on the traffic and community during the construction of the support of excavation using staged construction. In every stage, we provided two lanes of traffic (one east bound, and one west bound) occupying a width of 24 ft and provided a work zone areas with a width of 44ft. See figure 13 for work zones 2A and 2B as illustration to the staged construction.

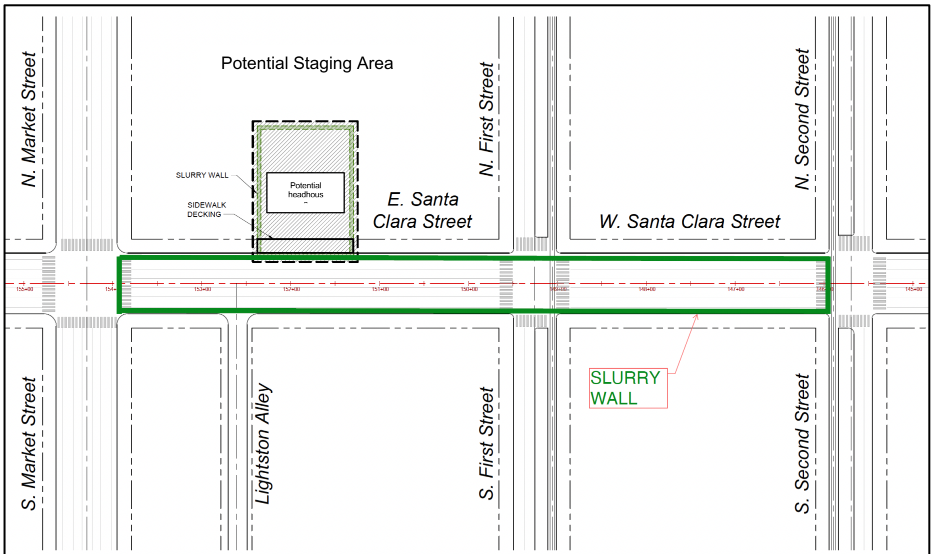

Figure 12 – Location of DTSJ Station

It is anticipated that two slurry wall rigs will be used to construct the perimeters of the excavation in stages. The slurry wall panels are assumed to be 18 to 25 ft wide, 4 ft thick and 140 ft deep to ties into impervious soil layer for groundwater control. Street decking beams will be installed within each work zone and precast decking panels will be provided. Utilities can be supported in place from the decking beams. See example in Figure 14. Upon the completion of the installation of the support of excavation and decking, the traffic will be restored to normal. Station excavation, concrete work, interior structures, finishes, mechanical/electrical work, etc. will be done under the protection of the street decking. The station entrance site and the adjoining construction staging area will be used for access, material delivery, and muck removal. The slurry plant will be located at this site to support all work zones.

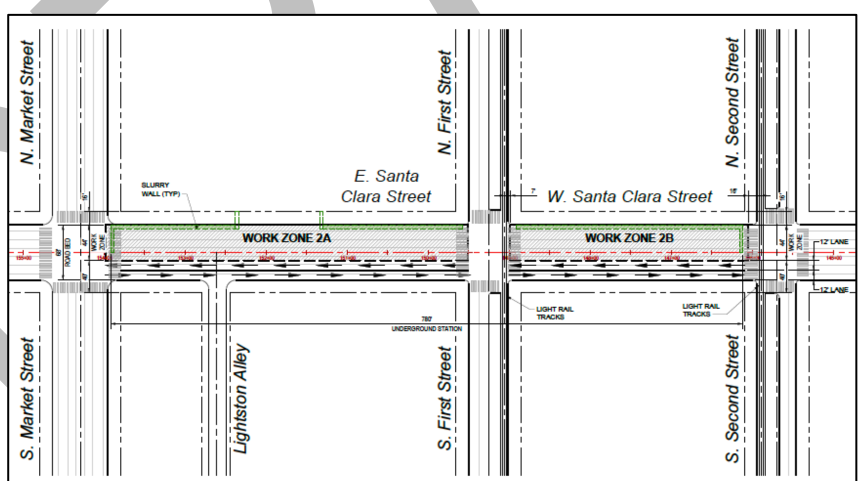

Figure 13 – Staged construction of DTSJ station

Upon the completion of the construction, the decking beams will be removed, and the street will be restored to its original configuration in stages always maintain through traffic on Santa Clara Street.

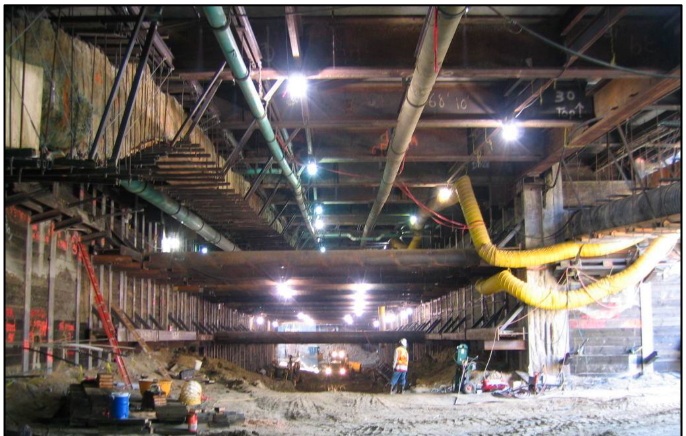

Figure 14 – Support of utilities by decking beams (LA Metro)

Based on our analysis, it is anticipated that the restricted traffic of two lanes on Santa Clara Street in the work zone for the installation of the support of excavation, decking beams, and decking is estimated to be in the range of 38 to 42 weeks working two shifts per day, 5 days per week. Upon completion of the construction, the removal of the decking beams and restoration of the surface will take significantly less time.

This concept is presently being evaluated by the design team and conclusions are expected shortly.

7.2 Mid-size Single-Bore tunnel with Sequential Excavation Method (SEM) for DTSJ Station

This concept is similar to the one described above "Mid-size Single-Bore tunnel with cut and cover stations" except for the downtown station; it will be constructed using the Sequential Excavation Method (SEM) rather than the cut & cover method. The intent of using the SEM method is to minimize disruption and impact of the traffic, utilities, and businesses in the downtown area.

It is anticipated that two TBMs with an outside diameter in the range of 38.5ft (11.7m) will excavate the two tunnels one from the East Portal and one from the West Portal meeting at the Downtown Station. Diridon and 28th Street/Little Portugal stations will be constructed using the cut and cover method with side platforms as described above. The DTSJ station will be constructed using the SEM tunnelling method. The alignment will follow the southern alignment of Diridon Station to avoid impacting Caltrain tracks. The two TBMs will terminate at the Downtown Station.

The Sequential Excavation Method (SEM), referred to it as the New Austrian Tunnelling Method (NATM), is a tunnelling method using mining techniques in which the excavation is carried out in small headings and short round lengths in order to maintain its stability. A recent project using the SEM method is the Chinatown Station as part of the Central Subway in San Francisco. Figure 15 illustrate a potential configuration of the SEM tunnelling of DTSJ station. From the headhouse site, a crosscut will be constructed using SEM tunnelling across Santa Clara Street, then SEM tunnelling of the station progress from the crosscut east and west to complete the excavation of the station. Initial support of lattice girders and shotcrete will be installed after every round of every heading. It should be noted that the station can be designed with a center platform as shown in Figure 15, or with side platforms. Also, the TBM tunnels can stop at the stations or if preferred and based on the construction schedule, one of the TBM can progress through the station area excavating significant volume of the station. The remaining volumes will be excavated using the SEM tunnelling method similar to the construction of Chinatown station in San Francisco. See figure 16. Figures 17 illustrates the sequential excavation method:

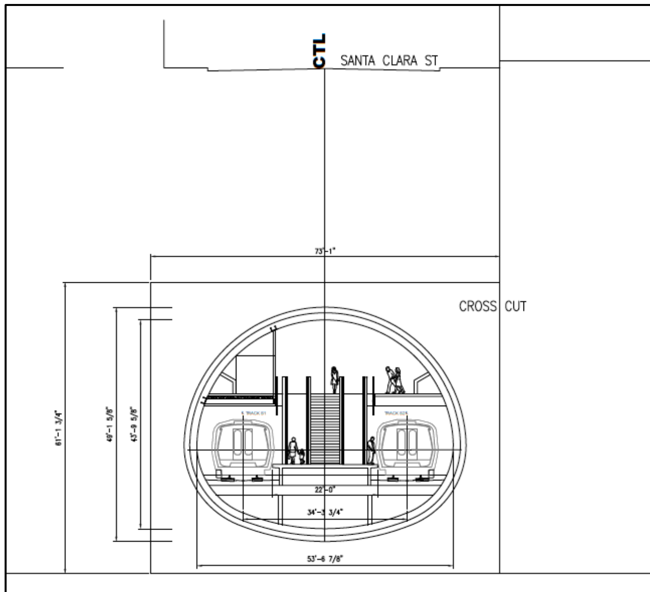

Figure 15 – DTSJ Station using SEM tunnelling

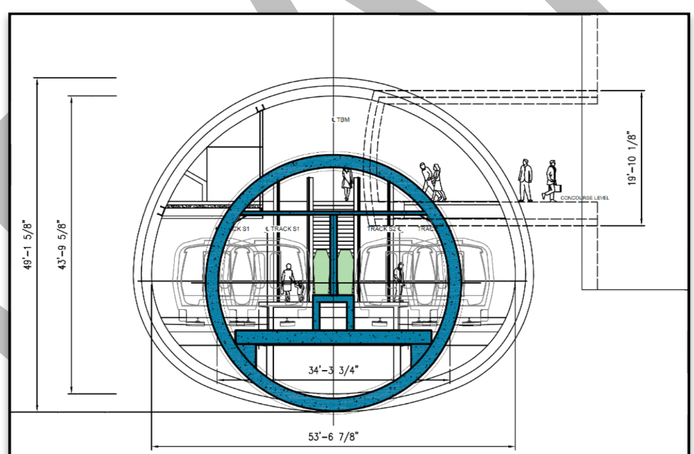

Figure 16 – DTSJ Station - TBM/SEM interfacing

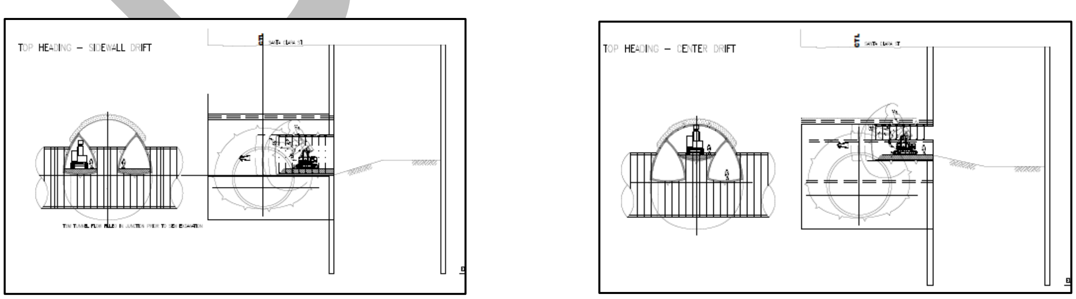

Figure 17 – DTSJ Station – Sequential Excavation

A variation to the configuration of the DTSJ station using SEM construction is the potential use of double arch or triple arch configuration which will reduce the excavation volume, raise the station elevation higher, and reduce risks. Figures 18 and 19 illustrate these configurations which were made for a Twin-Bore concept by they can be adopted for a mid-size Single-Bore also. Examples of the double arch can be seen in Fort Totten Station in Washington DC; and numerous triple arch stations are built in Europe.

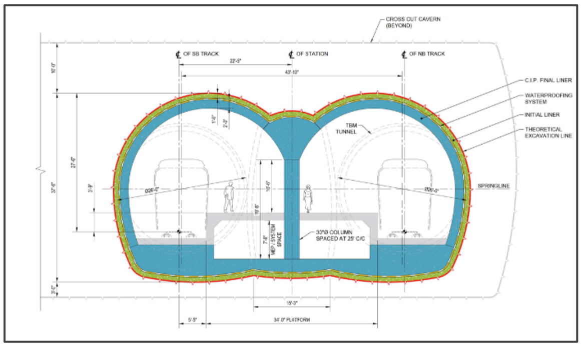

Figure 18 – Double arch SEM station

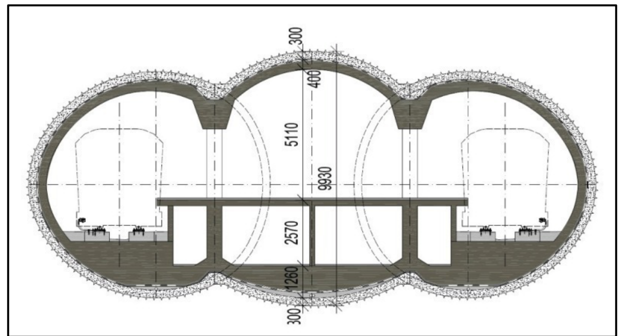

Figure 19 – Triple arch SEM Station - Prague

Due to the ground and the groundwater conditions at the downtown site, ground stabilization would be required. Several potential options are possible including dewatering, jet grouting (vertical or horizontal), freezing, interlocking pipe arch, and others.

This concept is presently being evaluated by the design team under Cost Saving Level 3 Task Force including its potential configuration, and the ground improvement methods and conclusions are expected shortly.

8 CONCLUISONS AND RECOMMENDATIONS

Our review of the "Twin-Bore Estimate Update Revision B, dated September 25, 2024", prepared by the Mott MacDonald Wong Engineering Team (MMW) reached the following conclusions:

- The report does not compare the Twin-Bore vs the Large Single-Bore concepts nor does it provide advantages/disadvantages of either of the two methods, or address risk assessments of either method. The report simply modifies the Twin-Bore concept to accommodate certain changes in the modified design criteria and provides a Rough Order of Magnitude (ROM) cost estimate in 2024 dollars using Class 4 cost estimate according to AACE, then escalating the cost to Year of Expenditure (YOE) based on an assumed contract packaging and associated construction schedules.
- The estimated construction cost of SCC categories 10 to 50 in YOE dollars is $8.872B. This is higher than the 2008 cost estimate escalated to YOE. Several drivers attributed for the potential increase in the cost including larger tunnel diameter, the creation of underground "smoke reservoirs", provisions of underground back-of-the house (BOH) rooms, increasing the number of cross passages, using the northern alignment for the Diridon Station, using of box jacking technique under Caltrain tracks, using DBB as the project delivery method, starting the construction in 2029, extended construction schedule, and several other drivers.
- The cost update did not assess the cost categories of SCC 60 to 100, nor did it assess the cost reductions identified in Cost Reduction Levels, 1, 2, and 3 Task Forces.

- We believe the assumptions used in this report are conservative and excessive resulting in a potentially overstated cost estimate
- In addition, the report presents construction sequencing of the DTSJ station requiring the closure of Santa Clara Street in segments for extended period of time. We believe that this construction sequencing is not warranted. Alternative staging plan will minimize the impact on the downtown area.

Our recommendations are as follow:

- To address the public comments and elected officials' concerns, a comparative evaluation of the Large Single-Bore with the Twin-Bore and/or any other potential cost saving alternatives be performed. The comparison should address cost, schedule, advantages/disadvantages, risks, construction impacts, and affordability. The evaluation should be based on the same basis and assumptions taking into consideration potential cost saving ideas developed under Cost Saving levels 1, 2, 3, and 4 Task Forces.
- Optimize the costs of the Twin-Bore while maintaining efficiency. Alternative solutions of the proposed Twin-Bore concept should be considered. These include re-evaluating the tunnel size and the stations configuration, potentially modifying construction packages and delivery methods, eliminating the smoke reservoirs, re-evaluating BOH rooms placement, using the southern alignment of the Diridon Station and addressing the ventilation system without the addition of mid-tunnel ventilation plants if possible.
- Consider accelerating the construction by using the 2008 design (about 80 to 85% complete) and using DB or CMGC contracting mechanism to expedite the start of the construction and the construction duration.
- Consider a mid-size Single-Bore tunnel (34'-6" internal diameter) housing two tracks, and the use of the cut & cover construction method for all three stations underground stations using the southern alignment at Diridon Station. In our opinion, this proposal of a smaller Single-Bore with cut & cover stations is the most cost-effective solution for the project. Also consider a mid-size Single-Bore tunnel (34'-6" internal diameter) to house two tracks, and the use of sequential excavation method to construct DTSJ Station while the two other stations to be constructed using the cut & cover method. These two proposals are being evaluated by the project team under Level 3 Cost Saving Task Force.
- Consider a hybrid approach—combining twin-bore and a mid-size Single-Bore tunnel could further reduce cost by reducing the excavation volume, expediting construction schedule, streamline logistics, and minimize urban disruption. By refining the design and construction methodologies, significant cost savings can be achieved without compromising safety and operational effectiveness, ensuring that the chosen tunneling method is technically feasible and financially sustainable.

PROJECT MEMORANDUM

VTA's BART SILICON VALLEY PHASE II PROJECT EXTENSION

DATE: July 3, 2025

TO: Nasri Munfah, Gall Zeidler Consultants Staff

FROM: VTA's BART Silicon Valley Phase II Project Team

SUBJECT: **VTA BSVII Staff Summary Responses to "GZ Feedback on the Twin-Bore Estimate Update, Sep 25, 2024 MMW Report" Memorandum, dated June 1, 2025**

cc: Scott Johnson, VTA Auditor General

INTRODUCTION

This memo provides summary responses and commentary on the "GZ Feedback on the Twin-Bore Estimate Update, Sep 25, 2024 MMW Report" Memorandum ("GZ Memo"), dated June 1, 2025. The responses and commentary have been categorized into the following categories:

- General
- Design Criteria and other Technical Requirements
- Construction Schedule
- Construction Cost Estimate
- Other Station and Tunnel Configurations
- Recent VTA Cost Savings Efforts

GENERAL

- The GZ Memo correctly notes that the MMW Update "modifies the Twin-Bore concept to accommodate certain changes in the modified design criteria and provides a Rough Order of Magnitude (ROM) cost estimate in 2024 dollars using Class 4 cost estimate according to AACE, then escalating the cost to Year of Expenditure (YOE) based on an assumed contract packaging and its associated construction schedules". Comparisons to other station and tunnel configurations referenced in the Memo were not part of the MMW Update study. It should be noted, this report was prepared in summer 2024, before recent cost savings efforts began in earnest, and results therefrom were not considered for the twin bore configuration.
- References to construction sequencing options for the DTSJ station described in the GZ Memo, whereby traffic is maintained on Santa Clara Street in lieu of the block-by-block

full closure approach, would restrict contractor operations making execution of the work less efficient, thereby adding time (and associated cost and risk). It should be noted that the block-by-block approach was included in VTA's approved environmental documents, and is an industry standard approach to cut-and-cover construction in densely populated urban environments.

- References to assumed DBB delivery method and ability to start construction earlier are noted; however, the assumed January 2029 construction start date was a mutually agreed reasonable date to inform the MMW Update, based on anticipated duration for environmental clearance, completion of design, and development of procurement documents to enable the twin bore configuration to move forward. (Also, the GZ Memo indicates that 2029 is the contract award date, but the MMW Update shows that construction starts in early 2029. Contract award would have occurred up to 12 months earlier).
- References to the three major civil contracts assumed for purposes of the MMW Update, and other approaches the GZ Memo discusses related to more and smaller contracts that may result in cost and schedule advantages, would require further evaluation. However, we do not believe they would fundamentally affect the ROM estimate included in the MMW Update.
- References to tunnel advance rates (32 v. 45-50ft/day) in the GZ Memo are noted. The 32 ft/day rate used in the MMW Update is an 'all-in' average production rate. This average rate includes start-up and learning curves, maintenance and routine TBM downtime and cutterhead interventions. This average also includes the peak production rates of 50 to 60 ft/day referred to in the GZ Memo. This average production was developed on a bottom-up basis and is well in line with recent industry experience, ranging from as low as approximately 25 ft/day on LA Metro Purple Line Section 3 to as high as approximately 64 ft/day on Regional Connector. Adjusting the production rate at this time would not significantly impact the cost estimate. For planning purposes, we feel the 32 ft/day average all-in production is appropriate.
- The GZ Memo incorrectly states that VTA's 2008 designs are at 80% - 85% complete. The designs were paused at the end of 2008 at approximately 65% level of completion.
- Statements in the GZ Memo about supporting utilities from the deck beams are consistent with the approach taken both in the 2008 65% design and the MMW Update.
- The GZ Memo references five entrances to the DTSJ station. The cost for three entrances is included in the estimate, consistent with VTA's 2008 65% design.
- Section 6.1 of the GZ memo presents "Examples of Twin Bore with Cut & Cover Stations". All of the examples cited in this section are similar in nature to the approach that would be taken on BSVII. This is all standard 'twin bore tunnel / cut & cover station' work undertaken in a similar manner around the world. Some cities maintain traffic during construction; others employ full width street closures. It should be noted that all of the LA Metro projects with cut-and-cover stations in the public right-of-way completely closed the street to install the deck beams and decking for either a series of weekends or an extended period of time, for example, Crenshaw Blvd was closed for three weeks to install the deck beams and decking for Expo Station on the Crenshaw/LAX LRT Extension. The VTA spent five years developing the concepts reflected in the 2008 65%

design, which were the basis for the MMW Update, and which were informed by global underground design and construction experts experienced in this type of work and familiar with detailed site specific considerations and constraints associated with the BSVII project.

DESIGN CRITERIA AND TECHNICAL REQUIREMENTS

- The MMW Update considered impacts to the VTA's 65% Engineering station and tunnel configurations driven by code and criteria changes enacted since the design was paused in 2008. The GZ Memo indicates that those code and criteria driven changes are not necessary and need not be considered; however, we believe that for purposes of a ROM cost update they should be considered. Note that any deviations from the current BSVII Design Criteria Manual (DCM) will require joint VTA and BART approval.
- Regarding the statement in the GZ Memo that the number of cross passages between the bored tunnels has been increased from 27 to 33, it should be noted that the 2008 65% Engineering design included 33 cross passages.

CONSTRUCTION SCHEDULE

- The GZ Memo makes many comments on activity durations, which appear to be opinion-based rather than analysis-based. There is no logically tied schedule included to support the reported time savings. The approach taken in the MMW Update was to use 'conservative but reasonable' assumptions to inform the schedule, and not overly aggressive assumptions or 'crashing' the schedule.
- The GZ Memo states that the overall duration used in the MMW Update "are excessive" as compared to similar projects nationwide. Included below is a summary of the three sections of the Purple Line Extension in Los Angeles which are the most recent and most relevant comparison to BSVII's twin bore concept.
  - Purple Line Section 1, 3.9 miles of underground heavy rail with three underground stations, started construction in January 2015 and is expected to be in operations in Fall 2025 which is approximately 125 months.
  - Purple Line Section 2, 2.6 miles of underground heavy rail with two underground stations, started construction in April 2017 and is expected to be in operations in 2026 which is a minimum of 110 months.
  - Purple Line Section 3, 2.6 miles of underground heavy rail with two underground stations, started construction in January 2019 and is expected to be in operations in 2027 which is a minimum of 72 months.
  - From this summary, the proposed schedule is reasonable.
- The GZ Memo suggests that the construction contract can be awarded in 2026 with construction starting in 2027 if funding issues and the delay of the FFGA are not considered. Funding and the FFGA must be considered when awarding a construction contract of this size.

CONSTRUCTION COST ESTIMATE

- Discrepancies between the MMW Update twin bore costs and the single bore costs for like items (eg: the Newhall Yard and Maintenance Facility) noted in the GZ Memo would require further investigation and evaluation. We are unclear as to which single bore cost estimate the GZ Memo makes reference and comparison. The discrepancies may be a result of escalation differences resulting from differing construction schedules for the two schemes, incorporation of cost savings ideas that were not reflected in the MMW Update, etc.
- It should also be noted that BART stations, due to their 700 ft platform length, are larger than most if not all the other projects referenced in the GZ Memo, and therefore are expected to be more expensive. Statements regarding station costs being "high compared to other similar cut and cover subway stations" should be supported with specific examples and details to allow for further review and response.
- Further, ground and groundwater conditions in San Jose are challenging, and require a very deep and robust Support of Excavation (SOE) system to enable cut-and-cover construction. These SOE systems come at a much higher cost than the shallower, more flexible SOE systems commonly used in LA Metro projects.
- Staff takes exception to certain statements such as 'overinflated' and 'questioning the validity' and requests supporting examples and details to allow for appropriate review and response.

OTHER STATION AND TUNNEL CONFIGURATIONS

- The GZ Memo recommends adopting the Diridon South alignment instead of Diridon North, to avoid construction under the Caltrain tracks. A comparative assessment between alignments could be included if desired, but the Diridon South alignment does not avoid construction under the Caltrain tracks. Note that other considerations would come into play as well, including right-of-way acquisition costs and future TOD potential.
- The GZ Memo recommends using the narrower 22' wide platforms currently included in the Single Bore design instead of the 28' wide platforms included in the 2008 65% Engineering design. The MMW Update did not contemplate narrower station platforms; as it was based on the 2008 65% design which had undergone extensive analysis and review with BART.
- Section 7 of the GZ Memo (and other prior sections) includes discussion on alternative project configurations, which are being studied under VTA's Tunnel Task Force and were not considered as part of MMW's Update efforts as this report was prepared in summer 2024.

RECENT VTA COST SAVINGS EFFORTS

- Statements in the GZ Memo suggesting that savings related to VTA's recent cost savings efforts be applied to the MMW Update – it should be noted that the MMW Update was prepared in the summer of 2024, prior to commencement of the Level 1/2/3 cost savings efforts.

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MEMORANDUM

To:	Tom McGuire, Scott Johnson
From:	Nasri Munfah, GZ Consultants
Cc:	Ronak Naik, Monica Born, Vojtech E. Gall, Ritika Kundu, Louis Falco, Harald Leiendecker, Wolfgang Kreiner
Subject:	Response to VTA Staff comments on "GZ Feedback on the Twin-Bore Estimate Update Report, dated Sep 25, 2024,"
Date:	July 15, 2025

We appreciate receipt of the VTA BSVII Staff Summary Responses dated July 3, 2025, addressing Gall Zeidler Consultants (GZ) memorandum on the Twin-Bore Estimate Update dated June 1st 2025.

This memorandum provides our follow-up commentary and clarifications on specific matters raised.

OVERVIEW

GZ Consultants' comments were intended to offer constructive, experience-based input to assist VTA in achieving cost-effective, technically sound evaluation of the Twin-Bore configuration. Our comments remain the same because they are grounded in practical underground engineering experience and cost optimization strategies, with the shared goal of project success.

We acknowledge that the Twin-Bore Estimate Update Report was prepared in summer 2024 prior to the cost-saving exercises (Level 2 and 3) undertaken subsequently. For accurate comparative evaluations and future planning, GZ recommends utilizing the outputs of those more recent cost saving task forces in VTA's evaluation.

SPECIFIC COMMENTS

1. Construction Schedule and Start Date

We note VTA's explanation regarding the agreed-upon 2029 construction start. However, our suggestion to explore earlier starts through alternative procurement methods, contract packaging, and simultaneous construction activities (e.g., multiple competitive contracts, CMGC, DBB delivery, advanced packages) was made with an intent to promote flexibility, adaptability, and to allow early start of the work. While VTA states that funding and FFGA timelines govern this assumption, and considering the FTA issued a Letter of No Prejudice (LONP), we urge the project team to consider early work activities that could advance the construction schedule without violating funding constraints. This approach can be applied to any project configuration.

2. DTSJ Station Construction Sequencing

Our recommendation to maintain traffic flow on Santa Clara Street through partial closures as we provided in Level 3 Task Force for the DTSJ Station construction was based on best practices of tunnelling in urban areas. The LA Metro Purple Line example demonstrates that full closures can be beneficial and can be granted under certain conditions to expedite the work. For the LA Metro Purple Line project, this was done during the COVID pandemic where traffic was minimal and non-essential businesses were closed which allowed a full closure based on the Contractor's request to expedite the construction. However, we recognize that such instances are not the norm nor the standard practice in urban areas. We agree that stakeholder impacts, and urban constraints must be evaluated on a case-by-case basis, but the cost and schedule impact on the project must also be considered.

3. Tunnel Advance Rate

We understand VTA's justification for using a 32 ft/day "all-in" average rate. However, recent advancement of TBM tunnelling for comparable tunnel sizes has achieved significantly higher "all-in" average advance rate for typical subway tunnels. Our reference to higher daily rates was to highlight the advancement in tunnelling technologies that can easily be achieved and to be reflected in the cost estimate. We understand that planning can adopt a conservative baseline, but there should still be recognition for technological advancements allowing to use realistic advance rates and corresponding cost estimates.

4. Station Entrances and Platform Width

While the GZ Memo referred to five potential DTSJ entrances, we concur the estimate includes three entrances. Although we agree that the station platform widths and their consistency be acceptable to BART's operational standards. However, considering that the present design of the Large Single Bore having a center platform width of 22' which is acceptable to BART and considering that the twin bore concept was modified to meet the revised criteria, it would be prudent to consider the revised criteria in all aspects including the platform width. We encourage re-examination of station sizing to optimize the space proofing and its cost without compromising the system capacity, operation, or safety.

5. SOE Systems and Cost Assumptions

We recognize the challenging soil and groundwater conditions at DTSJ and agree that robust SOE systems contribute significantly to cost. However, we maintain that the shallower alignment and the use of cost-effective SOE will provide realistic values. Furthermore, cost benchmarking with specific comparable projects—both in terms of construction method and urban setting—remains valuable especially in similar ground conditions as demonstrated in a nearby high-rise building construction.

6. Design Criteria Changes

While GZ expressed concerns over design additions not strictly required, we respect that the Cost Estimate Update Report needed to account for updates to design criteria and codes. However, we believe that deviations that would result in cost saving, such as the reduction of the platform width of all three stations, should be accommodated. Furthermore, deviations from the design criteria that would result in cost saving can be implemented by proposing criteria variances through BART-VTA joint approval. We strongly recommend maintaining a value engineering lens during this process.

7. Alternative Configurations and Task Force Studies

We understand that alternative configurations discussed in our memo (e.g., Diridon South alignment, narrower platforms, smaller single bore, etc.) were beyond the Twin Bore Estimate Update scope. However, we recommend that these alternative concepts be considered.

We remain available to support these evaluations as needed.

CONCLUSION

GZ Consultants reiterates our intent to collaborate in identifying practical, cost-effective strategies that advance the project toward timely and successful implementation. We value VTA’s thoughtful engagement with our comments and look forward to continued partnership as the project progresses.