San Francisco Planning

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TO: File

FROM: AnMarie Rodgers
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RE: Rail Alignment and Benefits (RAB) Study and 2014 Scope of Services

In 2014, the City and County of San Francisco initiated the Rail Alignment and Benefits Study (RAB) as a multi-agency analysis of major transportation and land use issues resulting from the Downtown Rail Extension (DTX) project, the electrification of Caltrain, and the arrival of High Speed Rail service.

The RAB study identifies alternatives for integrating these major transportation projects – many of which were planned independently when demand for housing and transportation were lower than today and far lower than projections for the next 30, 50 and 100 years. The study, per the 2014 scope of services, consists of five components on unique time frames:

1. Rail alignment into the Salesforce Transit Center (SFTC);
2. Railyard reconfiguration/relocation;
3. Urban form and land use opportunities;
4. Salesforce Transit Center extension/loop; and
5. Interaction of rail with the north end of I-280.

The attached, consultant-written Final Technical Report details the relative advantages, disadvantages and supporting documentation for alternatives in each of the five RAB components described above.

Over the past year, San Francisco staff from the Planning Department, San Francisco County Transportation Authority, Public Works, Municipal Transportation Authority and Office of Economic and Workforce Development have focused this analysis on advancing the most time-sensitive component: the Rail Alignment into the SFTC. Based on the 2014 scope, consultants reviewed three conceptual alignment options: 1) Future with Surface Rail, 2) Pennsylvania Avenue Alignment and 3) Mission Bay Alignment.

The Executive Summary Report summarizes the consultant's Final Technical Report, provides additional staff analysis, and presents preferred policy directions for each study component. It identifies Pennsylvania Avenue as the preliminary preferred alignment for further study. At their September 25th, 2018 meeting the Board of Supervisors, in their roles as Commissioners of the San Francisco Transportation Authority, recommended the Pennsylvania Avenue Alignment and adopted the Planning Department's Executive Summary Report of the RAB Study.

As the City seeks to proceed with the next phase of study along Pennsylvania Avenue it is important to note that:

1. In any case where the Technical Report and the Executive Summary report differ, we direct you to the adopted Executive Summary Report; and,
2. While the City no longer intends to study alignments at grade or through Mission Bay, future plans could incorporate elements from other alignment options.

These two points converge around the ongoing discussion of where to locate the northern railyards for Caltrain and High Speed Rail. The Technical Report studies the relocation of the railyard as part of the Pennsylvania Avenue alignment option, when, in fact, many, though not all, of the benefits of the Pennsylvania Avenue Alignment could occur while retaining the railyard in its current location at or below grade.

The RAB Study is only the beginning of the planning work to guide these century-long investments. But it identifies pathways for integrating significant public investments and coordinating multiple agencies, with the ultimate goal of bringing Caltrain and High Speed Rail into the heart of downtown while supporting the next generation of San Francisco communities.

REPORT OF FINDINGS

Rail Alignment and Benefits Study
Final Technical Report

Prepared for

City of San Francisco Planning Department

September 2018

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Acronyms and Abbreviations

REQUIRES EXPANSION

CGS	California Geological Survey
CWG	Citizen Working Group as conveyed for the RAB study
CHSRA	California High Speed Rail Authority
CalSTA	California State Transportation Agency
Caltrans	California Department of Transportation
DTX	Downtown Rail Extension
I	Interstate
MTC	Metropolitan Transportation Commission
PCJPB	Peninsula Corridor Joint Powers Board (Caltrain)
PCEP	Peninsula Corridor Electrification Project – also known as Caltrain Electrification
PUC	Public Utilities Commission
RAB	Rail Alignment and Benefits Study (Feasibility Study)
SEM	Sequential Excavation Method – a type of construction of tunnels
SCL	Sprayed Concrete Lined – a type of construction of tunnels
SFCTA	San Francisco County Transportation Authority
SFMTA	San Francisco Municipal Transit Agency
SFTC	Salesforce Transit Center – formerly called Transbay Transit Center (TTC)
TBM	Tunnel Boring Machine
TJPA	Transbay Joint Powers Authority
TTC	Transbay Transit Center now called Salesforce Transit Center (SFTC)
USGS	United States Geological Survey
WGCEP	Working Group on California Earthquake Probabilities

1 Background

The Rail Alignment and Benefits Study (RAB) has been established by the City and County of San Francisco as a multi-agency project intended to study the transportation and land use issues surrounding the southeast quadrant of the City that will need to be addressed in the next ten years and will affect San Francisco for the next 100+ years. The Study seeks alternatives to integrate the anticipated and known transportation and infrastructure developments including the Downtown Rail Extension known as the DTX, Caltrain electrification including work on the 4th/King Railyard, high speed rail operating along the Caltrain tracks and into the Salesforce Transit Center (SFTC), as well as other modal needs, desires, issues, and opportunities in this portion of the City. The study is a holistic look at both land use and transportation in the area south of Market Street down to the County line.

The Problem at 16th Street

Current plans to connect the Peninsula rail corridor(Caltrain) to the Salesforce Transit Center (SFTC) call for the construction of the environmentally approved Downtown Rail Extension, commonly called the DTX. (See section 3.1) The DTX and the SFTC will bring new high speed rail trains to San Francisco, and increase the number of Caltrain trains serving the Peninsula. This increased rail traffic supports regional transportation goals, but increases pressure on the current at-grade rail crossings at 16th Street and Mission Bay Drive/7th Street. Since the DTX was conceived (2004), the neighborhoods surrounding the 4th/King Railyard have undergone dramatic change. Growth in the Mission Bay and Central SoMa area have established 16th Street as a major east west thoroughfare and the ambulance emergency route to local hospitals. In addition, plans are in place to improve transit throughput on 16th Street with red bus-only lanes and construction of an electrified trolley route for the 22 Fillmore.

Figure 1: 16th Street At-Grade Rail Crossing

Increased vehicle traffic on 16th Street and its designation as a key transit route are in conflict with the increased gate down time anticipated with increased rail traffic from both Caltrain and High Speed Rail. The San Francisco Planning Department recognizes that a DTX plan which retains the at-grade rail

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crossing at 16th Street (and Mission Bay Drive) will bring increased congestion, increased emergency response times, and could degrade the quality of life in surrounding neighborhoods. Through the RAB study, the Planning Department considered existing plans as well as grade separation rail alignment alternatives that could unlock opportunities for neighborhood development and sustained growth, while simultaneously removing the limitation on train volume through this crossing.

Neighborhood Barriers vs. Benefits

Two major pieces of infrastructure have long served as vital connections between San Francisco and the Peninsula. The I-280 freeway brings motor vehicles to two points in the South-of-Market neighborhood, while surface rail brings Caltrain commuters to 4th/King Station. These major pieces of infrastructure deliver benefits to the cities they connect. However, they also act as barriers that separate neighborhoods, interfere with local travel by all modes, and render dozens of city block faces unsuitable or undesirable for neighborhood-serving uses such as housing, retail, offices, or parks. The surface rail and elevated freeway are stacked as they run from 18th Street south to the 4th/King area, creating a physical and visual dividing line bisecting the southeastern quadrant of the City.

In the past, this infrastructure was generally accepted as part of the industrial character of the neighborhood. Low density and corresponding low trip demand meant that the impact of these structures was minimal. With the development of the Mission Bay neighborhood to the east, increased commercial and housing density in the South-of-Market (SoMa) area, infill around the new Central Subway stations, and more east-west trips relying on the 16th Street corridor; these two structures have become a clear deterrent to development and trips in the surrounding neighborhoods. Some see this deterrent as needed insulation from growth pressures that threaten the character of an existing neighborhood. Others see this deterrent as a constraint on urban mobility and livability worthy of investment to create a more modern urban neighborhood.

This study is intended to identify the physical possibilities for changes to the surrounding infrastructure, and offer choices for policy considerations by stakeholders and elected officials.

Development Opportunities

Figure 2: Planned Future Infrastructure

The footprint of the infrastructure in the project area is approximately 22 acres. This is a significant urban footprint. Rail and freeway infrastructure significantly limit the opportunities for pedestrians, bicyclists, buses, emergency vehicles, and private vehicles to cross and/or access this area. Rethinking this infrastructure in ways that liberate portions of this footprint for housing and commercial development would not only support local and regional development goals, but could potentially bring ridership and economic benefits to support improved transit.

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Past Studies, Future Growth

The RAB builds on the past work of Caltrans, California High Speed Rail Authority (CHSRA), Transbay Joint Powers Authority (TJPA), Caltrain, and the San Francisco Planning Department, including the Salesforce Transit Center project, the 4th & King Street Railyards Study, and the Caltrain North Terminal Feasibility Assessment.

For the last 10 to 15 years, the Mission Bay, South of Market and Showplace Square/Lower Potrero Hill neighborhoods have experienced significant change: growth of residential and office development, and major Bay Area regional transportation infrastructure projects and investments are currently under construction and planned in the area. With the multiple infrastructure projects taking place, it is imperative that the City takes a holistic look at the future of this area.

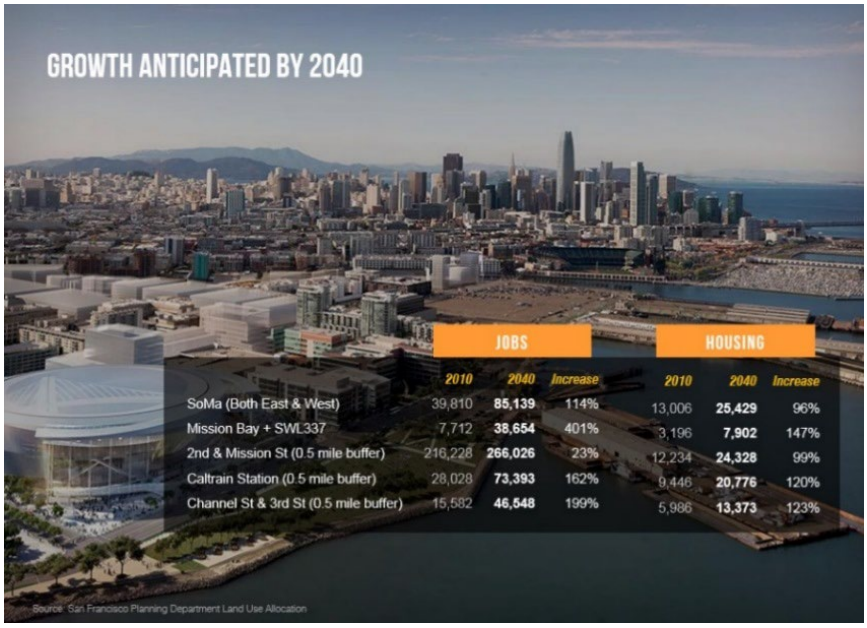

Figure 3: Growth Anticipated by 2040

Study Goals

1. Collaborate on plans to bring Caltrain and HSR downtown to the Salesforce Transit Center in a way that benefits City neighbors and stakeholders.
2. Improve/address east/west access in, though, and around Mission Bay including current at-grade rail crossings.
3. Coordinate efforts so all planned projects improve (not degrade) the urban environment in the area.
4. Determine the best methods of construction for various projects.
5. Understand the potential for increased urban form (e.g., street connections) and land use (e.g., housing and job growth) in the area.
6. Determine the cost and potential revenue sources of the various projects.

In pursuit of the above goals, five components were identified by the City for combined analysis:

1. **Rail Alignment to the Salesforce Transit Center (SFTC)** – Review of the Downtown Rail Extension (DTX): Verify and/or potentially modify the proposed DTX including the alignment and construction methods.
2. **Salesforce Transit Center (SFTC) Extension/Loop** – Revisit the potential of a loop track out of the east side of the Salesforce Transit Center and in association with work being completed under the rail alignment component.
3. **Railyard Reconfigure/Relocation** – Reconfigure and/or relocate portions/all of the activities currently to be completed at 4th/King (including operations, storage, and/or maintenance).

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4. **Boulevard I-280 –** Conduct traffic analysis and consider compatibility of near-term projects (like the DTX) with the long-term concept of replacing the elevated portion of I-280 north of Mariposa with a surface boulevard, similar to the Embarcadero or Octavia Blvd. While removal of I-280 is not a near-term objective, the RAB study will document the impact of near-term projects on the long-range opportunity to reconsider the current freeway configuration(s).
5. **Urban Form and Land Use Considerations** – Changes related to the other four components may liberate parcels for restoration of the street grid, improved bike/pedestrian connections, elimination of rail hazards and noise, and construction of housing, commercial development and open space. The RAB study could create opportunities for new public spaces, and for housing and jobs at the 4th/King railyard site nearby parcels, along the existing I-280 corridor, and in the adjacent vicinity, including the potential to raise additional revenues to realize the transportation infrastructure. The study will consider what the possibility of involvement of various urban form and land use options with the other components and how value capture might factor into construction of needed infrastructure.

Phase I and Phase II of the RAB study have been completed and are documented in this report. These are the first two phases of what is anticipated to be a five-phase process.

Phase 1: Technical Feasibility Assessment to review existing work to date and consider options for each of the five components. This phase began in June 2014 and engineering analysis was completed by June of 2015, while technical coordination tasks including outreach, project library assembly, and final reporting continued through 2016.

Phase II: Alternatives Development to focus on the further analysis of select options identified in Phase I, and the development of integrated alternatives. The RAB study team will produce a matrix to understand how each potential option for each component affects the other components as well as overarching goals of traffic, cost, accessibility, etc. Engineering analysis for Phase II is to be completed by January 2017, with technical coordination tasks lasting through June 2017.

Phase III: Preferred Alternative Approval and Design

Phase IV: Environmental Clearance of Preferred Alternative

Phase V: Implementation

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2 RAB Study Scope

The RAB study team was selected through a competitive bid process in May 2014 to provide technical support for the City's Rail Alignment and Benefits Study (RAB). In Phase I, potential options were identified, scanned for fatal flaws, and qualitatively assessed for potential benefits. Physically viable options were recommended to the City for further consideration in Phase II. Working with the San Francisco Planning Department, the RAB study team has performed following tasks and deliverables defined as Phase II, *Refinement of Alternatives and Determination of Final Alternatives*:

1. Rail Alignment to the Salesforce Transit Center (SFTC) Study Refinements
    - Summary of existing conditions and development of conceptual engineering alternatives
2. SFTC Extension/Loop Study
    - Conceptual analysis of viable loop options
3. Railyard Reconfiguration/Relocation Study
    - Summary of existing conditions and development of alternative train storage scenarios including reconfiguration/relocation options
4. Urban Form and Land Use Considerations
    - Planning level visual explorations of the streets and neighborhoods that could result from approved and proposed changes.
5. I-280 Traffic Study
    - Investigation of current I-280 traffic conditions and an estimation of future 2040 traffic levels to determine what future street connections could be made and what configuration might be required for an I-280 boulevard.
6. Rail Operations Modeling
    - Operations investigation of needed capacity for future rail operations
7. Economic Analysis
    - Economic Analysis of potential land value and capture opportunities in the area.
8. Additional Studies
    - Quantitative and qualitative analysis including economic and value capture analysis for various land use configurations.

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Figure 4 defines the combined project area by study component. By considering the entire project holistically, the study was slated to inform and expand the proposed solutions to these related projects.

Outreach and Technical Coordination

The RAB study team has also supported the City with stakeholder outreach and technical coordination. Outreach has included working with transportation agencies on a Technical Advisory Group (TAG) and community stakeholders as part of a Community Working Group (CWG). Technical coordination has included the integration of ridership, traffic, and planning data to perform economic analysis. As part of Phase I, the RAB study team compiled a comprehensive library of related background data, geotechnical data on the project area, completed studies, and planning documents. (See Appendix I, Index to Background Documents).

Figure 4: RAB Combined Project Area

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3 Engineering Feasibility

The RAB study team has conducted a feasibility analysis related to five components of the RAB study:

1. Rail Alignment to the Salesforce Transit Center (SFTC)
2. Salesforce Transit Center (SFTC) Extension/Loop
3. Railyard Reconfiguration/Relocation
4. Boulevard I-280
5. Urban Form and Land Use Considerations

3.1 Rail Alignment Options to the Salesforce Transit Center (SFTC)

The first component of the RAB Study is an analysis of the Caltrain and HSR rail alignment traveling through the City and County of San Francisco. This study began with a review of the existing rail alignment and the planned Downtown Rail Extension (DTX) as the approved and environmentally cleared alternative. The RAB study further considered if there are other alignment options that could provide a higher value to the City and region given the dramatic transformations that have taken place in the project area over the past decade since the DTX was planned.

Continued development, increased jobs and housing density, and the implementation of large infrastructure projects (such as the Central Subway) have altered the neighborhood context around the DTX. The City and County of San Francisco remains fully committed to a rail extension to the SFTC. The RAB study's exploration of alignment options considered whether the planned DTX, or some feasible alternative, maximizes this investment for the benefit of both the region and the neighborhood.

Since the current DTX plan was developed, the project area has changed significantly:

- The success of Mission Bay and the ongoing transition of Central SoMa have resulted in greater demand for all modes of transportation; investment in the rail extension to the SFTC must help alleviate vehicle congestion (especially on 16th Street), connect to transit, and encourage pedestrian and bike trips.
- The 4th/King railyard neighborhood has become a central location for jobs and housing; rail options that maximize transit-oriented development would greatly benefit riders, the region, and sustainable urban growth.
- As the project area has grown and changed over the years, the proposed rail alignment(s) should help improve the quality of street-life (noise, safety, emissions) and be compatible with complete streets that serve local residents and workers while still managing to provide vital regional throughput.
- 2nd Street is now home to mature businesses and major office buildings; rail alignment options should seek alternatives that minimize the disruption of cut-and-cover construction methods required with the planned DTX.
- There are new growth and connectivity patterns that have come into greater focus since the original DTX alignment was planned (such as the Central Waterfront, Bayview, and a second Bay crossing); rail alignments need to be compatible with changing growth patterns.

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This study compares the current DTX plan (which includes the existing Caltrain surface alignment plus the environmentally cleared Downtown Extension) to conceptual designs for technically feasible alternatives (identified in Phase I of the RAB study). All the alternatives connect the Salesforce Transit Centre (SFTC) in downtown San Francisco at the knockout location for the throat (entrance point for trains located at the SW corner of SFTC. The alignment options considered were:

- **Future with Surface Rail:** DTX + Trenched Streets
  The DTX – the environmentally cleared option already substantially designed by the TJPA from the current 4th/King railyard area into the SFTC along with what the City will need to do to maintain access east west (grade separating both 16th Street and 7th/Mission Bay Drive intersections with the streets below the tracks.
- **Pennsylvania Avenue Alignment:** DTX + Extended Tunnel
  Underground tunnel bore north of Cesar Chavez within available rights of way along Pennsylvania Avenue connecting to roughly the same current alignment and utilizing the DTX alignment into the SFTC.
- **Mission Bay Alignment:** Modified DTX + 3rd Street Tunnel
  Underground tunnel bore north of Cesar Chavez following an alignment east of the current right of way, under Third Street up through Mission Bay and into the SFTC.
- **Tunnel Under I-280 Alignment**
  No longer considered technically feasible by the RAB study, this option called for trenching directly beneath existing I-280. Due to the location of columns of the elevated I-280 freeway, it is impossible to construct this alignment without significant structural changes to the I-280 freeway as well as taking Caltrain out of service to both 4th/King north for more than two years.

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Figure 5: Alignment Options as shown in Appendix A conceptual design drawings.

For each alignment alternative the following elements have been considered in an assessment of risk, and a comparative estimate of probable cost:

- Known Geology
- Tunneling Approach
- Station Locations
- Constructability
- Fire Life Safety

Conceptual design drawings showing alignment options and potential station locations can be found as Exhibit 1.0 in Appendix A, Conceptual Design Drawings, Alignment Alternatives for rail alignment options 1-3.

3.1.1 Future with Surface Rail

This option includes existing surface rail conditions south of Mission Bay Drive, then connects north into the environmentally approved DTX (See Figure 6). As part of the TJPA's approved plans, this established option is already well-documented. Appendix A, Exhibit 2.1 shows the DTX as currently designed and environmentally cleared.

- Includes the Downtown Rail Extension (DTX) as designed and environmentally cleared.
- Assumes 4th/Townsend Station as part of the DTX (and 4th/King station remains in service).

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- Assumes Caltrain PCEP (Peninsula Corridor Electrification Project – also known as Caltrain Electrification).
- Uses existing surface Caltrain tracks under I-280 south of 18th St.
- Maintains plans for electrified Caltrain 4th/King Railyard for operations, staging, storage, and maintenance.
- Requires the elevated I-280 structure and touchdown ramps to 4th/King and 6th/Brannan remain in place permanently; surface rail tracks planned in this alternative run directly under the freeway.
- Does not require Caltrain to be out of service for any significant duration during construction.
- Has been deemed by the City to require grade separation of two existing at-grade intersections at 7th/Mission Bay Drive and 16th Street (streets depressed below the existing Caltrain tracks) to maintain traffic flows in accordance with City policy.

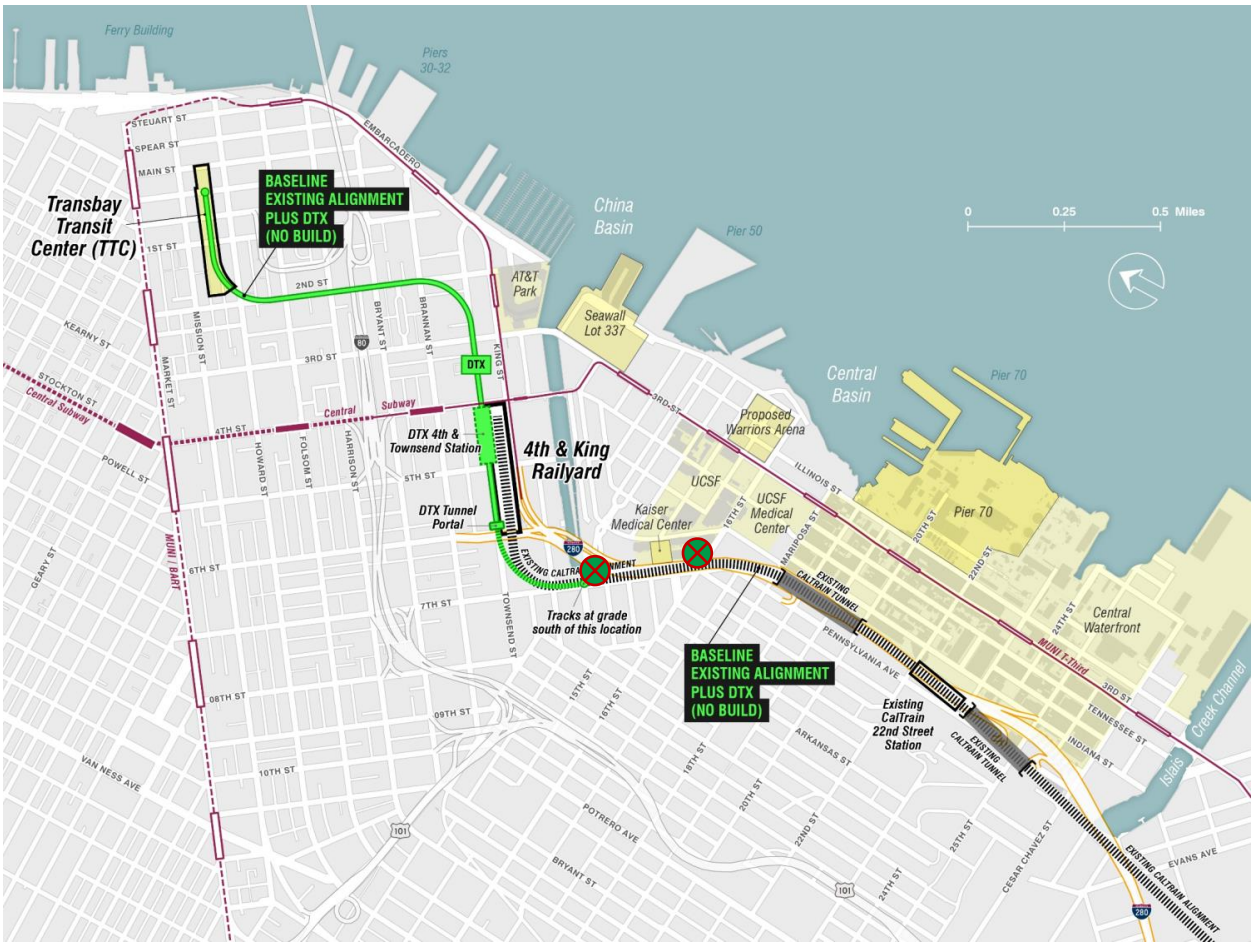

Figure 6: Future with Surface Rail, including locations of grade separations.

4th/King Railyard Access – Remains As Is

This RAB option consists of the existing plans for both Caltrain/HSR and the SFTC including the existing surface tracks and the DTX along its proposed and environmentally cleared alignment. 4th/King operations, maintenance, and storage would remain (although some Caltrain sub options have previously explored a slightly smaller footprint on the 4th/King railyard site).

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In this alignment option, Caltrain trains terminate either at SFTC or at 4th/King – one or the other. SFTC-bound trains will stop at the 4th/Townsend underground station, adjacent to the surface 4th/King station but not directly connected, and in proximity to the Central Subway.

Note that the rail connection between SFTC and the 4th/King railyard presents obstacles to both the trackway and the roadway. Non-revenue trains, stored at the 4th/King railyard and traveling between the SFTC and 4th/King, will be required to make a cross-track move south of 16th Street, then come to a complete stop before reversing directions to head north into the railyard (or vice versa and also requiring a cross-track move). Specifically, these trains would depart the SFTC, bypass the underground 4th/Townsend station, travel to the surface crossing 16th Street, require a cross-track move, stop south of 16th Street on a new tail track (tail track #69), then reverse direction as part of a cross-track move, travel north across 16th street again, then enter the surface railyard at 4th/King for storage. Caltrain simulations (LTK, 2015) estimate that this move could take 10 minutes, though the actual impact to operations highly depends on scheduling and capacity. Of primary concern to the City and the RAB study is the potential impact of this added traffic on the at-grade intersections of 16th Street and 7th/Mission Bay Drive as these movements would close these intersections an additional two times each time a train was moved into/out-of operation and from 4th/King to SFTC.

Constructability

The RAB study concurs with the TJPA's detailed assessment of constructability and known risks. The current construction methods of the DTX are cut and cover (through Townsend generally and sequential excavation method (SEM) along 2nd Street). There are risks to all construction methods in the poor soil conditions found throughout the project area. Poor soil and conflicts with existing structures identified as part of the environmentally approved DTX are considerations for all of the alternatives in the RAB study.

The 16th Street Problem – Not Addressed

Neither the existing Caltrain alignment nor the approved DTX extended their view past the corner of 7th/Townsend for impacts to the existing system. Both agencies involved (Caltrain and TJPA) have stated that this is outside their respective project area. Specifically, neither Caltrain (in their electrification EIS) or TJPA (in their DTX EIS) consider what happens at at-grade rail crossings in the City (16th Street and 7th/Mission Bay Drive). The City believes that these projects are all connected, and provide the opportunity to provide new pedestrian, bike, and vehicular connections east/west between the Mission Bay neighborhood and the west. With the amount of trains that are anticipated after High Speed Rail comes into the City, including additional Caltrain service, totaling 10 trains per peak hour per direction, the City maintains that impacts to intersections further south need to be considered.

The RAB Study team did not do an analysis of the at grade rail crossings. The City provided the RAB study team with field observed intersection closure time (red warning lights start to blink, gates come down, train goes through intersection, gates come up, and red warning lights stop blinking indicating that traffic can now proceed through the intersection) which the City indicates as different than intersection occupation times estimated by Caltrain (the time in which a train is actively occupying an intersection). The City states that each train is anticipated to close the intersection of 16th Street between 60 and 100 seconds. The City calculates the intersection of 16th Street (and 7th/Mission Bay Drive) being closed during the peak hour between 20 and 30 minutes. Specifically, 16th Street serves as a major east/west corridor an ambulance route for the Hospital as well as the 22-Fillmore BRT route. Closure of this magnitude is not acceptable to the City from a need to provide critical lifesaving services to the hospital.

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Based on the City's traffic analysis, the only option under the Future with Surface Rail alignment that maintains current levels of service east/west across 16th and 7th/Mission Bay Drive is to depress the streets into a trench with the Caltrain/HSR tracks remaining on the surface.

4th/Townsend, 4th/King, and Central Subway Link

There have never been plans to link the proposed 4th/Townsend underground station or the surface 4th/King station with the future Central Subway station. Having two stations (4th/Townsend and 4th/King) in such proximity to Central Subway, but not connected will likely result in confusion for riders, especially occasional or one-time users.

Roadway Trenching

The development of roadway trench concepts and the estimation of trenching costs is outside of the RAB study team scope of work. As part of the RAB study, the City internally developed high-level cost estimates based on San Francisco Department of Public Works trenching requirements. These requirements are complicated by the existence of major underground PUC infrastructure that cannot be relocated and therefore affect not only the depth (35-50 feet) of the trenched street(s) but also the cost. The PUC infrastructure is described in more detail as part of the Pennsylvania Alignment later in this section.

I-280 Freeway – Remains Permanently

Because the Future with Surface Rail alignment is at the surface and directly under the I-280 elevated freeway, this option assumes the elevated portion of I-280 remains unchanged and continues to its current touchdown and the 4th/King and 6th/Brannan intersection(s).

Summary and Recommendations

The RAB study recognizes the Future with Surface Rail as a technically viable alternative. This partially environmentally approved alternative (rail alignment approved, street trenching is not) should be carried forward in subsequent policy considerations of what alternative to pursue. The RAB study has used this alternative as the comparative baseline for many of the constructability, risk, and cost assessments of other alternatives.

Key considerations for future policy analysis:

- Does not address the 16th Street and 7th/Mission Bay Drive problems, exacerbating the issues with additional anticipated surface conflicts (which the City has determined would require long vehicle trenches further separating communities in the project area)
- Assumes a "split-station" passenger experience with some trains originating/terminating at 4th/King and some at SFTC (and utilizing 4th/Townsend)
- Maintains the 4th/King operations, staging, and storage and maintenance railyard
- Does not assume development of the 4th/King Railyard site
- Is the least expensive alternative and is already partially environmentally approved, but will require future trenching of roadways at additional cost

3.1.2 Pennsylvania Avenue Alignment

This rail alignment option incorporates the planned DTX, then proposes to tunnel the alignment south of DTX 4th/Townsend Station. This alignment begins at the SFTC following the approved DTX alignment southeast along 2nd Street, turning southwest along Townsend Street to a new underground 4th/Townsend station parallel to the existing 4th/King Street station. From here the alignment turns again southeast below 7th Street before turning almost due south to run below Pennsylvania Avenue (and within the street right-of-way) to connect to the existing alignment between 25th Street and Cesar Chavez Street (See Figure 7). The alignment could be constructed with almost no disruption to Caltrain service with disruptions over 1-2 weekends for tie-ins to existing lines on either end.

- Includes the Downtown Rail Extension (DTX) as designed and environmentally cleared.
- Includes the 4th/Townsend Station as identified in the DTX.
- Assumes a future phased relocation of 4th/King staging, and maintenance and storage functions; assumes a satisfactory new south railyard that meets all requirements of Caltrain service.
- Allows for potential relocation of the 22nd Street Caltrain Station to a more accessible location to be determined as the next phase continues.
- Proposes a parallel alignment under Pennsylvania Avenue west of the existing surface Caltrain tracks.
- Assumes Caltrain PCEP (Electrification).
- Continues use of elevated I-280 to 4th/King and 6th/Brannan, but compatible with I-280 remaining or future removal.
- Does not require Caltrain to be out of service for any significant duration during construction.
- Provides the opportunity for an expanded 4th/Townsend underground station to accommodate potential staging and storage (which might be used if trains need to terminate before SFTC, or serve special events).
- Provides for opportunity to provide new pedestrian, bike, and vehicular connections east/west between the Mission Bay neighborhood and the west.

Figure 7: Pennsylvania Avenue Alignment, with potential surface connections.

PLEASE NOTE: Many variations on this alignment and its assumptions are possible. But for the purposes of analysis and cost estimating, the conceptual alignment and elements described above were chosen for further study. This does not signify a preferred option for the Pennsylvania alignment or package of elements. If this alignment moves forward, a full analysis of different connection points, alignments, and station location(s)/configuration(s) would be undertaken.

4th/King Railyard Access – Eliminated

In this alternative, all rail operations are completely underground north of the Caltrain 22nd Street station. There is no longer any surface rail connection to the 4th/King railyard.

The RAB study recognizes that the 4th/King railyard currently serves multiple essential functions, but each of those functions might be served as well – or better – at other locations. Under the Pennsylvania Alignment, storage and maintenance functions would be served at a new southern railyard. (See Section 5.0 Railyard Reconfiguration/Relocation.) An expanded 4th/Townsend could potentially replace station and staging functions remaining 4th/King. One option would be to expand the planned 4th/Townsend station to either a four or six track station (with three tracks continuing through the station and onward to SFTC as already planned, and the remaining tracks terminating underground at 4th/Townsend). An expanded 4th/Townsend station, with a modified track layout, could allow for turnbacks thus serving the station functions of 4th/King. In addition, increasing the number of trains completing the journey and taking passengers all the way to the SFTC would not only improve service, but also reduce the layover requirements of the 4th/King surface railyard. The right combination of strategies will depend on the blended service plan yet to be adopted by Caltrain and CHSRA. Once the blended service plan is

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established, a modified 4-track 4th/Townsend station could have the capacity to handle the station and staging requirements for the 10 trains/peak hour/direction (4 HSR and 6 Caltrain) – the maximum proposed rail traffic in the corridor at this time. RAB operations analysis suggests that as many as 12 or more trains might be managed even if 4th/King is eliminated entirely. (See Section 4, Rail Operations Analysis.)

Preliminary analysis shows a six-track 4th/Townsend station (with no 4th/King availability) would match the service capability being built into the environmentally approved DTX alternative and provide for capacity well beyond all anticipated blended service levels now or in the future. In fact, a six track 4th/Townsend station could provide the tracks and platform space required to handle all planned Caltrain and CHSRA service even without the SFTC. While such a robust station (on par with what is currently proposed) is unlikely to ever be required, there are other long-term advantages to moving necessary infrastructure underground. It is important to note that none of the assumptions made (modified Townsend station, SFTC operating environment capacity of up to 10 trains per hour per direction, and a viable southern railyard) have been agreed to by the two operators and the TJPA. The RAB Study suggests more detailed operations and engineering analysis is required to determine the viability of this alternative.

Both four-track and six-track 4th/Townsend station permutations are technically feasible. Moreover, offering all Caltrain and HSR service from a single unified station (SFTC) would provide a better passenger experience compared to the split stations of the approved DTX where one southbound train might originate at SFTC and stop at the underground 4th/Townsend station located in the DTX, but the train departing 10 minutes later departs from "the other station" (above ground at 4th/King).

The new Pennsylvania alignment could be developed in parallel with a new southern railyard built to handle storage and maintenance functions required under the new blended service operating plan still in development. Upon completion of the Pennsylvania Avenue alignment and a new southern railyard, the existing 4th/King railyard would no longer be connected to surface rail. The surface railyard at 4th/King would become available for alternative use and future development.

Like the staged construction already planned for the 4th/Townsend station, sequencing of the Pennsylvania Avenue alignment would minimize disruption to Caltrain service. The underground 4th/Townsend station is anticipated to be constructed utilizing cut and cover, with both the potential modified four-track and six-track expanded station options extending to the south of Townsend Street under the footprint of the existing railyard.

4th/Townsend, 4th/King, and Central Subway Link

There have never been plans to link the proposed 4th/Townsend underground station with the future Central Subway station. With the removal of operations at the 4th/King railyard, the confusion of two interim stations would be removed as well, with all passengers using the 4th/Townsend underground station. The Central Subway connection would still be approximately a 5-minute walk from the 4th/Townsend underground station to the 4th/Brannan Central Subway station.

Constructability

Soil Conditions and Geologic Hazards

The subsurface soil conditions along the proposed Pennsylvania Avenue Alignment were developed using the available soil information collected at nearby locations and are depicted on Exhibits 2.1 through 2.3 in Appendix A. Prior to any actual construction, additional geological analysis would need to be undertaken. Given the information available, the following analysis was completed.

The Pennsylvania alignment follows existing plans for the DTX between SFTC and 4th/Townsend, so it encounters the same underground conditions. Along the 2nd Street alignment near its transition to the Salesforce Transit Center (Stations ±10+00 to 27+00 on the DTX design plan set, Exhibit 2.1 in Appendix A), bedrock of Franciscan Complex is encountered near the ground surface. The eastern part of the alignment along the 2nd Street and those on the Townsend Street and Pennsylvania Avenue are underlain by Artificial Fill and Quaternary deposit of Young Bay Mud that directly overlies the bedrock. Bedrock is expected to outcrop from the 19th Street to the southern terminus of the alignment.

The following primary geotechnical issues with the Pennsylvania alignment are largely the same as those associated with the construction of the DTX:

- Potential for poor rock and groundwater ingress along the Sequential Excavation Method (SEM) tunnel alignment (in 2nd Street)
- Construction of cut and cover and open cut structures in soft ground, subject to the above mentioned seismic hazards (along Townsend Street)

In addition, the following risks are also associated with the bored section of tunnel:

- Normal risks associated with pressurized face tunneling with TBMs in water bearing soft ground (north half of the alignment)
- Normal ground treatment requirements for the construction of cross passages in soft water bearing ground
- Managing wear on the TBM cutterhead (whole length)

Configuration

Identical to the approved DTX, beginning at the SFTC box a cut and cover throat structure would serve as the transition section from six tracks within the SFTC box to three tracks entering the tunneled section below 2nd Street. The first portion of the tunnel would utilize the approved DTX three track sprayed concrete lined (SCL) tunnel along 2nd Street and down Townsend Street to a new underground station parallel to the existing 4th/King Street Station and utilizing part of the adjacent existing railyard.

South of the underground 4th/Townsend station, whereas the approved DTX alignment rises to the surface and continues on the existing Caltrain right-of-way, this proposed alignment continues underground almost to 7th Street. At this point the twin bored pre-cast concrete segmentally lined tunnels would begin and run for the rest of the alignment underground beneath the existing right-of-way along 7th Street as well as Pennsylvania Avenue to the southern station and south of the southern station to connect to the existing Caltrain alignment somewhere between 25th Street/Cesar Chavez Street.

Major PUC infrastructure located at the southwest end of China Basin must be accommodated. There are two proposed crossings of this infrastructure in the proximity of 7th Street.

Firstly, there are four 9-foot-diameter micro tunnels crossing perpendicular to 7th Street. Their proposed location dictates the low point of the rail tunnel alignment where sufficient clearance between the two pieces of infrastructure (the micro-tunnels and the rail tunnels) is required to reduce impacts.

The second conflict is less clear from the information available to date. Labelled as the Division Street Diversion Structure, it passes from the outfall structure at the southwest corner of China Basin almost due east under 7th Street. The available information suggests the structure is shallow but pile supported requiring some adjustments to accommodate both structures.

Plan and profile drawings of the Pennsylvania Avenue alignment option can be found in Exhibits 2.1 to 2.3 in Appendix A.

Portal and Approach structures

At the southern portal there is a substantial site area immediately to the west of the existing rail lines with a rocky outcrop that could be cut to form a suitable face to either launch or receive the tunnel boring machines. The alignment is shown in the figures as being at grade with the existing rail level, although there is the potential to put the approach into a retained cutting if a deeper portal is required. In addition, there are also areas around Cesar Chavez that could be purposed for a TBM launch site.

Further, under the Pennsylvania Avenue alignment option, it may be possible to continue a bored tunnel through part of the proposed DTX section minimizing impacts as well as decreasing costs to the overall project. To do this, additional engineering and environmental clearance to the Pennsylvania Avenue alignment would need to be completed and that work combined with the TJPA DTX work prior to construction of the DTX. Otherwise, the Pennsylvania Avenue alignment could be constructed as an independent project and connected up to the DTX underground at the corner of 7th/Townsend without disruption to Caltrain/HSR service operating in the DTX due to the tail track provided in the SEIS/R of the DTX at the request of the City and County of San Francisco.

Note that the Pennsylvania Alignment underground extension is not a new concept, but one that has been explored by TJPA at the request of the City and County of San Francisco in the supplemental environmental document (draft 2015). Figure 5: TJPA 2015 drawing of previously conceived Pennsylvania Avenue Alignment underground extension connecting through to the 4th/Townsend station.

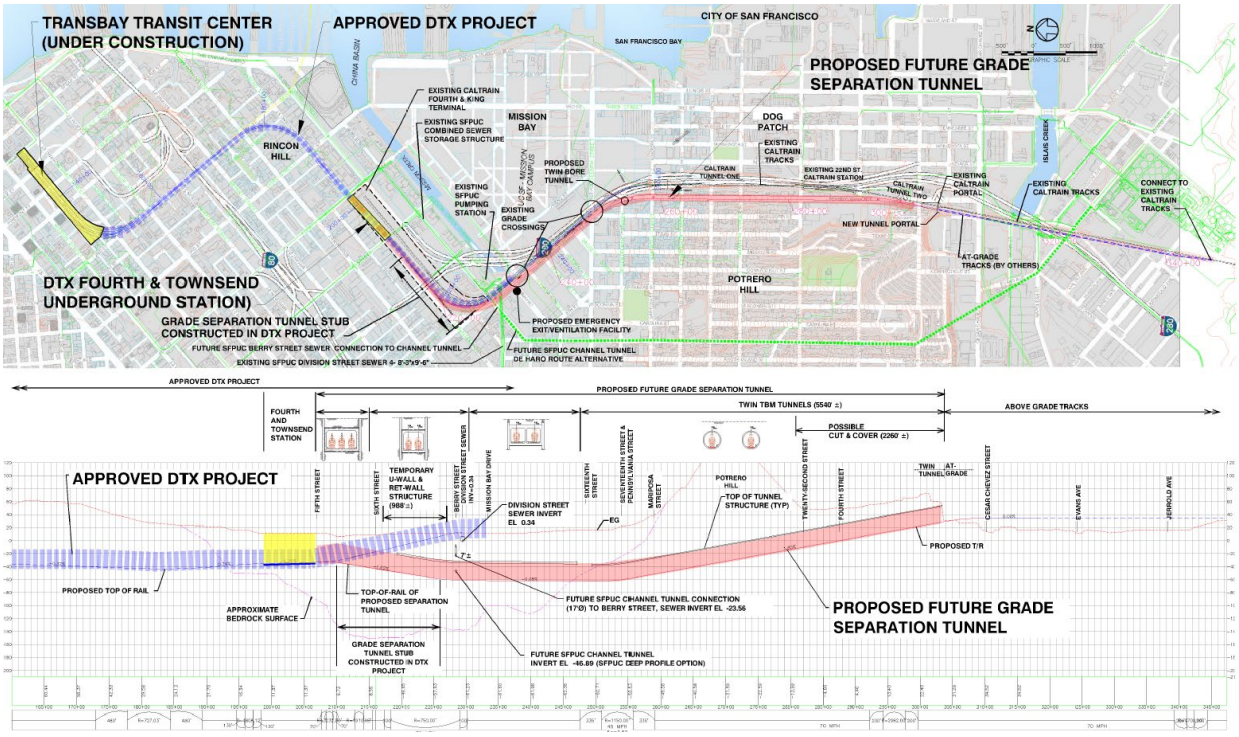

Figure 8: TJPA 2015 drawing of previously conceived Pennsylvania Avenue Alignment underground extension connecting through to the 4th/Townsend station.

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Tunneling Methodology

For comparison purposes, the RAB study has assumed the same tunneling methodology as TJPA for those portions of the Pennsylvania Alignment which are identical to the approved DTX. From the SFTC the alignment follows the DTX proposal of a three-track tunnel excavated using sequential excavation mining tunneling techniques. Sometimes referred to as SEM, this technique involves installing temporary support to the ground just excavated – usually using some combination of rock bolts, shotcrete and steel arches, and then excavating the next small length of tunnel, and so on until the tunnel is completely excavated. A permanent waterproof lining would be installed to provide permanent support of the ground and water above the tunnel.

This SEM construction method is maintained into Townsend Street where the construction method changes to cut and cover, which involves excavating a wide trench, constructing the box shaped concrete tunnel inside it, and then covering it over to reinstate the original street level. The cut and cover tunnel continues along Townsend to the new station at 4th/Townsend Street.

The presence of three tracks necessitates the construction of emergency egress passages roughly every 800 feet over both SEM and cut and cover sections of the tunnel between the SFTC and the 4th/Townsend Street Station. These are constructed using cut and cover techniques.

To the south of the 4th/Townsend Street Station the alignment continues in cut and cover structures, as shown in the figures. It essentially matches the DTX alignment for cut and cover structures that permit future installation of a bored tunnel.

The bored tunnel is shown as commencing at station 72+50. This section of the work comprises two circular tunnels of approximately 20-foot internal diameter, located approximately 45 feet apart, (center to center). The tunnels are connected by cross passages at approximately 750-foot centers and constructed totally under City right-of-way.

Note: The RAB study has chosen to assume the cut and cover approach along 2nd Street to conform to existing TJPA plans for the environmentally approved DTX. If the Pennsylvania alignment is adopted, the RAB team recommends the TBM approach be considered for tunnel sections through and north of 4th/Townsend. The City is eager to determine if this approach can decrease costs and time for the DTX portion of the project. To determine possible savings, additional design and environmental clearance would need to be completed and in a timeframe that would not deter continued work on the DTX so as not to delay the operations of trains into the Salesforce Transit Center. The City has expressed its eagerness for this work to be undertaken without delay and as a shared priority for the City and the TJPA.

Right-of-way

The preponderance of the alignment would be below city streets and fit within the existing right-of-way, assumed to be between 90 and 110 feet between property lines, with the following exceptions:

- The structures on both the north and east corners of the Howard Street and 2nd Street intersection would have to be removed to make way for the cut and cover throat structure. It is assumed this has already been considered as part of the approved DTX alignment.
- As the alignment turns 90 degrees from 2nd Street to Townsend Street the tunnel would pass below numerous structures to the west of that intersection. The tunnel at this point in the alignment would potentially transition from rock into soft ground, which could have an impact

on the structures above. It is assumed this has already been considered as part of the approved DTX alignment.

- As the alignment transitions from below 7th Street to Pennsylvania Ave a number of structures, up to six stories high, immediately adjacent and to the west of the I-280 may be affected between 16th Street and Mariposa Street. It is currently assumed that these structures would be founded in the bedrock above the level of the proposed tunnel, but this would need to be verified in future stages of design development. Constructing within the right-of-way is not anticipated to require additional right-of-way but considerations of nearby foundations would need to be investigated.
- To the south of the southern station near 22nd Street the alignment passes below several structures as it transitions from Pennsylvania Avenue to tie in with the existing tracks. Depending on the location of the tie-in, it may be necessary to be outside of the existing right-of-way. Considerations of these potential impacts would be investigated as further design of the alignment continues. Geologically, the alignment here is expected to be in bedrock minimizing the impacts and facilitating the use of a TBM in the area.

In its final form, the proposed Pennsylvania Avenue alignment does not interface with the 4th/King Railyard, yet it is assumed that upon completion of this alignment the 4th/King station and railyard would no longer be required and that the land would become available for urban form improvements and land use considerations. As noted previously, significant additional analyses would need to be completed and agreed upon to determine the level of vacation of the 4th/King railyard.

Stations

4th/Townsend Three-Track Underground Station

As currently designed under the DTX SEIS/R, the 4th/Townsend underground station is anticipated to be three tracks and one center platform. This would allow for a HSR train to pass two Caltrain stopped trains at 4th/Townsend and continue directly to SFTC.

With the removal of the 4th/King surface railyard, there may be need for additional storage/maintenance options in the northern portion of Caltrain's rail line. Therefore, the RAB Study looked at two additional permutations of the 4th/Townsend underground station to allow for different configurations. Further operations and engineering analysis of either configuration would need to be completed and environmental clearance would need to be sought to include them in the construction footprint of the DTX.

4th/Townsend Four-Track Underground Station

The four-track station permutation includes an additional stub-end track to the south (southeast) of the existing three tracks (and under the existing 4th/King surface railyard). The 4th/Townsend underground station would consist of four tracks each served by a platform face. All four tracks would be serviced from the south with one track terminating at the station and the other three passing through to the north to connect to the SFTC box.

The station structure would be approximately 1,300 feet in length comprising of a 200-foot transition section between SFTC and 4th/Townsend platforms, 700-foot platform length and 400-foot transition section accommodating crossovers between 4th/Townsend and approximately the corner of 7th/Townsend. The box would have an excavated width of approximately 135 feet.

Track level would be between 35 and 50 feet below road level. This includes a clearance above the track level of 23 feet, 6 inches, and up to a 12-foot high mezzanine level as an access point between platforms and street level. The mezzanine could potentially accommodate a ticket hall, plant rooms and income generating retail and commercial space.

It is assumed this station would replace the existing 4th/King Street Station and adjacent railyard thus releasing an area of the existing railyard for alternative use and future development. For more detail, refer to Exhibit 4.1 in Appendix A as shown in Figure 6: Expanded 4th/Townsend Station Concept.

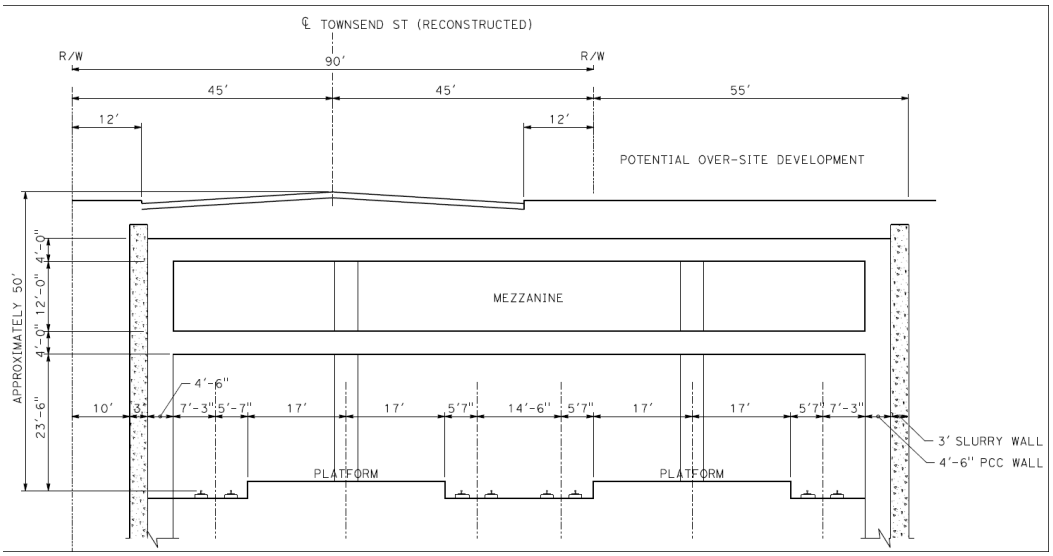

Figure 9: Expanded 4th/Townsend Station Concept, four tracks

Street access to the 4th/Townsend underground station would be via an entrance structure located near the current 4th/King Street Station with escalators descending to the mezzanine level of the station box. This entrance structure and additional points of access would also be provided within the over-site development building. Additional stair, elevator and/or escalator access points could be provided on the north (northwest) side of Townsend Street if necessary. The ticketing and other station facilities would be located at the mezzanine level within the station box and multiple vertical circulation points would provide access to the center platform.

The right-of-way below Townsend Street is approximately 90 feet in width and this proposed station would be constructed with a 10-foot clearance to the northwestern edge of the right-of-way, extending into the existing railyard for approximately 55 feet beyond the southeastern edge of the right-of-way.

4th/Townsend Six-track Underground Station

The six-track permutation includes an additional 3 stub-end tracks to the south (southeast) of the existing three operational tracks (and under the existing 4th/King surface railyard). The six-track option is larger than the 4th/Townsend four track station permutation described above and extends further under the existing railyard. The station would consist of six tracks each served by a platform. All six tracks would be serviced from the south with three tracks terminating at the station and the other three passing through to the north to connect to the SFTC box.

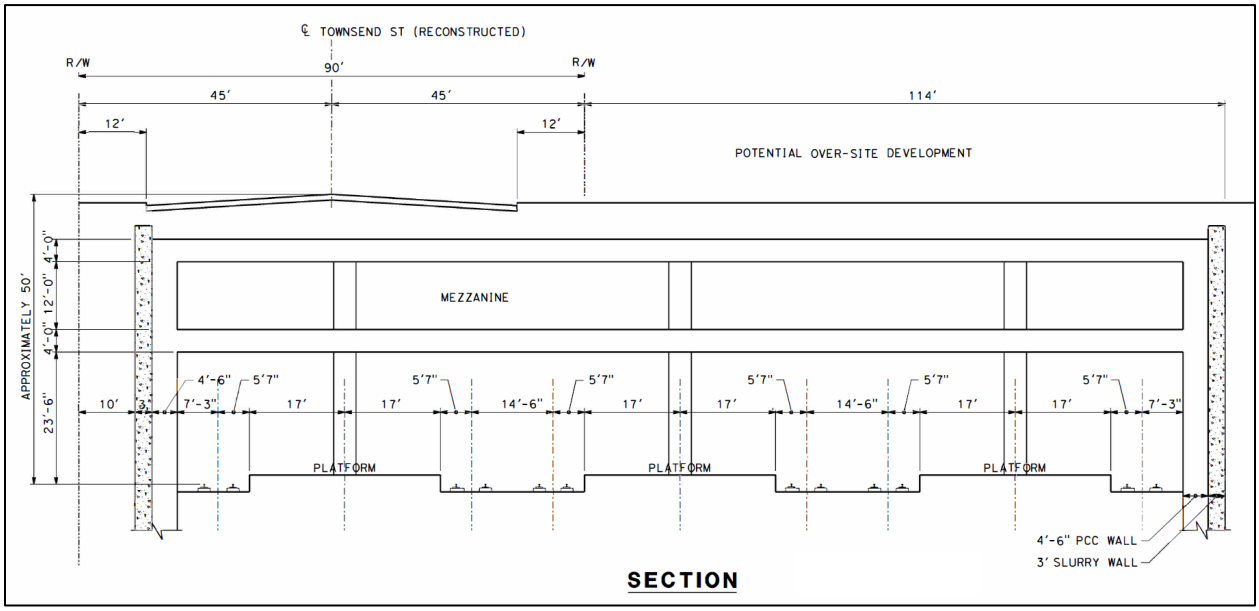

Figure 10: Expanded 4th/Townsend Station Concept, six tracks

The station structure would be approximately 1,500 feet in length comprising of a 200-foot transition section between SFTC and 4th/Townsend, 700-foot platform length and 600-foot transition section accommodating crossovers between 4th/Townsend and approximately the corner of 7th/Townsend. The box would have an excavated width of approximately 194 feet.

Track level would be between 35 and 50 feet below road level. This includes a clearance above the track level of 23 feet, 6 inches, and up to a 12-foot high mezzanine level as an access point between platforms and street level. The mezzanine could potentially accommodate a ticket hall, plant rooms and income generating retail and commercial space.

It is assumed this station would replace the existing 4th/King Street Station and adjacent railyard thus releasing an area of the existing railyard for alternative use and future development. For more detail, refer to Exhibit 4.2 in Appendix A.

Street access to the 4th/Townsend underground station would be via an entrance structure located near the current 4th/King Station with escalators descending to the mezzanine level of the station box. This entrance structure and additional points of access would also be provided within the over-site development building. Additional stair, elevator and/or escalator access points could be provided on the north (northwest) side of Townsend Street if necessary. The ticketing and other station facilities would be located at the mezzanine level within the station box and multiple vertical circulation points would provide access to the center platforms.

The right-of-way below Townsend Street is approximately 90 feet in width and this proposed station would be constructed with a 10-foot clearance to the northwestern edge of the right-of-way, extending into the existing railyard for approximately 114 feet beyond the southeastern edge of the right-of-way.

Pennsylvania Avenue Alignment – 22nd Street Station

The southern station (22nd Street Station) on this alignment is proposed to be re-located into a shallow cut and cover box below Pennsylvania Avenue. It will be parallel to and west of the existing station. Other options for locating this station exist. As the design progresses, and the TBM launch site (portal) is

identified, the 22nd Street Station location/relocation can be refined with a full study of access and opportunities.

The width of Pennsylvania Avenue is quite narrow (only 80 feet between buildings) but from information available the underground tunnel is expected to be in rock. The station could be constructed inside the tunnel either as completely cut and cover or using a combination of cut and cover and conventional tunneling techniques, depending on the quality of rock and desire to reduce surface impacts, or relocated outside of the tunnel portal south likely nearer to Cesar Chavez. It is expected that for either option where the station is located inside of the tunnel, the excavation will be from within the footprint of Pennsylvania Avenue itself, although the possibility of excavating from the existing rail land under I-280 could be investigated at a later stage if desired.

It is assumed this station will be within the right-of-way of Pennsylvania Avenue.

Further Station Considerations

The RAB team recognizes that there are additional 22nd Street station location alternatives to be explored that utilize most of the existing 22nd Street station footprint, or locations that would provide more east/west connection options. While worthy of further study, only the alternative described able was used as the basis for this conceptual alignment.

The 16th Street Problem – Resolved

With the Pennsylvania Avenue Alignment, all existing surface tracks are eliminated prior to the 22nd Street station, thus eliminating all at-grade intersection conflicts.

Roadway Trenching – Eliminated

There are no surface conflicts; no roadway trenching is required. The rail is moved underground and the surface is retained for vehicle access east/west and north/south.

I-280 Freeway – No Change, Future Flexibility

The Pennsylvania Avenue Alternative does not require any changes to the I-280 freeway and the RAB study proposes no changes to I-280. The undergrounding of all rail infrastructure in the project area would provide future flexibility to consider surface alternatives to I-280 in a future study.

Summary and Recommendations

The RAB study finds that the Pennsylvania Avenue Alignment is a technically viable alternative that should be considered in future policy decisions. At the time of the writing of this report, and without the benefit of a completed blended service operations plan, the RAB study recommends further operations and engineering analysis of a four-track 4th/Townsend underground station to provide additional flexibility for both Caltrain and High Speed Rail. While a six-track underground alternative could be viable to construct, it is our assumption that no likely future service plan requires that much station capacity (assuming a new south railyard is developed). Further, a six-track station could limit the heights of development above ground due to the diameter of support structures for the above ground development being in conflict with rail design requirements underground.

Key Pennsylvania Alignment considerations for future policy analysis:

- Solves the 16th Street Problem, eliminates all surface conflicts in project area

- Provides an opportunity to re-knit over 1 mile of the city longitudinally east/west – provides for more connections across where the Caltrain tracks are today
- With further analysis, all Caltrain and high speed rail trains could utilize Salesforce Transit Center (total of up to 10 trains per direction per hour), or 8 trains to SFTC and with 2 terminating at an expanded underground 4th/Townsend
- Unifies the station experience at 4th/Townsend (all tracks in one sub-surface station) by assuming that current 4th/King passenger operations move to the new underground 4th/Townsend station.
- Allows for further study of a potential relocation (to a more accessible location) of the 22nd Street Caltrain station
- Follows along the majority of existing and environmentally cleared DTX alignment – minimizes additional environmental work that would need to be completed
- Assumes a new southern railyard for Caltrain storage and maintenance (as yet to be agreed upon) as all access to use of 4th/King surface yard is eliminated
- Allows for transit oriented development of the 4th/King Railyard site
- Is more expensive than the environmentally approved DTX as doubles the length of the underground rail tunnel, but avoids cost of trenching roadways

3.1.3 Mission Bay Alignment

This rail alignment option proposes to tunnel the alignment south of the SFTC and along a new Third Street alignment. This alignment begins at the SFTC following the approved DTX alignment southeast along 2nd Street (though diving deeper than the approved DTX) and then continues towards the southwest side of AT&T Park to cross China Basin below the 3rd Street Bridge. From here the alignment travels south below 3rd Street to 18th Street where the alignment turns southwest passing below the existing I-280 elevated freeway to connect to the current rail alignment in the vicinity of 23rd Street (See Figure 11).

PLEASE NOTE: Many variations on this alignment and its assumptions are possible. But for the purposes of analysis and cost estimating, the conceptual alignment and elements described above were chosen for further study. This does not signify a preferred option for the Mission Bay alignment or package of elements. If this alignment moves forward, a full analysis of different connection points, alignments, and station location(s)/configuration(s) would be undertaken.

The proposed Mission Bay alignment only interfaces with the existing Caltrain alignment on the southern end of the study area around 22nd Street. Mission Bay would be constructed completely off-line of the existing Caltrain alignment and connected with minimal service disruption over a limited number of weekends.

This alignment proposes a new underground station below 3rd Street between the 3rd Street Bridge and China Basin Street (exact location to be determined at a later date). This proposed underground station would be a 15 minute walk east from the proposed 4th/Townsend station (included in the Future with Surface Rail and the Pennsylvania Avenue alignment options) it would be replacing. A southern station between 22nd Street and 23rd Street would be constructed in the alignment and in the vicinity of the current 22nd Street station.

In its final form, the proposed Mission Bay alignment does not interface with the 4th/King Street Station and Railyard, yet it is assumed that upon completion of this alignment the station and railyard would no longer be required and that the land would become available for urban form improvements and land use considerations.

- Proposes an alignment on 3rd Street east of the existing surface Caltrain tracks.
- Proposes a 3rd Street underground station to serve the Mission Bay community
- Relocates 4th/King storage and maintenance functions; assumes new south railyard.
- Assumes no surface rail north of 25nd Street Station (no 4th/King surface railyard access).
- Assumes Caltrain PCEP (Electrification).
- Continues use of elevated I-280 to 4th/King and 6th/Brannan, but compatible with future alternatives.
- Does not require Caltrain to be out of service for any significant duration during construction.
- Provides for opportunity to provide new pedestrian, bike, and vehicular connections east/west between the Mission Bay neighborhood and the west.

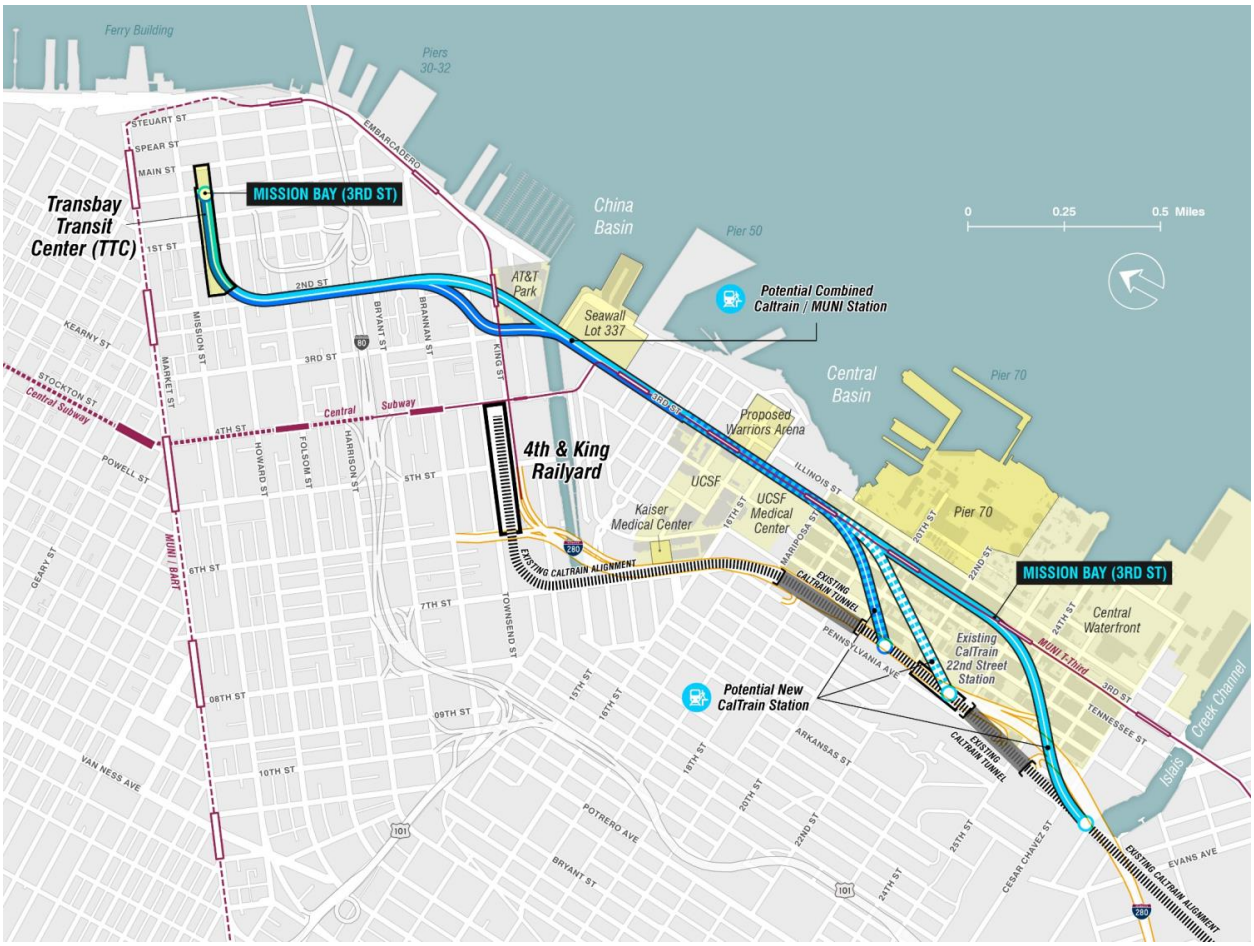

Figure 11: Mission Bay (Third Street) Alignment

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4th/King Railyard Access – Eliminated

In this alternative, all rail is completely underground north of the station near 22nd Street. There is no longer any surface rail connection to the 4th/King railyard. All station and staging functions would be accommodated in a Mission Bay station under Third Street. All storage and maintenance functions would be served at a new southern railyard. (See Section 3.3, Railyard Reconfiguration/Relocation Study.)

Constructability

Soil Conditions and Geologic Hazards

Subsurface soil conditions along the proposed Mission Bay Alignment were developed using the available soil information collected at nearby locations and are depicted on Exhibits 3.1 through 3.3 in Appendix A. Based on that information, the proposed alignment along the 2nd Street is almost identical to that for the Pennsylvania Alignment. Portions of the alignment that pass near the AT&T Stadium and across the China Basin, as well as the proposed 3rd Street underground station, are underlain by Artificial Fill and a more complex Quaternary sediments of Young Bay Mud, Upper Layered Sediment, Old Bay Mud, Lower Layered Sediment and slope debris of varying thicknesses. Bedrock is expected to be near the ground surface or outcrops from near the 16th Street to the southern terminus of the alignment.

Construction Option 1 – SCL and Twin Bore Tunnels

Construction Option 1 for the Mission Bay alignment is similar to the Pennsylvania alignment, with the following differences:

- The excavation of the SEM tunnel will enter a 600- to 700- foot section where there is old bay clay in the crown of the tunnel. This length will require more ground treatment and higher support requirements including face support and pre-support to control movements and limit settlement.
- The Mission Bay Station is much deeper than the 4th/Townsend Street Station on the Pennsylvania Alignment (2 to 2.5 times deeper), which will require significantly more support to control ground movements.

Construction Option 2 – Large Diameter Tunnel

While it follows the same alignment as Construction Option 1, for Construction Option 2 the geotechnical issues will differ from those of Construction Option 1 as follows:

- Issues with ground treatment are largely eliminated, although careful control of the TBM will be required to control ground movements along significant lengths of ‘mixed face’ conditions where both rock and soils are present in the tunnel horizon.
- Issues with cross passage construction are eliminated.
- Settlement issues with the Mission Bay Station are significantly reduced due to the smaller station footprint.

This remainder of this section describes the overall alignments, the main tunnel components, and their construction.

Configuration (Construction Option 1 – SCL and Twin Bore Tunnels)

Beginning at the SFTC box a cut and cover throat structure would serve as the transition section from six tracks within the SFTC box to three tracks entering the tunneled section below 2nd Street. The first

portion of the tunnel would utilize the same profile as the approved DTX three track sprayed concrete-lined (SCL) tunnel along 2nd Street and across China Basin to the proposed Mission Bay underground station.

South of the Mission Bay station this proposed alignment continues underground in twin bored pre-cast concrete segmentally lined tunnels the rest of the alignment to the southern station near 22nd Street then south of the southern station. Beyond the southern station the alignment would continue in a retained cutting below the I-280 freeway to connect to the existing alignment at approximately 23rd Street.

Plan and profile drawings of this alignment option can be found in Exhibits 3.1 to 3.3 in Appendix A.

Portal and Approach Structures (Construction Option 1 – SCL and Twin Bore Tunnels)

The proposed twin bore portals are situated at 22nd Street, just to the north of the new 22nd Street station. The new station and tunnel portal are at the site of the existing bus depot, which would have to be resumed. However, if the site is resumed in full then there would be ample room for construction and tunneling activities.

The alignment must ensure that there is sufficient ground cover to safely tunnel under the existing properties to the north of 22nd Street. To achieve this, the track alignment at the exit of the existing tunnel to the south of 23rd Street would have to be lower than existing, which would require lowering of the invert of the existing tunnel.

Methodology (Construction Option 1 – SCL and Twin Bore Tunnels)

The tunnel from the SFTC is constructed by conventional Sequential Excavation Method in the same way as the DTX and Pennsylvania Avenue alignments up to around Station 30+00, before curving through a double reverse S curve into 3rd Street. To take this route the alignment passes deeper than the DTX and Pennsylvania Avenue alignments to avoid piled foundations of the AT&T Stadium and the 3rd Street Bridge as well as to get below Mission Creek (as it is a navigable waterway).

Some foundation replacement/underpinning may be required, and the alignment should be optimized at future stages to minimize the extent to which such work is required.

To the south of the Mission Bay box the tunnel is constructed by twin bore TBM tunnels of the same form as those on the Pennsylvania Avenue alignment. As with the Pennsylvania Avenue alignment it is anticipated that the tunnels would be driven from the south portal, but terminating in the Mission Bay Station in the case of the Mission Bay alignment. The first part of the drive dips quite steeply in order to ensure maximum cover to the tunneling operation as it passes from the rock into the soils of Mission Bay. This minimizes the risk of emerging into the softer materials closer to the surface, which is inherently more difficult to control settlement in, while also minimizing the impacts of any settlement that does occur.

Between the portal to the new tunnel and the portal to the existing tunnel to the south, some local relocation of I-280 bridge piers may be required (depending on the final alignment) to provide space for the alignment to turn and for the new 22nd Street Station. This would be achieved by the creation of new transfer beams beneath the existing supports to transmit the loads to new columns or strengthened existing columns, and demolition of obstructing columns. It is anticipated that the order of 3 to 5 transfer structures might be required.

If significant lowering of the alignment is required in the existing tunnel south of 23rd Street, then tunnel invert lowering will be required. The most effective way of achieving this would be through the following:

- Rehabilitate the existing (closed) western bore of the existing tunnel.
- Re-route existing rail services through the rehabilitated western bore, including a reconfiguration of the 22nd Street Station to accommodate the revised alignment, and associated relocation of isolated piers of I-280.
- Lower the invert of the eastern bore including underpinning the existing tunnel lining.

This approach to lowering the invert assumes that it is possible to rehabilitate the closed bore of the existing tunnel. Should this alternative prove to be impractical then alternatives would have to be sought.

Right-of-way (Construction Option 1 – SCL and Twin Bore Tunnels)

The majority of the alignment would be below city streets and fit within the right-of-way, assumed to be between 90 and 110 feet between property lines, with the following exceptions:

- The structures on both the north and east corners of the Howard Street and 2nd Street intersection would have to be removed to make way for the cut and cover throat structure. It is assumed this has already been considered as part of the approved DTX alignment.
- As the alignment transitions through a double reverse S curve between Brannan Street and King Street the tunnels would pass below numerous structures from three to twelve stories high. It is assumed the alignment will be in rock at this location and therefore below the building foundation level.
- As part of the AT&T Stadium complex, to the south west of the main stadium structure is a smaller entrance building that this proposed alignment passes below.
- At the south end of the proposed Mission Bay alignment the tunnel transitions from 3rd Street across Pennsylvania Avenue approximately between 18th Street and 23rd Street. As it does, it passes below several low rise structures and some up to six stories high. It is assumed the alignment will be in rock at this location and therefore below the building foundation level.

The impact of the stations on the right-of-way is discussed in Section 4 of this report.

Configuration (Construction Option 2 – Large Diameter Tunnel)

For this construction option a single large diameter pre-cast concrete, segmentally lined tunnel would run from the SFTC box along 2nd Street, across China Basin through the proposed Mission Bay underground station and on to the southern station connecting back to the Caltrain existing alignment around 23rd Street.

From the south portal traveling north, the alignment would be required to fall quite steeply to ensure a recommended minimum of one tunnel diameter's cover to the crown is maintained as the alignment enters the soft ground of the Mission Bay area. Thereafter the tunnel continues down at a steep grade to ensure that the crown of the tunnel is more than one diameter below the ground when the tunnel alignment enters the soft ground of Mission Bay. Maintaining this cover is necessary to help control settlement. During this length, the tunnel structure will be declining at the maximum track grade. Therefore, if the tracks are at the top of the tunnel at the portal then they must remain in the top half of the tunnel along the length of decline. This large bore could accommodate 3 tracks, and potentially 4 (2 stacked on top of an additional 2 tracks depending on CHSRA clearance requirements).

Portal and approach structures (Construction Option 2 – Large Diameter Tunnel)

The southern portal would be located immediately to the south of 22nd Street, the same as the twin bore tunnel. However, the crown of the tunnel would have to be deeper to provide the same level of safety to the buildings above. This means that the invert lowering of the existing tunnel south of the 22nd Street Station would likely have to be deeper than the twin bore tunnel solution, possibly requiring invert lowering of the existing tunnel of up to 25 feet.

If there is a need for the high-speed rail and Caltrain lines to be vertically separated at the portal, then the high-speed rail lines will be required to continue a downward gradient over the length of the 22nd Street Station, (while the alignment of the Caltrain Tracks would remain level over the same length). It is envisaged that this would require a wider and deeper box structure for the 22nd Street Station.

Right-of-way (Construction Option 2 – Large Diameter Tunnel)

The right-of-way implications would be the same as for the SCL and Twin Bore Tunnel options except that the overall width of the large diameter tunnel would be less than two smaller tunnels side by side plus the necessary clear distance of approximately one tunnel diameter between them. But clearance on top of the large bore tunnel is greater; as with any tunnel, the safe depth is at least one diameter of the tunnel between the top of the tunnel and the surface.

Stations

Third Street Station

Construction Option 1 – Three-track Cut and Cover Station

This option sites the Mission Bay station below 3rd Street just to the south of China Basin and the 3rd Street Bridge (although final location of the station would be determined in future analysis). This cut and cover station would contain three tracks with the two outer tracks served by a platform and the central track acting as a bypass track (or could be a center platform with an outside bypass track).

The station structure would be approximately 1,200 feet in length comprising of a 100-foot clearance between the SFTC and the north edge of the platforms, 700-foot platform length and a 400-foot section accommodating crossovers between the platforms and section continuing to the south. The box would have an excavated width of approximately 92 feet.

As an alternative, an additional two sequential platforms (double-berthing) could be accommodated to the south of the station if the box were extended approximately 800 feet to a total of 2,000 feet in length. This would provide additional capacity during events at the nearby AT&T Park and proposed Chase Stadium. It should be noted that double berthing is not a desired way to stage for Caltrain, but it is possible.

Track level would be approximately 100 feet below road level with the station box including up to three mezzanine levels between platforms and street level. These mezzanines could potentially accommodate a ticket hall, plant rooms and income generating retail and commercial space. For more detail, refer to Exhibit 5.1 in Appendix A.

Street access to the station could be via stair, elevator and/or escalator access points from the sidewalks either on 3rd Street on one or more of the cross streets. These access points would be constructed outside of the main box structure, which is located under the road. It may be necessary to adjust the road configuration to provide additional sidewalk width to gain space for the entrance openings.

Access to the platforms would be provided at the edges of the mezzanine to the back edge of the platforms using stairs, escalators and elevators.

The right-of-way below 3rd Street is approximately 110 feet in width and this proposed station would be constructed with a 9-feet clearance to the edges of the right-of-way.

Construction Option 2 – Four-track Bored Tunnel Station

This construction options assumes a large diameter bored tunnel is used for the whole of the proposed alignment. This option sites the northern station below 3rd Street just to the south of China Basin and the 3rd Street Bridge. This bored tunnel station would contain four tracks with two on an upper deck and two on a lower deck. The two on the upper deck would each be served by a platform whilst the two on the lower deck would act as bypass or storage tracks. To the north and south of the station the four-track layout would transition into a three track layout for the remainder of the proposed alignment.

The station would be accessed by a small footprint cut and cover entrance structure with an excavated width of approximately 92 feet.

As an alternative, an additional two sequential platforms could be accommodated to the south (double berthing). It is envisaged that additional platforms could require additional entrance structures. This would provide additional capacity during events at the nearby AT&T Park and proposed Chase Stadium.

Track levels would be approximately 105 and 129 feet below road level with the station entrance structures including up to four mezzanine levels between platforms and street level. These mezzanines could potentially accommodate a ticket hall, plant rooms and income generating retail and commercial space.

For more detail, refer to Exhibit 5.2 in Appendix A.

Street access to the station could be via stair, elevator and/or escalator access points from the sidewalks either on 3rd Street on one or more of the cross streets. These access points would be constructed outside of the vertical circulation box structure, which is located under the road. It may be necessary to adjust the road configuration to provide additional sidewalk width to gain space for the entrance openings.

The vertical access box structure would provide space for stair, elevator and/or escalator access to platform level. Ticketing and other station facilities may be provided with in this space or it could be provided by extending the near surface part of the structure if additional space is required.

It is assumed the right-of-way below 3rd Street is approximately 110 feet in width and this proposed station would be constructed with a 9-foot clearance to the edges of the right-of-way.

Mission Bay Alignment – Station near 22nd Street

The southern station near 22nd Street on this alignment is proposed to be located mostly in a retained cutting with a short length of cut and cover to the north. It is proposed to be located below the site of the existing bus depot between 22nd Street to the north and 23rd Street to the south and between Iowa Street to the west and Indiana Street to the east.

If the alignment were to provide dedicated high-speed lines from the portal then the station would incorporate platform(s) serving level Caltrain lines, with a central retained cut for the descending high-speed rail lines. This makes the overall box structure deeper and more complex. This arrangement is not currently considered in the current costs, but can be evaluated if providing the dedicated high speed rail lines is desired.

This station would be located diagonally across the current bus depot from the intersection between 22nd Street and Indiana Street and where 23rd Street passes below the I-280 freeway. It is assumed the whole of the bus depot would need to be acquired for the cut and cover station.

Further Station Considerations

The RAB team recognizes that there are additional 22nd Street station alternative locations to be explored that utilize some of the existing 22nd Street station footprint. While worthy of further study, those alternatives are not currently the basis for this conceptual alignment.

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The 16th Street Problem – Resolved

With the Mission Bay Alignment, all existing surface tracks are eliminated north of the station near 22nd Street, thus eliminating all roadway conflicts.

Roadway Trenching – Eliminated

There are no surface conflicts; no roadway trenching is required.

I-280 Freeway – No Change, Future Flexibility

The Mission Bay Alignment does not require any changes to the I-280 freeway and the RAB study proposes no changes to I-280. The undergrounding of all rail infrastructure in the project would provide future flexibility to consider surface alternatives to I-280 in a future study.

AT&T Park

Whilst the Mission Bay alignment has been routed to avoid passing below the main stadium structure, this proposed alignment does still pass beneath the stadium club house and store building between the stadium and 3rd Street. The stadium structure is built on the edge of China Basin and is founded on piles that have been driven through the sedimentary material, including the soft younger bay mud and the stiffer old bay clays, and into the bedrock. In the vicinity of AT&T park, the top of bedrock level is sloping towards the basin (reference marked up Figure 9: AT&T Stadium Pile Layout Showing Estimated Pile Tip Level Contours).

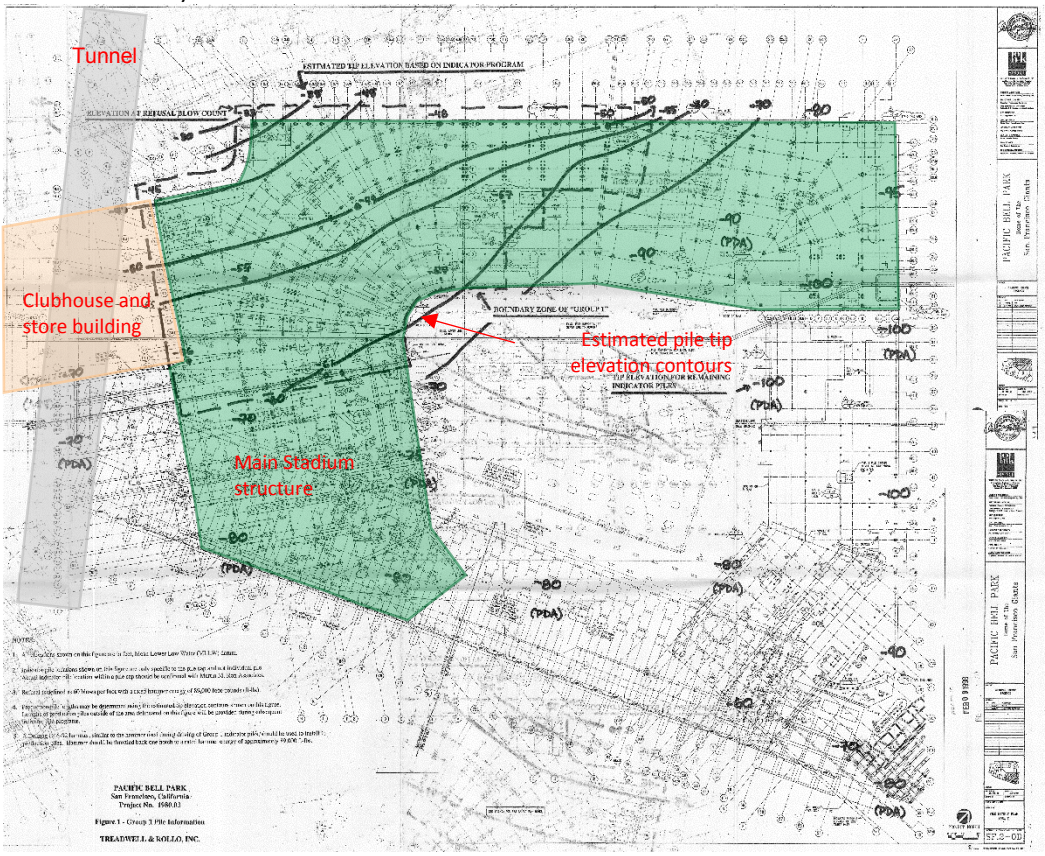

Figure 12: AT&T Stadium Pile Layout Showing Estimated Pile Tip Level Contours

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For the Mission Bay alignment, the preliminary alignment of the tunnel has been located to the west of the main stadium structure and avoids the piles supporting that structure, however it may still conflict with foundation piles associated with both current and previous structures on the west side of the stadium. This includes the stadium clubhouse and store building pictured on Figure 6-2. In addition, with the movement to avoid the piles supporting the structure, a double reverse S curve was put into the design. This is a tight turn that slows the operations of the trains.

Depending on the final size and configuration of the Mission Bay alignment if furthered, it may be worthwhile to study the potential to "tread the needle" of the piles and minimize the S curve. As that would require additional design it was not considered in this assessment and the double reverse S curve was included. In addition, further study could investigate whether it is possible to lower the tunnel alignment and avoid the direct conflict with the clubhouse and store building. This option would require detailed study of the piles both past and present to determine the sufficient clearance to the tunnel could be achieved. It would also steepen the rail grade from the Transbay terminal and further development of the track layout and operational requirements would be required to confirm the feasibility of this alternative. Because of the risks involved in these potential refinements, the more conservative reverse S curve has been assumed for this analysis.

Under the preliminary design proposed in the RAB study, the stadium clubhouse and store building would need to undergo significant modification to its foundation to transfer to a new foundation structure and potentially to remove the existing piles.

3rd Street Bridge

For locations where the Mission Bay preliminary alignment analyzed in the RAB study conflicts with the 3rd Street Bridge foundations, major protection works or reconstruction of the bridge may be required.

Light Rail

Depending on how the 3rd Street station is constructed, there may be a need to re-route the T-Third MUNI light rail line during construction. More information would be necessary and will be discussed further if this alignment moves forward for further design/analysis.

I-280

Between the portal to the new tunnel and the portal to the existing tunnel to the south (Tunnel 2 on the Caltrain alignment), some local relocation of I-280 bridge piers will be required to provide space for the alignment to turn and for the new 22nd Street Station. This would be achieved by the creation of new transfer beams beneath the existing supports to transmit the loads to new columns or strengthened existing columns, and demolition of obstructing columns. It is anticipated that the order of 3 to 5 transfer structures might be required.

Connection to Existing Railway

As stated above, depending on the final configuration of the alignment and the number of tracks to be provided, there may be the need for repurposing the abandoned tunnel for temporary use while lowering the tunnel invert of what will be the operating tunnel. If this alignment moves forward, additional design and analysis will be necessary to fully understand and mitigate impacts.

Assumptions and Exemptions

- The stratigraphy shown on the plan and profile drawings is based on limited information available at the time of study and may change with actual ground investigation.
- The proposed alignment assumes the relocation of the existing railyard at 4th/King.
- The proposed alignment and 22nd Street Station location and depth are indicative only.

Summary and Recommendations

The RAB study finds that the Mission Bay Alignment is a technically viable alternative that should be considered in future policy decisions. At the time of the writing of this report, and without the benefit of a completed blended service operations plan, the RAB study recommends a single large bore tunnel approach which allows for a four-track bored tunnel station.

Key Mission Bay Alignment considerations for future policy analysis:

- Solves the 16th Street Problem, eliminates all surface conflicts in project area
- Allows for transit oriented development of the 4th/King Railyard site
- Unifies the station experience at Third Street station (all tracks in one sub-surface station)
- Limits the Third Street station to two platform tracks which, depending on blended service operations plans, could become a constraint on rail operations in the corridor. There is an option to double-berth the platforms although that is not the current operating norm for Caltrain and not included as such in this analysis.
- Assumes 4th/King storage and maintenance activities relocated to a new location. Is the most expensive alternative; more expensive than the Pennsylvania Avenue alternative and much more expensive than the environmentally approved DTX, but avoids cost of trenching roadways

3.1.4 Tunnel Under I-280 Alignment

Please note: This rail alignment was removed from further consideration in Phase I due to it being infeasible for construction given the location of supporting structures for I-280 not having sufficient room to accommodate a tunnel between them. Information is provided below for consistency through the report.

This rail alignment option considers the feasibility of moving the rail tracks underground in the exact same location and alignment as the current rail. This would achieve grade separation at 16th Street and 7th/Mission Bay Drive, while keeping the alignment and required right-of-way unchanged. This option follows the existing alignment south of Mariposa. North of Mariposa, the rail alignment would dive down, traveling in a tunnel under the existing alignment and connecting to the existing DTX. In this option, the 4th/King Railyard would not be accessed from surface track so the maintenance/storage functions would move to a new location and all station operations would occur in the underground 4th/Townsend station contained in the DTX.

- Includes the Downtown Rail Extension (DTX) as designed and environmentally cleared.
- Assumes 4th/Townsend Station as part of the DTX.
- Grade separates Caltrain/HSR under 16th Street.
- Assumes no surface rail north of 22nd Street Station (no 4th/King surface railyard access).

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- Relocates 4th/King maintenance and storage functions; assumes new south railyard.
- Requires major structural re-work of I-280 pillars before work can commence to tunnel directly under freeway.
- Assumes elevated I-280 to 4th/King and 6th/Brannan remains; is also compatible with future I-280 alternatives such as a surface boulevard.
- Requires partial cut and cover construction because of impacts to I-280 columns and SFPUC pump station.
- Requires Caltrain to be out of service north of 22nd Street Station for 2 years or more during construction.

4th/King Railyard Access

Because this alternative was eliminated in Phase I of the RAB study, surface rail connection to the 4th/King railyard, or connection to an alternative yard, was not considered further.

Constructability

The distance between the I-280 columns is not wide enough to support use of a tunnel boring machine, would greatly complicate a sequential mining approach, would require relocation and reengineering of multiple freeway supports, would increase tunneling cost and risk, and would require that Caltrain be out of service for much of the construction period. For these reasons, this option was deemed inferior and infeasible and was not pursued in Phase II of the RAB study.

Figure 13: Tunnel Under I-280 Alignment, including planned DTX (in green)

The 16th Street Problem

Initial concepts for this alternative removed all existing surface tracks north of Mariposa and eliminated the 16th Street problem.

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I-280 Freeway

Because this alternative was eliminated in Phase I of the RAB study, the long-term interface with the I-280 freeway was not considered further.

Summary and Recommendations

Note that this option was found to be infeasible as part of the Phase I review and was not recommended for further analysis. This alternative is depicted in Appendix A, as excerpts from the RAB Phase I Draft Conceptual Alternatives. Only one variation has been presented in the drawings package for this option.

3.1.5 Summary of Alignment Options Considered

Future with Surface Rail

The study team's engineering review of this alignment option confirms that it is technically feasible. While there are known engineering challenges to be managed, the main drawbacks of this alignment option are operational and subject to further analysis and policy consideration.

1. The Caltrain Electrification EIS/EIR limits the number of trains that can travel the corridor, and considers the and the impact on east/west travel across the tracks at both 16th Street and 7th/Mission Bay Drive at-grade intersections. The crossings have been environmentally cleared for a peak of 6 TPHPD (trains per peak hour per direction) as part of the EIS/EIR. Level of Service for crossing vehicles in addition to 6 trains will further reduce vehicle throughput at the intersections of 16th Street and 7th/Mission Bay Drive.
2. The overall capacity of the SFTC is constrained. 10 TPHPD have been considered by Caltrain simulation efforts (LTK 2015), but that study suggests that capacity to the SFTC may be limited to 8 trains (if platforms are dedicated to either Caltrain or HSR only), with 2 Caltrain trains terminating at 4th/King instead of continuing to SFTC. The RAB study suggests, with further analysis, that with common platform heights at SFTC, and shared platforms between Caltrain and HSR, additional trains could be accommodated in the SFTC beyond the anticipated 10. As a safety measure, a new revised underground 4th/Townsend station could be expanded to provide additional storage or turnaround capability for Caltrain instead of the 4th/King surface yard.
3. Non-revenue movement between the SFTC terminal to the existing railyard at 4th/King require a lengthy reverse direction, cross track move and add train movements across 16th Street. Simulations from LTK (2015) show this movement to be approximately 10-minutes in runtime.
4. The currently planned DTX configuration assumes most or all of 4th/King railyard remains on the surface, limiting opportunities for development on the railyard site.
5. The currently planned DTX configuration relies on the existing surface rail alignment, which would then preclude any future consideration of I-280 Boulevard options as there is not enough right-of-way to have surface rail as well as a boulevard of sufficient width to accommodate the anticipated volumes of traffic.

Given the scale of the investment in the SFTC, the RAB study suggests the region should be looking at engineering and operating solutions that expand rail capacity to the SFTC beyond 8 TPHPD – as assumed in early operations planning. Operations analysis conducted as part of the RAB study has suggests potential solutions that expand capacity to the SFTC which are worthy of further consideration. (See Section 4, Rail Operations Analysis.)

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Further technical analysis should focus on rail and traffic capacity related to the existing DTX plan and the 16th Street problem. The future blended service operations plan will inform the future impacts to vehicle traffic as well as rail service provided along the Peninsula in the future. Traffic capacity on 16th Street will require further analysis to determine how future vehicle LOS (Level of Service) will be impacted by 6 trains, 8 trains, 10 trains, or more. The existing Caltrain electrification program has only considered the impacts of 6 trains across the 16th Street crossing. Expanding service to 10 trains under a blended service operations plan would force a difficult policy (and legal) decision by the City as to which service to choke down – the streets, or the rails.

Pennsylvania Avenue Alignment

Recognizing the construction complexities with tunneling underneath I-280 for the Tunnel Under I-280 Alignment, the Pennsylvania Avenue alternative proposes an option that avoids this. The key benefits of this alternative are:

1. Removes complexities of tunneling underneath I-280 and moves the tunnel under the City street right-of-way.
2. Eliminates need to take Caltrain out of service during construction.
3. Eliminates the 16th Street at-grade crossing by providing an opportunity to re-knit over 1 mile of the city longitudinally east/west – provides for more connections across where the Caltrain tracks are today.
4. Moves to a more regional perspective by ensuring that the capacity of train service is not constrained by the local at-grade intersections.
5. Provides opportunity to liberate 4th/King railyard for public use and/or development.

Although this alignment option eliminates the challenges of the first two alignment options (Future with Surface Rail and Tunnel under I-280), the costs and potential impacts increase. In addition, the success of Mission Bay and the ongoing transition of Central SoMa have brought forth the idea of providing better accessibility targeted for that neighborhood. Although this alignment option does help alleviate vehicle congestion (especially on 16th Street), connect to transit, and encourage pedestrian and bike trips, it does not provide better accessibility for the Mission Bay neighborhood.

The RAB study confirms that the Pennsylvania Avenue alignment is feasible and should be considered for further development/analysis/design, to establish capacity and operational requirements. As conceived, the Pennsylvania Avenue alignment and its 4th/Townsend station concepts have a high degree of design flexibility and will be able to accommodate the anticipated range of likely operating requirements.

Mission Bay Alignment

The Mission Bay alignment option follows 3rd St and proposes a station for the Mission Bay neighborhood. The key benefits of this alternative are:

1. Removes complexities of tunneling underneath I-280 and moves the tunnel under the City street right-of-way.
2. Eliminates need to take Caltrain out of service during construction.
3. Eliminates the 16th Street at-grade crossing and provides an opportunity to re-knit additional east/west streets across where the Caltrain tracks are today.

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4. Moves to a more regional perspective by ensuring that the capacity of train service is not constrained by the local at-grade intersections.
5. Liberates 4th/King railyard for public use and/or development.

Similar to the Pennsylvania Avenue alignment, the Mission Bay alignment option eliminates the challenges of the first two alignment options (Future with Surface Rail and Tunnel under I-280) but with significant added costs due to risks and unknowns. This alignment option provides better accessibility for the SOMA neighborhood.

The RAB Study confirms that the Mission Bay alignment, while more complex than Pennsylvania Avenue, is likely feasible and should be considered for further development/analysis/design to establish capacity and operational requirements. As conceived, the Mission Bay alignment and its 3rd Street station concepts have limited design flexibility; defining clear operating requirements will be an essential next step in establishing whether the Mission Bay alignment can be refined to meet all of the needs for the rail corridor.

Tunnel Under I-280 Alignment

Several key benefits would be realized with the Under I-280 alternative:

1. Grade separation of 16th Street.
2. Increased opportunities to reconnect street grid under I-280.
3. Liberates 4th/King railyard for public use and/or development.

Although analysis shows grade separating Caltrain/HSR below 16th Street may be possible, construction would be complex. Significant work to the pilings and support structure of the I-280 freeway would need to be completed prior to the rail tunneling. Some freeway supports would need to be moved, with tunnel construction required in tight proximity to the freeway supports. While possible, this approach requires detailed risk mitigation and would also be time consuming and expensive. In addition, Caltrain would need to be taken out of service for 6-24 months, and potentially multiple times, as the tunnel boring machine would be operating in the Caltrain track right-of-way.

To complete this, the I-280 freeway support structures would need to be modified prior to any work along the Caltrain line. In addition, taking Caltrain out of service for extended periods during construction are highly undesirable and a likely fatal flaw, especially in light of other alternatives being studied that maintain Caltrain service during construction. This alignment option was recommended to not be considered for further analysis in Phase I of the RAB study due to risk, costs, and disruption to service.

3.1.6 Future Considerations and Next Steps

The alignment (and station) alternatives provide different solutions to satisfy operating requirements in terms of train movements, station service, and maintenance and storage needs.

The two RAB alignments proposed for further development/analysis/design (Pennsylvania Avenue and Mission Bay) are within walking distance from each other, but differ significantly in the catchment areas they would serve from their respective station locations at 4th/Townsend vs. 3rd Street. This technical report focuses on the engineering feasibility of potential alignments. However, policy makers will also need to consider the future density of jobs/housing that is either planned or possible in the vicinity of proposed station locations. The RAB study has quantified differences in catchment areas and the density

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of jobs/housing as part of the economic analysis included in this study. See section 6, Cost and Economic Impact Analysis.

It is worth noting that current estimates for future growth in jobs and housing suggest that the Pennsylvania Avenue Alignment (and its 4th/Townsend station) is most likely to serve a higher population density when compared to the Mission Bay alignment and station (which is located close to the bay shoreline thus reducing the potential catchment area by half). Appendix G, Rail Relocation Land Use Analysis, provides a detailed analysis of how the various alignments relate to future jobs and housing growth scenarios.

In order to determine a preferred alignment and station option, it will be essential to establish the capacity and operational requirements. The California High-Speed Rail Authority and Caltrain must define the blended service operation plan on which to base near-term requirements and long-term service goals. That blended service operations planning process began in July 2016 and is anticipated to be completed as part of the Caltrain Business Plan and incorporated into the CHSRA Blended Service environmental clearance both of which are on-going at the time of printing.

Clear operating goals established in the blended service plan must guide further project refinement in four key areas: strategic planning, design refinement, cost analysis, and operations analysis.

Strategic Planning Next Steps

- Develop concept for southern station for the preferred alignment option(s).
- Assessment of pedestrian movement to and through stations.
- Station planning, beyond basic provision of circulation.
- Propose plans for work sequencing, staging, worksites, and launch of a tunnel boring machine(s).
- Further develop a strategy for staging and construction of the proposed 3rd Street station on the Mission Bay alignment.
- Preliminary construction schedule based on proposed sequencing and assessment of impact on current infrastructure.

Design Refinement Next Steps

- Conduct full ground investigation for the preferred alignment option(s).
- The potential for various geologic hazards should be evaluated in detail using the station and alignment specific soil data that will be collected during subsequent design phases.
- Develop concept for throat structure (and potential modifications) and connection between SFTC box and tunnels.
- Develop concept for tie-in to existing Caltrain rail alignment at southern end of proposed alignment.
- Develop a strategy to minimize impacts to known structures.
- Consideration of rail operation requirements (switches and crossings and in-line platforms).
- Develop fire life safety strategy and location of required structures.

- Location and sizing calculations for ventilation and emergency access / egress structures suitable for cost estimating.

Cost Analysis Next Steps

- Refined engineering and cost estimates including sizing of structures, as quantified for a "built-up" cost estimate based on a specific list of structures.
- Cost of land and property acquisition/easements.
- Analysis of potential benefit of the space created within the station structures for income generating retail and commercial use.

Operations Analysis Next Steps (in conjunction with the operators)

- Determine the operational and engineering feasibility of a modified 4th/Townsend Station to permit turnbacks and provide operational flexibility.
- Determine the operational and engineering feasibility of the remaining southern railyard site alternatives.
- Based on the results of the above two analyses, determine the combined capacity of the SFTC, DTX and modified 4th/Townsend to handle 10 trains TPHPD and therefore the required use, if any, of the 4th/King Railyard.

3.2 Salesforce Transit Center (SFTC) Extension/Loop to the East Bay Options

The RAB study team was tasked with investigating the potential for loop/extension to the East Bay options as an addition and potential change to the stub-end SFTC currently designed. Specifically, the study team was to establish whether a loop/extension could provide new operating alternatives and unlock efficiencies that could reduce the operating requirements at the 4th/King railyard, and along the Caltrain alignment and/or reduce the number of tracks required for the DTX.

Specific questions included:

1. Are there viable loop/extension alternatives?
2. Does a loop/extension unlock efficiencies that could reduce the need for other planned infrastructure?
3. Should loop/extension options alternatives previously dismissed as financially infeasible in 2008 (before Mission Bay development) be reconsidered in 2016?

Background

As part of the Downtown Rail Extension Project (DTX), the TJPA commissioned the Loop Concept Summary Report, dated May 12, 2008 which was developed by Parsons Transportation Group. The following excerpts from that report summarize the TJPA's work on TTC (Transbay Transit Center, now referred to as the SFTC) loops between 2005 and 2008 as follows:

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> Assessment of the cost and operations of the Locally Preferred Alternative (LPA) in early 2006 resulted in Value Management recommendations to consider potential cost savings and operational efficiencies through the development of loop options which would be achieved by continuing tracks along Main Street to The Embarcadero and Townsend Street back to the 4th and King Streets station, together with reconfiguration of the TTC.

Six alternatives were developed and evaluated in the Loop Study (TJPA 2008). Beginning with a meeting of staff from the TJPA, the PMPC, SFCTA, the MTC Regional Rail Study team, and the Parsons team, loop configurations were developed considering track configurations along portions of 2nd, 3rd, 7th, Mission, Howard, Main and Townsend Streets and The Embarcadero, the number of tracks and platforms at the SFTC, provision for a connection to the potential East Bay extension, and operating plans that met the needs of Caltrain and HSR services. The TJPA loop investigation (2008) concluded, at that time, that the preferred alternative was a Main Street Loop, with proposed alternatives for track configuration within the DTX and the approach to the SFTC.

Estimated cost was the subject of a May 14, 2008 Parsons report for the Transbay Terminal Program, Downtown Rail Extension Project entitled DTX Loop Track Cost Report.

Since the 2008 TJPA loop investigation, the DTX alignment has been confirmed and does not include a loop track. Subsequent analysis found that a three-track DTX design into a stub-end SFTC station was the most cost-efficient means to develop an adequately robust and resilient Northern terminus. Furthermore, that a loop track was prohibitively expensive.

The SFTC as built and the approved DTX do not preclude a future loop/extension track that could provide added capacity for the corridor and a future connection to the East Bay. However, current DTX plans do not depend on a loop to meet anticipated levels of service to the SFTC. The TJPA's July 2, 2014 technical memorandum entitled "East Bay Connection Update" provides the most recent status on loop plans.

RAB Study Approach

With the emergence of the Mission Bay and Central SoMa neighborhoods over the last fifteen years, the City has commissioned the RAB study to determine whether a loop/extension alignment could facilitate ongoing growth by reducing the need for DTX tracks, reducing the functions required at a 4th/King railyard, and facilitating a future connection to the East Bay. With the goals of increasing rail capacity to the SFTC and unlocking potential land value, the City asked that the RAB exploration of loop/extension concepts not be cost constrained. This allowed the RAB study team to consider loop/extension alignments that may have been previously dismissed by the TJPA as cost prohibitive.

The study team started with a thorough review of the extensive body of work already conducted around loops and the SFTC.

The approach followed the following steps:

1. Consider all possible loop/extension concepts – regardless of cost or engineering complexity – starting with those previously considered by the TJPA.
2. Consider operational benefits of possible loop/extension concepts and whether a loop/extension could help reduce other infrastructure requirements related to the DTX.

Note that the RAB assessment of loop/extension options was conceptual and operational. Initial design drawings are available for the four engineering concepts considered further in Phase II of the RAB study (See Figure 14). Cost was not part of the RAB analysis.

Assumptions and Requirements

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The RAB study team accepted the assumptions and requirements of the prior TJPA work with the following exceptions based on direction from the City.

First, the RAB study recognized that the TJPA's objective for loop analysis was the efficient and cost-effective connection between the 4th/King railyard and the SFTC. The TJPA assumption was that the 4th/King railyard property was an available and desirable location for station, staging, and storage functions. For the TJPA work, the loops ability to reduce functions required at 4th/King may not have been a desired benefit. In contrast, one of the RAB study goals is to reduce the requirements at 4th/King and potentially reduce the railyard footprint. For the RAB study, a loop/extension that could reduce or relocate the operating requirements on 4th/King would be a significant benefit, and could justify additional cost.

Second, the original TJPA work was conducted as part of a value engineering exercise. Cost containment was a primary motivator for the 2008 TJPA Loop Study. Those cost constraints and the perceived value of potential alternatives fit the context of 2008 – before much of the neighborhood around AT&T Park was built out, before Mission Bay was developed, before the Central Subway began construction, and before the Central SoMa development plan. In contrast, the City has requested that the RAB loop/extension analysis be unconstrained by cost, reflecting the significant shift in potential value to the project area if a loop/extension alternative could facilitate the reduction or removal of the 4th/King railyard and allow for the continued evolution of the neighborhoods in the project area.

Third, Caltrain and HSR are currently planning on a maximum of 8 trains traveling to the SFTC at peak. The City has much higher hopes and expectations for future rail travel to the SFTC, both up the Peninsula and potentially across the Bay. An unconstrained exploration of loop/extension options recognizes the future value of expanding capacity to the SFTC well beyond its modest limitations as a stub-end terminal.

Metrics used to analyze potential loop options included:

- Accommodates Caltrain trains
- Accommodates HSR trains
- Compatible with planned SFTC Trainbox
- Impacts to existing buildings
- Delivers added rail capacity and flexibility

Analysis

The study team reviewed all the loop alignments previously documented in the TJPA report, and considered other alternatives that may be feasible assuming the latest tunneling technology, or changes to current buildings. The RAB study considered loop alternatives not only for their potential to increase capacity to the SFTC, but also for their long-term role in providing a robust future connection to the East Bay. The RAB study analysis settled on four loop/extension options to consider:

1. Main Street
2. Spear Street
3. Steuart Street
4. In the Bay

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Figure 14: Four Extension/Loop Options considered by the RAB Study

Early in the RAB team's secondary analysis of the TJPA work, two options were removed from further consideration as they did not allow for HSR operations on the loop/extension options due to the radii not meeting minimum requirements. Conceptual designs were further developed for two of the alignments:

1. Steuart Street
2. In the Bay

Appendix B, Conceptual Design Drawings, Loop Alternatives includes design drawings for the loop options studied in greater detail as part of the RAB project. The Extension/Loop option analysis did not include engineering analysis beyond the proposed plan alignment. Subsurface conditions and current building foundation locations were considered to the extent that they had been documented previously by the TJPA analysis or existing building documents for the area. The focus of the RAB study analysis was on expanding loop/extension alternatives and considering loop/extension operations.

Cost analysis for loop options was beyond the limited scope of the RAB study. The RAB analysis was able to confirm the TJPA's earlier findings that loop options do not have any near-term bearing on the size or capacity of the DTX. Therefore, further design analysis of loop options, and associated cost estimates, remained outside of the work scope.

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3.2.1 Main Street Extension/Loop Option

The Main Street Extension/Loop option analyzed as part of the RAB study confirms the alignment proposed in earlier TJPA analysis. The RAB study team agrees with the 2008 TJPA study assessment and notes the following key attributes:

- Serves Caltrain only (due to turning radius exiting the SFTC to align under Main Street)
- Would require relocation of Caltrain platforms to south side of SFTC. Currently the northern platforms in the SFTC are identified as the Caltrain platform as track 6 (the most northern track) will not be extended the full-length due to the existence of substructures for neighboring buildings
- Impacts the proposed building foundation under Block 5 (which recently sold for $170M)

The Main Street Loop was the preferred alternative coming out of the 2008 TJPA study and was therefore shown as a conceptual loop option in each of the alignment options depicted in the RAB Study Phase I Draft Conceptual Alternatives (see appendix A). However, this was to show general compatibility of all alignment options – including the proposed shift to a Mission Bay Alignment – with a future loop alternative. Further analysis of this loop alternative show that HSR trains would not be able to utilize the loop/extension as the turning radii is not sufficient for HSR trains. The findings detailed below recommend further analysis of loop options capable of handling both Caltrain and HSR trains, which does not include the Main Street loop option.

3.2.2 Spear Street Extension/Loop Option

The Spear Street Extension/Loop option analyzed as part of the RAB study confirms the alignment proposed in earlier TJPA analysis. The RAB Study Phase I Draft Conceptual Alternatives (included as Appendix A) shows a conceptual draft of how this alignment could be adjusted to work with all proposed rail alignment options. The RAB study team agrees with the 2008 TJPA study assessment and notes the following key attributes:

- Serves Caltrain only (due to turning radius exiting the SFTC to align under Spear Street)
- Would require relocation of Caltrain platforms to south side of SFTC. Currently the northern platforms in the SFTC are identified as the Caltrain platform as track 6 (the most northern track) will not be extended the full-length due to the existence of substructures for neighboring buildings.
- Impacts foundations of up to 3 existing buildings

3.2.3 Steuart Street Extension/Loop Option

The Stuart Street Extension/Loop option analyzed as part of the RAB study confirms the alignment proposed in earlier TJPA analysis. The RAB study team agrees with the 2008 TJPA study assessment and further developed this option by designing a conceptual vertical profile. The Steuart Street Loop drawing in Appendix B shows a conceptual draft of how the vertical profile aligns with the existing buildings, LRT, and geology. The study team notes the following key attributes:

- Serves both Caltrain and HSR trains
- Only 5 of 6 SFTC tracks can access the proposed Stuart Street Extension/Loop (track 6 will not be extended due to neighboring building substructures).

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- Impacts foundations of up to 7 existing buildings

3.2.4 In the Bay Extension/Loop Option

The In the Bay Extension/Loop option analyzed as part of the RAB study is an alternative not assessed as part of the 2008 TJPA analysis. The In the Bay Loop drawing in Appendix B shows a conceptual draft of how this alignment could be designed to work with all proposed rail alignment options. The profile view shows how this option would align with the existing buildings, LRT, geology, and bay seawall.

The study team believes that this alternative could be technically feasible, but complex due to the interaction with the bay seawall. The initial conceptual assessment reveals the following key attributes:

- Serves both Caltrain and HSR trains
- Only 5 of 6 SFTC tracks can access the In the Bay Extension/Loop (track 6 will not be extended due to neighboring building substructures)
- Impacts foundations of up to 6 existing buildings

3.2.5 Summary

As stated previously, the RAB analysis focused on loop/extension concept development and operations analysis rather than engineering feasibility. The RAB study team's review of prior TJPA work revealed that the engineering feasibility already completed on versions of the Main Street, Spear Street, and Steuart Street was both reliable and adequate for the purpose of the RAB analysis.

The study team's effort to consider new loop/extension options did result in the addition of the In the Bay option – an option that was either not considered previously, or may have been viewed as unrealistic in earlier studies due to cost or the potential impacts to the seawall. The study team has also theorized an Embarcadero Extension/Loop Option that is integrated into a future seawall structure itself could become viable if an extensive seawall project is advanced simultaneously.

The study team's assessment of loop/extension options centered primarily around improving operations. The basis for the operations opinions can be found in Section 4, Rail Operations Analysis.

It is the opinion of rail operations experts convened on the RAB study that a 3-track approach to the SFTC provides ample (and potentially excess) capacity to handle initial operating goals; and that a loop/extension option is not necessary at this time. The study team concurs with the TJPA's high-level conclusions regarding the loop alternatives – loops/extensions do not allow for either the reduction in the number of tracks in the DTX (or any alternative alignment), or a significant reduction in required station and staging facilities.

Therefore, the RAB study analysis of the Extension/Loop options (Steuart Street and In the Bay) focused on the following objectives:

1. Establish the operating capacity levels at which a loop/extension alternative will be required. (Defining the maximum operating capacity of the SFTC and at what level of service a loop/extension to the East Bay would be required.)
2. Identifying existing building foundations are in conflict with the Steuart Street and In the Bay loop options. (So that the City can pursue easements on these buildings as they reach the end of life and come up for renewal.)

The sketch-level operations planning by the RAB Study team revealed that current infrastructure, without a loop/extension, is capable of handling 10 and potentially 12 trains to/from the SFTC.

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Therefore, no loop/extension is needed until blended service operations is expanded beyond 12 trains. A loop/extension would not provide capacity benefits for service levels currently being considered by Caltrain and CHSRA.

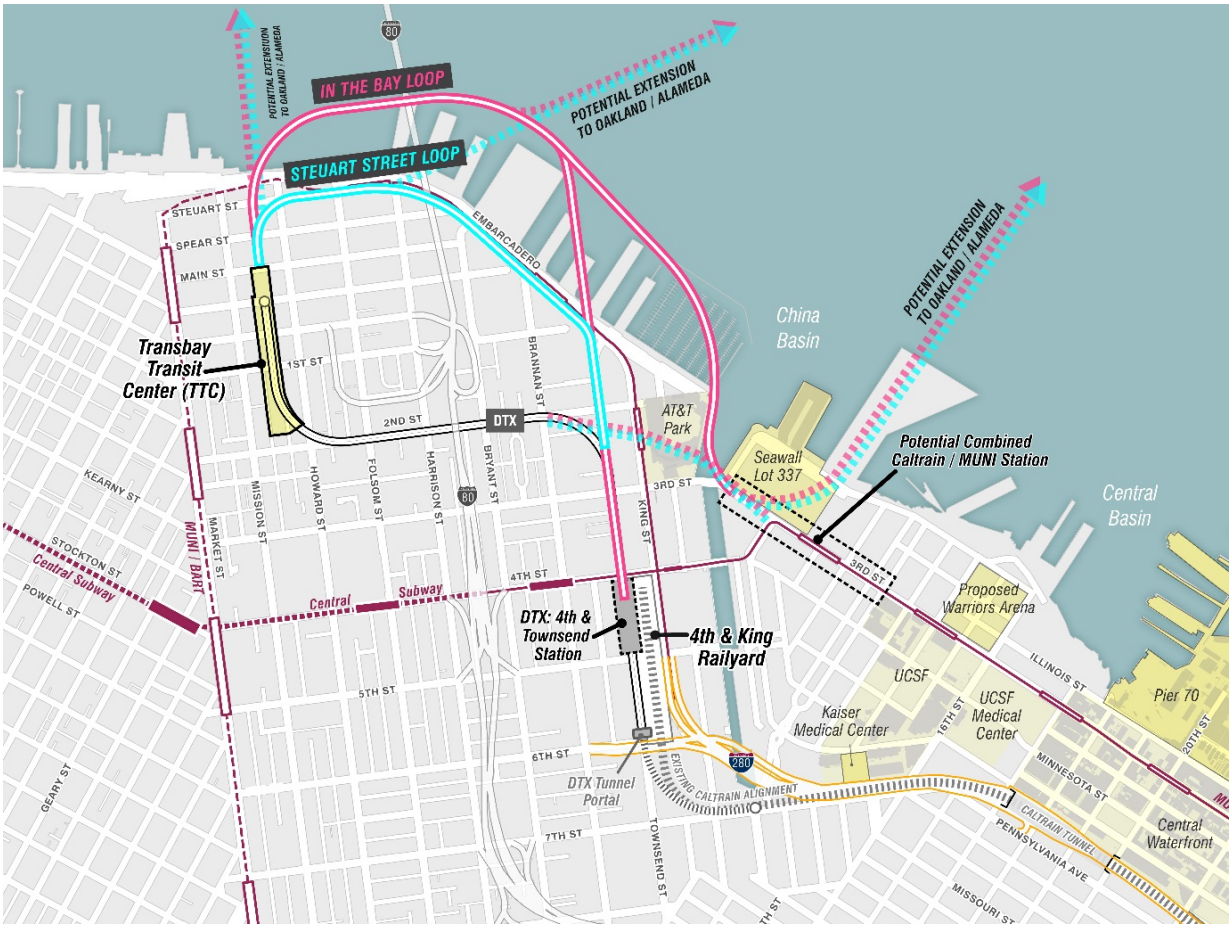

Figure 15: Recommended Extension/Loop Options -- Steuart Street and In the Bay

The RAB study has developed conceptual drawings of the Steuart Street and In the Bay loop/extension options available in Appendix B. These drawings show plan and profile assumptions and suggest which current buildings are likely to be in conflict with a long-term vision for the loop/extension.

The region's Core Capacity Study under the direction of the Metropolitan Transportation Commission (MTC) is also looking at related questions regarding the feasibility of another rail crossing of the Bay. That study will also have bearing on how any loop/extension alternatives should be implemented. Currently there are 6 options from the Core Capacity project for a second transbay crossing. Four of those options directly connect to the study and the proposed alignments.

3.2.6 Study Findings

Because a loop/extension does not affect the capacity or significantly alter the station, staging, or storage requirements for the northern end of the railway, based on current operation plans, any loop/extension alternative should be viewed as a separate long-term project with the goal of connecting to the East Bay, and/or greatly expanding the rail capacity of the entire corridor. A loop/extension alternative need not be considered for its near-term potential to alter the requirements of the DTX or

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the 4th/King railyard. Yet, loop/extension options are likely to be needed at some point in the future (in conjunction with other capacity upgrades on the existing Caltrain Corridor) as demand increases for travel on the peninsula, and across the Bay. It will be important to keep these infrastructure options open as surrounding parcels are developed over the next 50 years.

The study team recommends that future Extension/Loop studies no longer consider feasibility and benefits of Main Street and Spear Street options as neither meets the requirements for HSR trains and need no further analysis.

Should a loop/extension be needed in the future, the study team's unconstrained conceptual assessment concludes that an "In the Bay Extension/Loop" passing through the seawall could potentially be a preferred alternative because it would allow both Caltrain and High Speed Rail to travel through the extension. However, the In the Bay Extension/Loop Option has not yet undergone full engineering feasibility analysis, and that should be part of any future analysis. As plans for the seawall continue to advance, the possibility of a cut-out for future rail connection should be considered.

3.3 Railyard Reconfiguration/Relocation Study

The RAB study team was tasked with investigating and documenting the operating potential for five alternative railyard locations identified by the City, all south of the 4th/King Railyard. The study team worked with Caltrain and their consultants to document a set of likely future railyard operating requirements for the three functions that are currently co-located at the 4th/King railyard:

- Station
- Staging
- Storage/Maintenance

Station functions are associated with the facilities and services that directly support passengers. Location is a primary feature of the station function.

Staging functions requiring track and facilities to position trains to efficiently deliver operations and maintain the schedule. Staging must accommodate normal operations, peak operations, and special events while considering flexibility, resiliency, and failure recovery.

Storage/Maintenance functions require a railyard location and facilities for overnight or longer storage/maintenance of vehicles. Storage for HSR trains has also been identified as a potential need for a future railyard (either 4th/King or elsewhere). Lastly, from an operational and labor cost standpoint, Caltrain wanted a potential southern railyard no greater than 10 minutes travel time from 4th/King.

Background

Caltrain performed a Feasibility Assessment (2013) to document the operating requirements at 4th/King and determine whether functions at that railyard could be consolidated and the footprint of the railyard reduced.

The 2013 Feasibility Assessment referenced two options for reducing the size of the railyard. The first option proposed an alternative concept that retained all station, staging, and storage/maintenance functions at the 4th/King location while reducing the railyard size by 68 feet along Townsend Street (though that reduction did not consider any accommodation of HSR at 4th/King). The second option referenced by Caltrain stated that the 4th/King footprint could potentially be reduced further while accommodating station and staging needs, but that would be depended on the development of a new

as-yet-unidentified southern railyard addition to accommodate some of the storage and maintenance functions. That report made clear that no southern railyard locations were under consideration and that it would require effort on the part of the City of San Francisco to identify and develop an alternative railyard. Further, the 2013 Feasibility Study identified the maximum run-time (for non- revenue movements) from the 4th/King railyard that a southern railyard could be located.

The RAB Study builds on the Caltrain Feasibility Study by examining potential alternative railyard locations required to pursue a significantly reduced and potentially removed Caltrain 4th/King railyard replacing it with a southern railyard location for storage/maintenance. The RAB Study acknowledges that reduction or elimination of the 4th/King railyard requires the reconfiguring and/or relocating of essential operating functions elsewhere along the system and would be a change to how Caltrain operates currently.

The RAB study also draws operating and facilities guidance from the Caltrain Northern Terminus Study (2010).

Approach

For the purpose of this task, the RAB study team has worked to identify and separate the three current railyard functions: station, staging, and storage/maintenance. The RAB study assumes that station functions could not be relocated significantly south and would need to remain part of a San Francisco station (such as an underground and expanded 4th/Townsend, or a new 3rd Street underground station). Therefore, the study team focused railyard relocation efforts on the storage/maintenance functions and access requirements, while also recognizing that staging functions were likely to be shared across several locations including the SFTC, other San Francisco station(s), and a new southern railyard. Despite the relatively close proximity of 4th/Townsend to the SFTC, the RAB study has assumed that a second "downtown San Francisco" station (such as 4th/Townsend or Mission Bay) would continue to be a project requirement.

The RAB study team included experts in both track design and rail operations with significant experience working with Caltrain in this corridor. Those experts worked with Caltrain (and LTK as Caltrain's consultants) to establish a set of operating requirements anticipating likely future requirements of a new southern railyard. As of the time of this report, those requirements remain tentatively defined as Caltrain and HSR continue to plan and negotiate operations as part of the blended service operations plan still in development. The RAB study team has used the best available data as of mid-2017.

Assumptions and Requirements

The RAB study team established the following operating requirements for their railyard investigations.

Equipment set size:	Caltrain 8-car EMU, approximately 700 feet HSR set 1,368 feet.
Storage Requirements:	Up to 10 Caltrain EMU sets HSR storage needs at a shared or separate yard are uncertain, but desirable for future flexibility

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Facilities Required (based on recently upgraded facilities at 4th/King):	Crew Room Management Office Maintenance Personnel Facilities Storage for tools and equipment Employee Parking Maintenance of Way office functions Optional: Temp Project and/or Construction Offices (if space available)
Required Functions	Daily federally mandated inspections and brake tests Small repairs Cleaning of interior of equipment Toilet servicing requiring 8 'paved access for Taylor Dunn car and tank at track level between storied sets Other track storage
Site Requirements:	Assume a fully electrified EMU fleet at off-site locations therefore, as required, space may need to be provided for both catenary poles and paved access. (Planning for interim Diesel and electrified train set storage and maintenance prior to full electrification will be essential, but is not a long-term railyard requirement.)
Location	Within 10 minutes runtime of the current 4th/King terminus bumpers. This was a requirement provided previously by Caltrain to avoid significant operating cost increases due to deadheading trains, as documented in the 2013 Caltrain Study. Caltrain has subsequently clarified that any move from the current location at 4th/King could result in additional operating costs.

Analysis

The City and consultant team identified five (5) potential alternative railyard locations, all within a 10-minute runtime of the 4th/King northern terminus bumpers. This runtime extends to South San Francisco and did not take into account jurisdictional boundaries, only runtime. The specific site locations remain confidential because the property identified involves both publicly owned and privately owned property. Identification of the potential site locations, challenges associated with property acquisition, and detailed property value were all outside of the RAB study team scope. It should be noted that for cost estimating purposes a, generic property value for each site was calculated based on similar projects.

The RAB study team assessed all five sites for the feasibility of locating a future railyard that would meet established criteria. This assessment included in-person site visits to the locations identified and with only minimal research into the current ground conditions.

For all five locations, one or more sketch-level concept layouts were developed to consider the opportunities and challenges of accommodating all the railyard requirements. The RAB study team led discussions with the City regarding the potential for developing each location, as well as the long-term potential for operating from each site.

The image below is an example of a sketch-level conceptual design proposed for one of the site locations as part of the RAB phase I: Technical Feasibility Analysis. The example site laid out below would accommodate up to 10 Caltrain 8-car trains and includes required maintenance tracks. In addition, the two tracks at the top of the site could accommodate full length HSR trainsets (<1400-feet) or double berth 2 Caltrain sets if necessary. The site also includes parking and a maintenance building sized for Caltrain standards.

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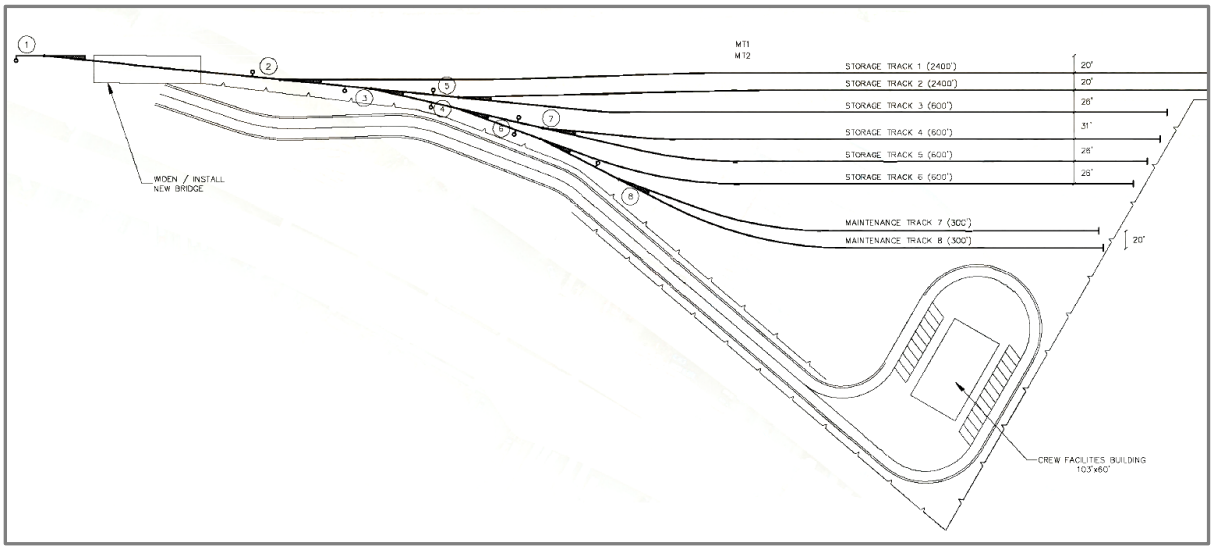

Figure 16: Proposed Conceptual level Phase I Railyard Layout

3.3.1 Summary

The RAB study team found that all five alternative locations identified could accommodate the functions required for maintenance and storage. All five alternative locations, as well as the current 4th/King railyard location, face similar challenges related to cross-track moves that may be needed to initiate daily service to/from the SFTC. However, some of the locations were constrained and offered less potential for future expansion and/or less flexibility for daily operations. Specifically, mainline access to the railyard and ease-of-movement within the railyard were top considerations in determining which sites should be advanced for further analysis.

Phase II analysis revealed that two of the five locations were found to have fatal flaws due to a combination of operating concerns, layout flexibility, and available space. The remaining three sites were further refined as part of RAB Phase II alternatives development. All three sites were within 10 minutes runtime of the 4th/King terminal bumpers in keeping with Caltrain's stated operating parameters. For each of the three sites, two to three design concepts were developed to show the potential of the site under different scenarios. While all three sites continued to show strong potential for layout flexibility and available space, one of the sites was determined to be less advantageous due to switch locations that would have increased the time required to move across tracks and send trains in the opposite direction. Therefore, two viable and preferred alternatives remain for the new south railyard.

One of the locations is located within the City and County of San Francisco boundaries, one is not. If the second option is pursued, the City and County of San Francisco would need to coordinate with that jurisdiction for the use and purchase of the necessary property.

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The image below is an example of a refined sketch-level conceptual design proposed for one of the site locations as part of the RAB phase II: Alternatives Development.

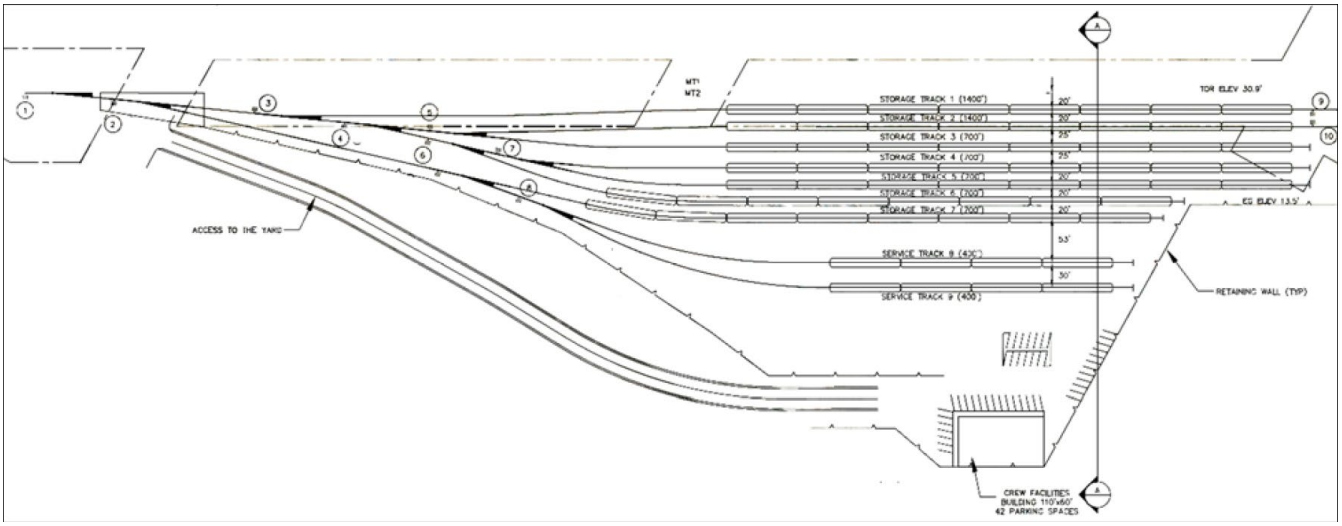

Figure 17: Proposed Conceptual Level Phase II Refined Railyard Layout

3.3.2 Review and Next Steps

The RAB study team met with Caltrain on several occasions to discuss the overall RAB project and specific railyard requirements as well as conceptual alternatives and potential operations on-site. High-level feedback was provided by Caltrain which underscored the complexity of operations and uncertainty around a future blended service operations plan (Caltrain and CHSRA operating on the same tracks) that would be required to judge any proposed infrastructure changes.

Caltrain staff noted that without more detailed yard drawings or a blended service operations plan (still under development) it was not possible to judge the suitability of any alternative railyard location. Caltrain representatives also conveyed that their future collaboration on a new yard location should not be misinterpreted as support for relocation.

With the City's concurrence on the RAB study team recommendation, two potential railyard sites are recommended as conceptual designs compatible with the requirement for a new south railyard to support recommended alignment alternatives.

Based on upcoming Blended Service Operations planning currently underway with CHSRA and Caltrain, these sites and the fully operations considerations would need to be updated and validated.

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3.4 I-280 Transportation Study

The RAB study was charged with documenting the impact of near-term projects (such as the DTX, 4th/King Railyard electrification and reconfiguration) on the long-range opportunity to reconsider the current I-280 freeway configuration. Specifically, the City wanted to fully understand how projects built over the next 10-20 years might support or limit change over the next 100 years.

Please note, as stated before, all RAB components are independent of each other but should be reviewed in concert to fully understand the benefits and any impacts one decision has on the others. With any other component, the I-280 Freeway could stay as is, or be removed north of Mariposa and turned into a boulevard as described below.

Background

Originally, I-280 was supposed to connect to I-80, the Embarcadero Freeway, and the Bay Bridge resulting in a ring road around San Francisco. For various reasons that ring was never built. Currently, the stub of the I-280 freeway segment ends at 4th/King and 6th/Brannan and gridlocks the system. The segment of I-280 under consideration for modification is roughly from Mariposa to 4th/King. This segment is approximately 1.2 miles in length with only two crossing locations under the freeway providing access to vehicles east/west (Mission Bay Drive and 16th Street). With the development in Mission Bay (including the university, the medical center, the hospital and others), traveling east/west under the freeway has also become increasingly difficult. These elements also affect the 22-Filmore planned BRT project on 16th Street.

San Francisco has replaced portions of two major elevated freeways with urban boulevards resulting in the Embarcadero and Octavia boulevards. The planning department recognizes that there are ongoing debates over whether the elevated portion of I-280 north of Mariposa or 16th Street is another candidate for replacement with a surface boulevard. Replacement of the I-280 elevated freeway is NOT an objective of the RAB study. However, the RAB study is intended to establish whether near-term transportation projects could preclude the possibility of changing I-280 at some future time; and whether traffic levels on I-280 could be possibly be managed on a surface boulevard.

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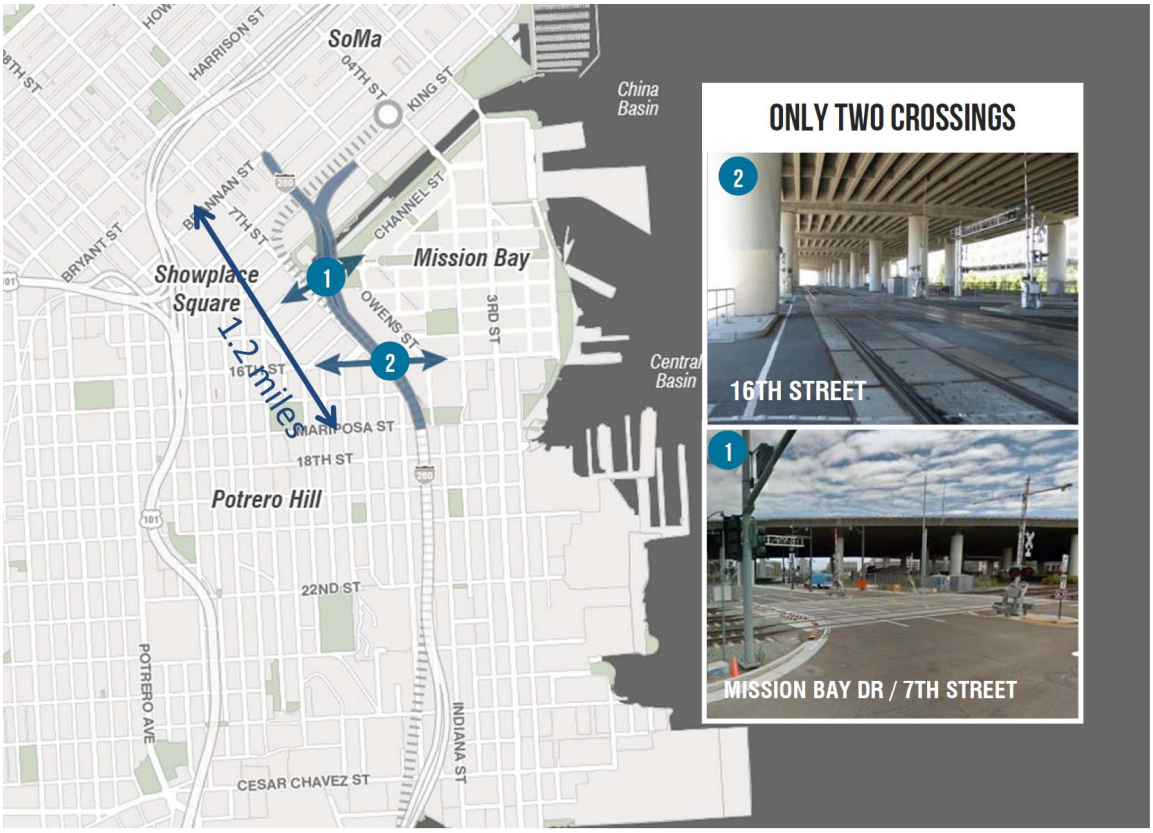

Figure 18: Project Area for I-280 Traffic Analysis

Traffic Analysis

In an effort to better understand the traffic that passes through this area – both on the surface and on the elevated freeway – the RAB Study analysis focused primarily on traffic counts and a deterministic traffic model. The goal of this analysis was to estimate the impacts of terminating the I-280 freeway further south, and whether it is possible to handle traffic on the I-280 freeway in another way (such as a boulevard).

The RAB study team, including local traffic analysis expertise of Fehr & Peers, evaluated I-280 boulevard alternatives for feasibility and fatal flaws. The process used in this analysis and the results are detailed in Appendix B, Deterministic Model Queue Results for I-280/Railyards/Boulevard Project. The analysis considers the ability of 16th Street and 7th Street/Mission Bay Drive intersections to accommodate Boulevard traffic, interminable queuing on surface streets and I-280 due to conceptual/theoretical Boulevard configurations, delays to MUNI bus service, and other factors. Intersection and freeway queuing has been reported in a series of simple graphics showing traffic operations and redistribution of trips for each I-280 boulevard alternatives as well as LOS, delay, and queue length. (See Appendix F, Traffic Analysis.)

A priority for the RAB study analysis was understanding the northbound freeway backup and considering when that queue length would impact the I-280/US-101 interchange. The southbound I-280 corridor is essentially free-flowing at all times of the day as the entrance to the freeway section southbound is limited by the City of San Francisco street light timings. The below figure shows the length of the traffic queue from the 4th/King off-ramps on I-280 by time of day.

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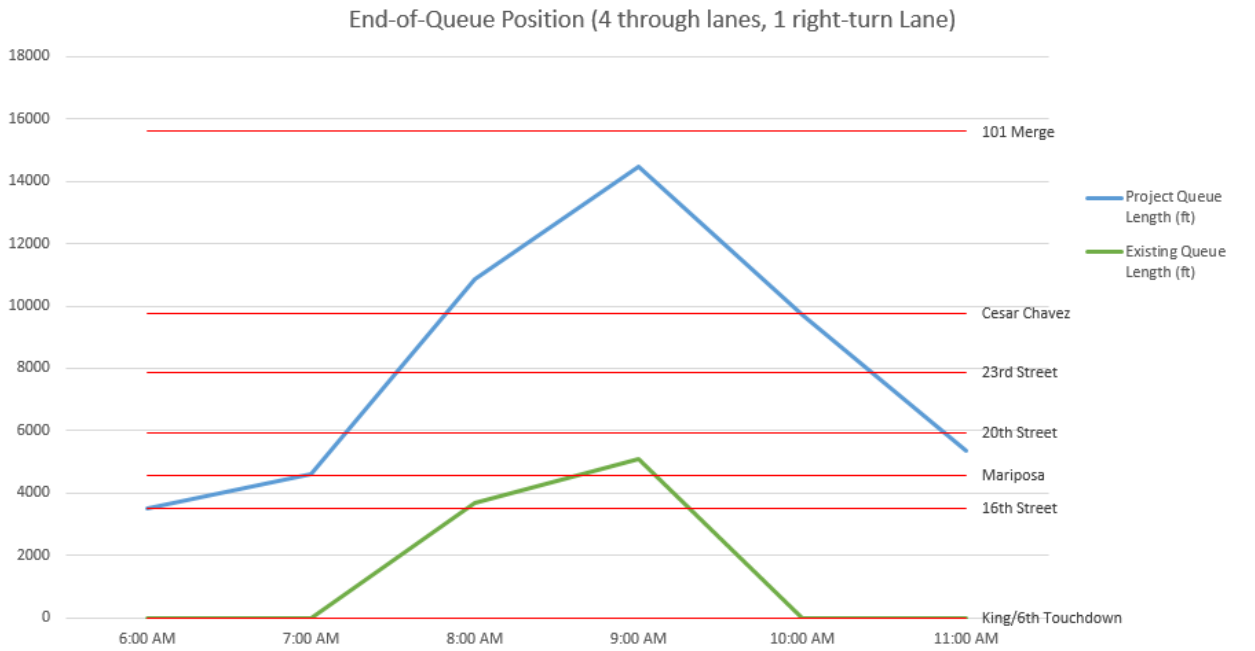

Figure 19: I-280 End-of-Queue Traffic Analysis

This initial Phase I analysis modeled three conceptual boulevard designs to provide a conceptual level of likely delays associated with various boulevard configurations.

- 3-Lane Configuration – A minimal footprint that would be compatible with a complete streets roadway design vision.
- 4-Lane Configuration – An urban arterial.
- 5-Lane Configuration – The number of lanes needed to handle anticipated traffic without adding delays to vehicle trips based on existing and projected traffic counts.

It is noteworthy that the 3-Lane Configuration could trigger future delays that back up freeway traffic all the way to the 280/101 interchange and beyond, or may shift trips to other routes given the significant increase in delays. It is also noteworthy that the 5-Lane Configuration (northbound) could accommodate all anticipated traffic with negligible delays over existing conditions.

NET DELAY PER VEHICLE (MIN)			
	3-LANE CONFIG	**4-LANE CONFIG**	**5-LANE CONFIG[1]**
6:00 AM	0	0	0
7:00 AM	19	2	0
8:00 AM	39	5	0
9:00 AM	60	8	0
10:00 AM	80	11	0
11:00 AM	88	4	0
12:00 PM	0	0	0

Notes:
1. The 5-lane configuration generates minimum queues and causes negligible delay over existing conditions

Note that the data used to calculate delay is described in *Appendix F, Traffic Analysis I-280* and sourced from various studies between 2010 and 2013.

3.4.1 Summary

The key findings to come out of RAB traffic analysis are two basic relationships between future rail alignments and the likely I-280 Boulevard footprint.

1. If the rail from 16th Street to the railyard approach is not undergrounded, then there is not enough space for a boulevard up 7th Street and the elevated freeway must remain.

If the surface rail remains, it is the opinion of the RAB study team that the limited width of 7th Street (combined with the barrier to turn options presented by the rail itself) would make it impossible to develop a reasonable boulevard to replace I-280. The study team recognizes that the functionality and capacity of a boulevard are policy matters, but the Deterministic Model Queue Results suggest that more lanes and turns would be required for any reasonable boulevard, even if significant reductions in vehicle throughput were deemed acceptable by local policy makers.

2. Removal or replacement of the I-280 elevated freeway is NOT a requirement for the rail alignment options, or railyard reconfiguration/relocation options recommended in Section 3.1 of this report.

The removal of I-280 has been determined to have minimal engineering relationship to the other component recommendations. There are, however, potential economic and placemaking benefits that would come with removal of I-280. First, property currently under the freeway could be made available as street space, public space, or sold for development of housing and jobs. Second, adjacent property values and development opportunities would increase. The RAB study team believes these economic and placemaking benefits are worthy of future study, but probably not on a scale that would make alignment or railyard projects dependent on changes to the current I-280. Further economic analysis of a future freeway project (which is outside the RAB scope) would be required to confirm this study team opinion.

In summary, there is no engineering reason to link the near-term rail infrastructure questions to a decision on I-280 changes. Further economic analysis is required to establish whether the economic and placemaking benefits related to removing I-280 – which could be transformative over time – might

translate into funding on a scale that determines whether other RAB components are financially feasible. Based on the initial traffic modeling, the consulting team's expert opinion is that boulevard configurations could be developed to support traffic volumes as projected through 2040, but this is a policy matter for future consideration that was not conducted as part of the RAB project scope.

The RAB Study traffic analysis details can be found in Appendix F, Traffic Analysis, I-280.

3.5 Urban Form and Land Use Considerations

The RAB study team developed a series of graphic visualizations related to key elements of the project. The purpose of these visualization exercises was to help stakeholders understand the potential placemaking outcomes that could result from policy decisions within the project area.

Three key elements of the project area have been explored:

1. 16th Street and 7th/Mission Bay Drive intersections – Trenching and/or other alternatives that would be required under the current environmentally approved DTX and included as part of the Future with Surface Rail alignment option.
2. Development of the 4th/King railyard site – Including a more fully integrated street network.
3. Neighborhood development – Showing opportunities that could come with removal of surface rail and the replacement of I-280 with a boulevard.

16th Street and 7th/Mission Bay Drive intersections

Figure 20: 16th Street and 7th Street, assuming no changes under current DTX plan

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Figure 5Figure 17 shows a graphic visualization of 16th Street and 7th Street under the current DTX scenario. This visualization considers how increased rail traffic will increase the amount of gate-down time experienced across 16th Street, and the impact to this key east/west corridor and the future bus lanes for major bus routes.

Figure 21: 16th Street and 7th Street, Future with Surface Rail including Trench

Figure 18 shows a graphic visualization of 16th Street and 7th Street under the Future with Surface Rail scenario with required grade separation. This visualization considers how a solution for 16th Street that moves vehicle traffic below the rail tracks will be experienced across 16th Street, and streetscape impact to this key east/west corridor.

Figure 22: 16th Street and 7th Street, Future with Surface Rail including Trench, street level view

Figure 19 shows a graphic visualization of 16th Street and 7th Street under the Future with Surface Rail scenario with required grade separation. This visualization considers how a solution for 16th Street that moves vehicle traffic below the rail tracks will be experienced across 16th Street by a pedestrian, and streetscape impact to what is an increasingly well-used pedestrian and bicycle corridor.

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Figure 23: 16th Street and 7th Street, with Rail Tunnel Alternatives

Figure 20 shows a graphic visualization of 16th Street and 7th Street under either the Pennsylvania Avenue or Mission Bay alignment options, where the surface is cleared of rail infrastructure and trains run in an underground tunnel. This visualization considers how a solution for 16th Street that moves rail underground would be experienced across 16th Street, and how the surface space might be repurposed.

Development of the 4th/King railyard site

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Figure 24: Looking South on 5th Street where it dead ends into the 4th/King Railyard at Townsend

Figure 21 Is a graphic visualization showing where 5th Street dead ends into the 4th/King Railyard at Townsend, forcing through trips around the railyard and limiting the connection between Central SoMa and Mission Bay.

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Figure 25: Looking South down 5th Street across Townsend if the railyard were developed in the future

Figure 22 is a graphic visualization showing where 5th Street currently dead ends into the 4th/King Railyard at Townsend, under a development scenario that includes an underground 4th/Townsend station, a continued roadway connection between Central SoMa and Mission Bay through to the planned bicycle and pedestrian crossing over Mission Creek.

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Neighborhood Development

Figure 26: 3rd Street and Mission Bay, with a future underground station

Figure 23 **i**s a graphic visualization showing 3rd Street where it intersects Mission Bay Drive, one potential location for a new station along the proposed Mission Bay alignment.

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4 Rail Operations Analysis

Following the development of the rail alignment alternatives presented in Section 3, the RAB study team collaborated with SMA Rail Consulting to conduct rail operations sketch planning analysis. This analysis established that the alternatives proposed would require significant changes to current operations plans, but offered reasonable alternatives to Caltrain and High Speed Rail that are worthy of further study. The sketch planning analysis also pointed to key aspects of the current DTX plans that were potentially limiting the capacity of the planned DTX. Where possible, the study also offered potential solutions to allow more trains to travel to the DTX, thus reducing service requirements at 4th/King station.

This section identifies major differences between the RAB modeling and prior modeling work completed under other agencies. A detailed presentation of SMA's step-by-step process, analysis, and conclusions is available in *Appendix C: Rail Operations Analysis*.

4.1 Prior Studies

The RAB study team started with a detailed review of the six major operations modeling and analysis efforts previously completed by the TJPA and Caltrain. Further studies in response to the RAB study findings have been conducted since the completion of this analysis, but these are the six studies on which the RAB analysis was based:

Title: Transbay Terminal Program, Loop Concept Summary Report, May, 12, 2008, Parsons Transportation Corp.

Purpose: To examine loop alternatives as a result of a VE study recommendation.

Equipment assumptions: No definitive equipment specified by Caltrain or CHSRA, looked at worldwide equipment available.

Infrastructure assumptions: Examined various double and single track loop alternatives exiting the Eastern end of the initial SFTC box with a loop along Main Street to the Embarcadero and Townsend back to 4th/King; looked at 2 and 4 platforms configurations at SFTC with 4, 5 and 6 station tracks. (This study predates the shift to Blended Operations and reduction from four tracks on the Peninsula.)

Service Assumptions: Examined up to 16 TPHPD (trains per hour per direction) at SFTC and through the loop with a maximum of 6 express Caltrain\6 local Caltrain \4 HSR trains.

Study results: Loop Alternative 6, which included 2 tracks into the SFTC and a single loop track back to 4th/King with 3 platforms and 6 tracks at SFTC, handled a stress level of 10 TPHTD (Caltrain and HSR) as effectively as the LPA alternative, which included three tracks into a stub-end SFTC.

Title: Transbay Terminal Program, Consolidated Rail Operations Report, May 13, 2008, Parsons Transportation Corp.

Purpose: Summarized the major rail operations reports prepared by the TJPA team. The report justified a refined LPA which included some modifications to the certified environmental document.

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Equipment assumptions: Eight-car EMU Caltrain sets

Infrastructure assumptions: Examined a 3-track DTX throat with a theoretical CBTC signal system; a 6-track, 3-platform layout (HSR to the north and Caltrain to the south); tail track; 4th/Townsend underground and 4th/King at-grade stations. 4th/King storage assumed to accommodate 8 trains on 750 ft. platform tracks and 5 additional train sets in storage. Also assumed 4 tracks on the peninsula for separated Caltrain and HSR service west of the existing Caltrain tunnels; predates Blended Operations.

Service assumptions: During the course of a two year period, Caltrain modified their desired headways from 5 minutes (12 TPHPD) to 6 minutes (10 TPHPD); CHSRA went from 6 TPHPD to 4 TPHPD.

Study results: Ridership study indicated 12 TPHPD with a mix of Caltrain and HSR was needed. Stress tests indicated that SFTC accommodated 8 Caltrain/4 HSR trains with the 3-track DTX throat layout and the dwell time and headway assumptions as identified above. If 10 TPHPD was still required by Caltrain and 8/4 was the maximum reliable capacity at stress of the DTX/SFTC, then 2 TPHPD had to be accommodated by the 4th/King Surface lot.

Title: Caltrain\California HSR Blended Operations Analysis, March 2012, LTK for the Peninsula Corridor Joint Powers Board

Purpose: Examined new "Blended System" which was endorsed by Caltrain and CHSRA in 2011 and addressed overtake tracks and speed variations (79 mph to 110 mph).

Equipment assumption: 8-car EMU train sets for Caltrain.

Infrastructure assumptions: Assumed existing infrastructure with a few minor additions (Tamien to 4th/King stations); analyzed overtake track options: no examination beyond 4th/King to DTX/SFTC.

Service assumptions: Specified that this was a proof of concept, not a service plan, included HSR priority at overtake locations like Millbrae to minimize delay to both. Utilized a skip-stop zone express pattern that is different from today's local and express pattern, but has better performance with EMUs with comparable travel times to today's schedule. Assumed reduced speeds at CP Irwin (last CP before 4th/King) and no DTX/SFTC, therefore, all HSR trains terminated at 4th/King.

Study results: More train traffic can be accommodated with electrification and CBOSS. 6 Caltrain/2 HSR TPHPD can be supported with electrification and CBOSS, but no overtake tracks. 6 Caltrain/4 HSR TPHPD can be supported with electrification, CBOSS, and overtake tracks. CBOSS decreased headways from 6 minutes to 3, and overtake tracks supported a 7+ minute travel time difference between Caltrain and HSR. To maintain a uniform schedule and headways, some Caltrain stops were added. No overtake track options were recommended awaiting more service analysis.

Title: Caltrain\HSR Blended Service Plan Operations Considerations Analysis (requested by Stakeholders) Final, June, 2013, LTK for CalMod Program Team

Purpose: Stakeholders requested analysis of additional blended system operational scenarios. Examined additional overtake track operations and track configurations (3 track not paired, 4 track paired) in overtake sections of the peninsula corridor. Looked at DTX and Dumbarton services as well as additional HSR stops.

Equipment assumptions: The simulation work assumed six 8-car EMUs. In response to a Stakeholder request, Caltrain also briefly discussed six (6) car EMU trains TPHPD vs. five 8-car EMU trains TPHPD to reduce train volumes at grade crossings.

Infrastructure assumptions: The SFTC configuration in the draft environmental TJPA document assumed Caltrain platforms on the north and this was assumed in the study's analysis of SFTC; as concerns overtake options on the peninsula, both 3-track versus 4-track configurations were examined. It is unclear whether a platform analysis was performed at SFTC, whether CBOSS was included in the DTX/SFTC, and what level of simulation analysis was completed at SFTC.

Study results: Study stressed that additional analysis needed to confirm the results of the simulation in a "real world" environment. Simulation results indicated that 6 Caltrain/4 HSR TPHPD with 5 Caltrain stations on the "Long-Middle 4 track" option (between CP Palm to CP Junction) operated best. The DTX/SFTC operation was examined with the "Long-Middle 4 track" option and 2 Caltrain/4 HSR TPHPD to SFTC and 4 Caltrain TPHPD to 4th/King. Higher levels of signal delay on the corridor resulted requiring additional Caltrain stops to mitigate those delays. Some of the signal delay resulted from the slow movement at CP Irwin into 4th/King. As a result of a stakeholder request, fewer but longer trains (see above) were examined and Caltrain indicated, qualitatively, that frequency positively increases ridership and that for many of the Caltrain stations, 8-car platforms were not feasible.

NOTE: The following study not released for public consumption

Title: Caltrain 4th & King Station and Yard Reduction/Removal Feasibility Assessment, Final Technical Staff Memorandum, November 12, 2013, LTK and HNTB for Caltrain

Purpose: To examine the reuse opportunities of portions of the Caltrain yard with current and 2019 initial electrification operations and no DTX/SFTC.

Equipment assumptions: 6 car EMU sets, diesel hauled locomotive sets with 4/5 trailers and 1 cab for 2019.

Infrastructure assumptions: Current 4th/King layout with room to store 10/11 overnight sets including one protect set and facilities for inspections, cleaning, and light duty maintenance

Service assumptions: Assumed an increase from 5 Caltrain to 6 TPHPD and no HSR or operation to SFTC; overnight storage only, no midday storage.

Study Results: Analyzed two rail yard footprint reduction alternatives – one with development along Townsend and the second with development along Townsend as well as King. Development along Townsend accommodated assumed rail service and assumptions. Development along King reduced the yard to the extent that alternative locations were needed for storage; however, no specific locations were identified. Relocating all storage from 4th/King was not studied.

Title: Salesforce Transit Center Plan, Supplemental Draft Environmental Impact Statement/Environmental Impact Report, August 25, 2014, USDOT, FTA and TJPA

Purpose: Refined the designs for Phase 2 of DTX/SFTC by adding other transportation enhancements, and allowing development of excess parcels. The DTX throat structure was widened, the SFTC train box was extended, and the 4th/Townsend Station was realigned to be contained within the existing street right-of-way as well as to accommodate HSR trains.

Equipment assumptions: Same assumptions as previous Blended Service Studies.

Infrastructure assumptions: SFTC included 6 tracks and 3 platforms. Caltrain relocated to 2 north tracks to provide larger radius curve and 1,335 tangent feet of track for HSR. A tunnel stub out was added in the vicinity of the 4th/King yard limits to conform to potential future track profile. (The prior 2007 Supplemental EIR/EIS accommodated future construction of the Townsend/Embarcadero/Main Loop and delayed the construction of the tail tracks.) The document states that the new plan, "… accommodates the City's desire to accommodate future development of the existing train yard…"

Service Assumptions: 6 Caltrain/4 HSR TPHPD as assumed in the previous Blended Service Analysis and the 2014 CHSRA Business Plan.

Study Results: While not intended to be a new operations analysis, TJPA confirmed acceptable maximum blended operations service with 6 Caltrain/4 HSR TPHPD.

4.2 RAB Rail Operations Sketch-Modeling, Phase I

The RAB rail operations (2015) analysis was a sketch planning study exploring the potential operating capacity under various constrained and unconstrained scenarios. Any proposed infrastructure changes proposed in this study were for modeling purposes only and are intended to highlight the current constraints in the system, and quantify the potential system gains if those constraints could be alleviated. In reading this summary, it is important to remember that the RAB operations analysis is not an engineering study or detailed train operations simulation. Appendix C, Rail Operations Analysis, contains presentations documenting the operations analysis conducted, assumptions used, and concepts explored as part of Phase I and Phase II RAB study analysis.

This RAB study confirms that a select few constraints significantly limit the operating capacity of the Salesforce Transit Center (SFTC). Whether or not there are reasonable engineering mitigations for those constraints remains the subject of future study. Moreover, the RAB study team agrees that the CHSRA blended service operations planning work, currently underway, will serve as the best starting point for the next level of operations analysis.

The purpose of the RAB study was to explore opportunities for development in the project area including the 4th/King railyard. Specifically, the rail portion of the RAB study is looking at the viability of:

- A relocated railyard for storage/maintenance
- Alternative rail alignment options
- Revised operations use and/or development of the 4th/King Railyards

The purpose of this initial sketch operations modeling was to explore the maximum capacity of proposed alignment options, including the Downtown Rail Extension (DTX) and SFTC. The study poses a planning question: Is it possible to run all planned service (10 trains per peak hour per direction or more) to the SFTC and therefore reduce storage and staging requirements of the 4th/King railyard?

The RAB Operations Analysis takes an entirely different approach from Caltrain's Shared Platform Study.

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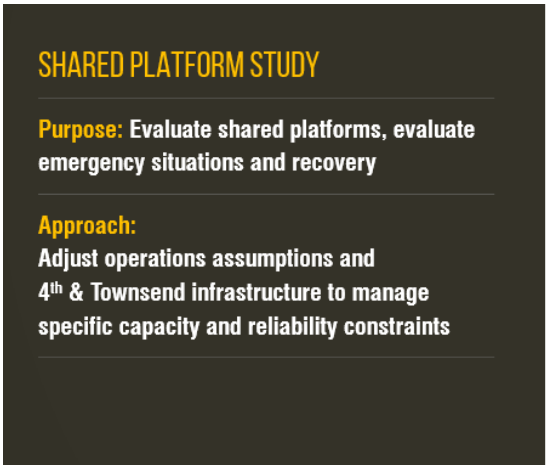
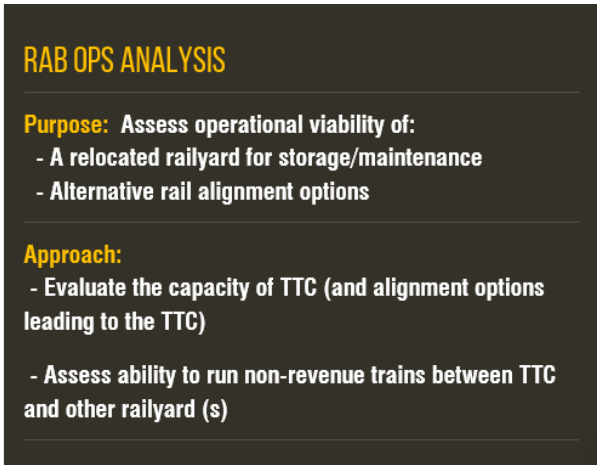




The RAB study methodology was as follows:

- Determine the runtime variations between alignment options under consideration; select the most conservative alignment as the basis for further sketch operations modeling analysis.
- Evaluate the potential capacity of SFTC (and the alignment options leading to the SFTC) for a range of operating scenarios.

Note that this initial study only looked at throughput of the SFTC, DTX and potential new alignments within San Francisco. Operations analysis of specific future railyard locations will require future study and analysis of the entire Caltrain line.

4.2.1 Basics

Study Area: The initial analysis completed for this RAB project did not include the entire Caltrain corridor, but only the area north of South San Francisco station; essentially only taking into account the following stations:

- South San Francisco
- Bayshore
- 22nd Street
- 4th/King and/or 4th/Townsend
- SFTC

For the options considering the proposed 3rd Street Alignment, the RAB study traded out the 4th/King or 4th/Townsend station with a theoretical Mission Bay station in a location yet to be determined. Constraints beyond this area were not taken into account.

Speed Limit Profiles: Using AREMA's "Practical Guide to Railway Engineering" Chapter 6 – Railway Track Design, as well as Caltrain's "Engineering Standards" Chapter 2 - Track Design.

- Two speed profiles were calculated using superelevations of 2-inches and 3-inches
- Speed profiles were simplified to multiples of 10 mph
- In specific tunnels 30 & 40 mph, where applicable, were assumed

- Standard Trainset: For Caltrain runs, an Electrical Motor Unit (EMU) double decker (Stadler KISS) was used; for CHSRA runs a Siemens Velaro was used.

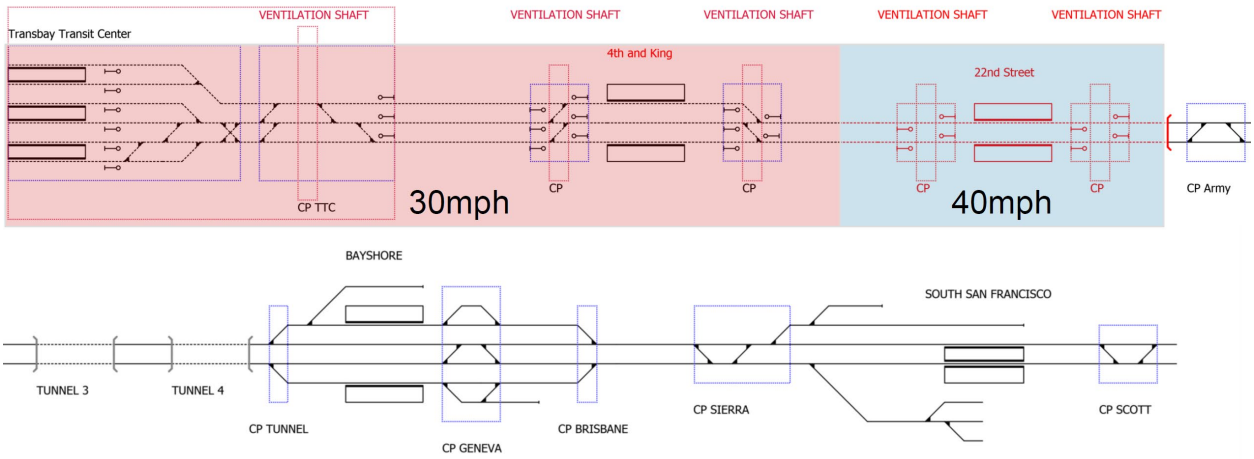
Initial Assumptions: We acknowledge the assumptions differ from those of the Shared Platform and Emergency Study completed by Caltrain (LTK). The initial assumptions used in the RAB analysis include:

- Service goal of 10 trains per peak hour per direction (TPHPD, revenue or non-revenue) including 6 Caltrain and 4 HSR – based on blended service study
- Caltrain Local Service: stops at SSF, Bayshore, 22nd Street, 4th/Townsend, and SFTC
- Caltrain Express Service: skips 22nd Street (but makes all other stops)
- HSR stop at SFTC only
- Cleared 2012 4th/Townsend side platforms (The TJPA decision to revise the 4th/Townsend layout was not known at the time this study was performed)
- Ventilation shafts in tunnel are located over the control points (CP) – allowing for one train per segment per track between the ventilation shafts (NFPA)
- Ideal dwell/turnaround times assumptions were 45 minutes for HSR, 20 minutes for Caltrain. An additional 2 minutes was included to all dwell times for platform clearance
- Utilized two structured "clock face" schedule patterns:
- 4 Caltrain local, 4 HSR both operating at 15 minute headways with 2 Caltrain express at 30 minute headways
- 6 Caltrain (local and/or Express – essentially operating at 10 minute headways) and 4 HSR operating at 15 minute headways

Initial sketch model runs resulted in the run times for each of the various alignments within the study area. The most conservative (slowest) runtime within the study area was that of the Pennsylvania Avenue alignment. Given the minimal differences between alignments, the Pennsylvania runtime (slowest) was used throughout the analysis as representative of all alignments.

Option	Run Time (CP Army – SFTC – CP Army) (min)	
	Caltrain	HSR
Mission Bay Alignment	11.7	9
Pennsylvania Ave Alignment	13.3	10.8
Current + DTX	12.7	10.0

The track layout and maximum speed per section to be used throughout the study area for the analysis is shown below.



4.2.2 Operational Scenarios

Three base scenarios were developed to investigate whether it would be operationally feasible the anticipated 10 Caltrain and HSR trains per peak hour per direction to terminate/start at SFTC. Those three base scenarios were defined by the number of platform tracks at the SFTC available for HSR trains – 5 tracks, 4 tracks, or 3 tracks available for HSR. Comparing these base scenarios would inform the question of whether SFTC capacity was being constrained due to platform availability, resulting from the operating choice not to share platforms between HSR and Caltrain service.

Testing variations on these base scenarios would also inform the potential effects if key parameters were adjusted as part of operations planning, including:

- Track Layout
- Tunnel Headways
- Separation Times
- Schedule (Service Concepts)
- Stop Pattern
- Platform Occupation Times

4.2.3 Analysis

For each platform track scenario, and some alternative variations, operations sketch planning proceeded through two separate approaches:

1. Theoretical operation plans were developed to optimize SFTC platform occupation for 10 trains (or more), and then impact on the line was observed and analyzed.
2. Theoretical operation plans were developed to optimize line throughput for 10 trains (or more), and then impact on the SFTC was observed and analyzed.

The analysis stepped through each of the base scenarios, starting with the 5-track scenario, exploring potentially viable alternatives adjusting planning variables including schedule, turn times, and stop pattern; then further exploring the potential effectiveness of a higher capacity CP SFTC, and a new track and signal layout.

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Numerous scenario variations and adjustments were explored; the most promising scenario alternatives have been documented in the table below. Detailed step-by-step review of the inputs, planning tools, observations, and adjustments for each of these scenarios is available in the explanatory slide presentation, RAB Operations Sketch Planning Analysis as originally presented in April 2015 and subsequently revised December 2015.

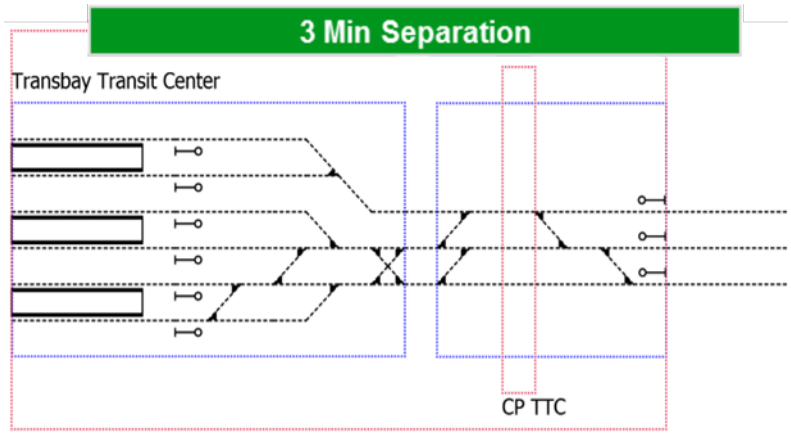
Platform Scenario		Base Assumptions							
No. of Platform tracks used by HSR	Schedule Interval	Dedicated Platforms	Resulting Turn Times		Tunnel tracks required	Platform Capacity used	Higher Capacity CP TTC	New Track and Signal Layout	Caltrain Express Stop Pattern
			HSR	Caltrain					
5	15 min	No	45	20	3	95%	Yes	Yes	Normal
	15 min	No	45	14/21	2	91%	Yes	No	**No 4th/Town**
4	15 min	Yes	45	7/13	3	79%	Yes	No	Add 22nd St.
	10 min	Yes	45	15	2	86%	Yes	No	Add 22nd St.
3	15 min	Yes	30	14/21	2	83-84%	Yes	No	Normal
Max Capacity (5)	Variable	No	20/24	12	2	83%	Yes	No	Normal

RAB Operations Sketch Planning Analysis Results

4.2.4 Preliminary Findings

Preliminary analysis shows potential for all Caltrain (6) and HSR (4) trains per hour per direction to access SFTC but only with modifications to the alignment design and reduced minimum dwell times for both agencies operations. If all SF bound trains were to access SFTC, it is anticipated that the platform occupation rates will be high, which could cause congestion during service and delaying incidents at the SFTC or along the line.

Modeling 10-train capacity to the SFTC required adjustments to planning variables including schedule, stop pattern, platform occupation times, and separation times, some of which assume infrastructure changes.



Separation time and run time in the alignment is critical to operations. The CP TCC design assumed in the early RAB analysis likely allows only a 3-minute separation between trains. The closer that operations can come to a 2-minute separation between trains, the easier it is to provide access to SFTC for all SF based trains.

Increased capacity through reduced separation times may be possible for the SFTC depending on reconfiguration of the control points from the SFTC through the DTX.

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Without a full corridor analysis (currently underway with Caltrain and CHSRA), as well as a specific schedule for the Caltrain and HSR trains anticipated to operate to/from SFTC and the willingness to minimize dwell times and headways, it is not possible to definitively answer whether or not all trains serving San Francisco (10 trains or more) can operate to/from SFTC. Further analysis is warranted.

4.3 RAB Rail Operations Sketch-Modeling, Phase II

The Phase II sketch modeling effort built upon the Phase I efforts, but performed more detailed analysis based on two key factors:

- Phase II analysis considered the differences in infrastructure and run-time between the three proposed rail alignment alternatives.
- Phase II analysis used draft peak-hour service plans coming out of the blended service operations planning process between Caltrain and High Speed Rail.

Overall, the Phase II analysis confirmed Phase I findings while also suggesting appropriate next steps in both operations planning and infrastructure refinement which would allow for the development of an alternative rail alignment that sends more trains all the way to the SFTC (rather than terminating at 4th/King Station), and therefore reduces the service requirements at 4th/King station.

The complete Phase II analysis can be found in Appendix C, Rail Operations Analysis.

Approach

For the Phase II analysis, static operation concepts were developed, applying planning parameters for signaling-enforced train separation times, station dwell times, terminal turn times, and run time recovery margins, in order to build a better understanding of the available capacity and viable service plans under normal conditions (i.e. absent of major disruptions).

Accommodation for minor every day disruptions should already be reflected in the analysis given that the planning parameters have some tolerance build in. However, dynamic simulation tools should be applied in future analysis to develop a detailed understanding of operational reliability under perturbed conditions.

In contrast to Phase I analysis (which recognized the minimal differences between proposed RAB alignments and carried out analysis using a single prototypical alignment composed of the most conservative parameters), Phase II analysis studied the three individual alignments in cases where even minimal differences had the potential to affect operational performance.

- Downtown Rail Extension (DTX)
- Pennsylvania Avenue (PEN)
- Mission Bay (MBY)

Throughout the course of the RAB study, Caltrain and CHSRA continued to discuss and rework their desired service outcome for the corridor, and those goals remain unresolved. Caltrain's service goal has been previously defined as "six trains per hour and direction" while HSR has a goal of four trains per hour and direction. In light of the uncertainty, Phase II analysis used the following three peak-hour service plans as inputs defining the range of desired service for the corridor:

- Service Plan 1: Prototypical LTK Blended Operations schedule
- Service Plan 2: Caltrain/HSR service plan for "No Additional Passing Track" (NAPT)

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- Service Plan 3: Generic service plan limited to area north of South San Francisco

A generic slot pattern (service plan 3) with six-minute headways (10 slots per hour per direction) was developed in addition to the LTK and NAPT patterns. The goal was to see how a frequent, repetitive pattern that efficiently meets operational requirements (i.e. SFTC turns as close to the 20-minute minimum and separation times at CP SFTC as close to the 3-minute minimum as feasible) performs against the preexisting patterns. In an attempt to push the bounds of what the railway might be capable of in the future, a five-minute generic pattern (12 slots per hour per direction) was developed in addition to the six-minute pattern.

Based on this approach, the sketch modeling resulted in key theoretical findings listed below. Of greatest significance to the RAB study is the overall finding that running more trains to the terminus at SFTC and expanding/modifying the 4th/Townsend station and track layout may be possible. In combination, these two solutions could significantly reduce or eliminate the station and staging requirements of a 4th/King surface railyard. If the only remaining functions of a surface railyard were storage and maintenance, then an alternative railyard location may allow for development at 4th/King.

It is important to note that only sketch modeling was performed as part of the RAB analysis. This type of analysis yielded theoretical findings that should be used to inform future modeling and simulation analysis as the follow on to this preliminary planning work. A perturbation analysis and complete simulation should be conducted to determine how the concepts perform under normal “theoretical” conditions as well as service disruption scenarios. No study conducted to date has performed a true simulation.

Key Findings

1. Workable operation concepts can be developed for every combination of service plan and infrastructure alternative (including the LTK blended operation schedule), allowing operation of 10 trains per peak hour and direction in and out of the SFTC, therefore potentially reducing the need to terminate trains at 4th/King (or Townsend) under normal operating conditions and without consideration of service disruptions and special events.
2. Under normal conditions, only two tracks are required in the tunnel leading up to the SFTC to operate the analyzed service plans. More detailed analysis is recommended to identify the most effective approach to provide infrastructure redundancy (e.g. the proposed third tunnel track) to help mitigate the potential effects of major service disruptions.
3. The 10-slot Generic Pattern developed for this study requires only five (5) platform edges at the SFTC, compared to six (6) edges required for the 10-slot LTK and NAPT patterns. In theory, this Generic Pattern could support a 12-slot pattern with all trains going to the SFTC, and no trains terminating at 4th/King (or Townsend).
4. Only two platform tracks are required for the 4th/Townsend underground station (or Mission Bay) in order to operate the regular peak hour patterns analyzed. Adding special event services or parking a protect unit at the station before the SFTC would require additional tracks at a 4th/Townsend station. A 4th/Townsend station capable of handling all service (e.g. in case of a major disruption to SFTC) could require six station platform tracks (and six platform faces).
5. Runtime differences between alignments (SFTC-DTX vs. Mission Bay) are minimal.
6. All concepts allowed separating HSR and Caltrain services at the SFTC, resulting in dedicated platform edges for both services.

7. The most constraining bottleneck was identified to be the control point before the SFTC (CP SFTC) due to the crossing conflicts between trains at this location as well as the platform space of the SFTC terminal itself.
8. Access to the proposed storage and maintenance yard locations seems possible if non-revenue trains going out of service use the revenue slot they would have used if they stayed in service. This should be a sound assumption, given that no splitting or joining of trains is anticipated. Entering and exiting various railyard locations, as well as movement within the yard locations, was not analyzed nor was any analysis performed on the storage or layover maintenance functions currently being performed at 4th /King and their relocation to any of these southern yard locations.

5 Additional Technical Analysis

5.1 Rail Relocation Land Use Analysis

See Appendix G

5.2 Soil Conditions and Geologic Hazards

See Appendix H

5.3 Tunneling

See Appendix H

5.4 Fire Life Safety

See Appendix H

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6 Cost and Economic Impact Analysis

The RAB study cost and economic impact analysis includes an estimate of *Probable Construction Costs* for each alignment option, as well as an *Overall Benefit/Cost Summary* which considers construction costs in conjunction with each alignment's revenue generating potential and other likely public benefits and impacts. With any major urban infrastructure project, it is essential to take a holistic view and consider short-term construction costs alongside the long term land use opportunities and impacts to surrounding neighborhoods.

6.1 Probable Construction Cost

This summary provides a framework for the preliminary estimates of probable costs developed by the RAB Study team.

- Estimates were developed with the express purpose to ***compare*** one alternative to the others. Component pricing is consistent across alternatives and based on validated TJPA DTX component pricing (which the RAB study confirms as reasonable for this purpose).
- Estimates are based on approximately 5-10% design.
- All estimates were completed in 2016 numbers and then escalated (where noted) at 5%/year as necessary.

Probable construction costs have been estimated for three major elements:

1. The specific rail alignment (Future with Surface Rail, Pennsylvania Avenue, or Mission Bay)
2. A new southern Railyard (located south of the current 4th/King railyard) as assumed in the Pennsylvania Avenue and Mission Bay alignment options.
3. 16th Street grade separations (with concepts and estimates provided by the City) as would be required with the Future with Surface Rail alignment.

The City's Planning Department collaborated with the San Francisco Department of Public Works to provide the design concepts and preliminary estimates of probable construction costs for element 3: the 16th Street grade separations. The RAB study team provided the design concepts and probable construction costs for elements 1 and 2: rail alignments and a new southern railyard.

6.1.1 Cost Methodology

With design concepts developed to only 5%, it was not possible or appropriate to construct a detailed "built-up" cost estimate. The study team developed comparative cost estimates based on similar projects and using the TJPA's existing estimate as the baseline according to the following methodology.

- The RAB Study team developed rates for components (as listed in section 6.1.2 below) using known major projects including:
    - DTX
    - Central Subway
    - SR-99 - Alaskan Way Viaduct Replacement (WA)

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  - SR-710 (CA)
  - Blue Plains Tunnel (CA)
  - Seattle University Link (WA)
- Using component averages from above, the RAB study team developed a probable cost estimate for DTX that was not precisely the same, but within a reasonable range of the DTX estimate as completed by both TJPA (2007) and MTC (2015).
- The RAB study team adjusted component rates to sync the component build-up to the MTC 2015 probable cost for DTX. This resulted in a basis of rates to be applied for all alignments as a comparative cost.
- Additional MTC cost items were added in to all alternatives based on the MTC 2014 estimate methodology.
- The RAB study team utilized the basis of rates and the same component methodology to calculate preliminary estimate of probably cost for Pennsylvania Avenue and Mission Bay Alignments.
- Contingency numbers applied to components and the program for Pennsylvania Avenue & Mission Bay Alignments:
  - Systems (25%)
  - Design/Construction (30%)
  - Project Development (32%)
    - PE/Enviro (4%)
    - Final Design (8%)
    - Construction Management (10%)
    - Project Management/Owner cost (10%)
- In addition, a Program contingency (27%) was applied as indicated in the cost summary

6.1.2 Summary of Probable Construction Costs

The study team's cost estimation analysis can be found in *Appendix F: Basis for Comparative Cost Analysis*. That appendix includes calculations for the basis of rates as well as a refined estimate based on the following cost components for each alignment as required:

- Cut and Cover Transbay Throat Structure
- SEM Tunnel (DTX box to Townsend Street)
- Cut and Cover Tunnel (Townsend Street to Station)
- 4th/Townsend Station (4 platform)
- Tunnels as required to 22nd Street Station
- 22nd Street Station (Cut and Cover)
- Tunnels as required South of 22nd Street
- Cross Passages
- Ventilation / Escape Structures
- Systems
- Railyard (New southern location
- Utility relocation and protection
- Mobilization
- Design/Construction Contingency
- ROW Acquisition
- Project Development / Management
- PE/Environmental
- Final Design
- Construction Management
- Project Management/Owner Costs
- Program Contingency

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The table below is a summary of the estimated probable construction costs as it also appears in the Appendix F. Additional cost estimating assumptions include:

- The estimates are expressed in current year (2016) dollars, therefore they are not a prediction of the future escalated actual costs. The cost estimates were prepared for the primary purpose of comparing the relative costs of each of the conceptual alignment alternatives, including the baseline DTX, with current and accepted cost estimates.
- Actual costs will vary depending on year of expenditure and market conditions, which were not estimated because project delivery schedules have not yet been established.
- Excavation quantities for tunneling work are based on the design length and cross sectional area for each type of excavation method.
- Assumed unit costs for the tunneling excavation are based on actual costs for work completed on similar projects, including the Central Subway/SF, Westside Subway/LA and the U Link/Seattle, among others.
- The RAB team was not provided the detailed estimates for the DTX, only the 2008 cost summary of $1,802 million. The RAB study team adjusted this estimate to 2016 dollars by applying an annual escalation rate of 3 percent, resulting in a cost of $2,159 million.
- The estimating process began with calculating the DTX tunneling quantities, applying unit costs described above, and applying cost factors to cover items not specifically quantified including allowances for systems, professional services for design and construction management among others.
- The total of these costs was compared to the 2016 DTX estimate described above to validate our estimating assumptions and consistency with the 2008 estimate. Our initial estimate was low, therefore higher unit costs were assumed, still within the typical range for similar projects, to obtain an estimate of $2,170, within 1% of the publicly available estimate.
- Once the estimating assumptions and method were validated against DTX, estimates were prepared for each of the other alternatives including the Pennsylvania and Mission Bay alignments.
- For these alignments, the needed right-of-way was not quantified. Instead, a right-of-way cost allowance was assigned equal to multipliers of 2x and 3x of the DTX right-of-way.
- Both the Pennsylvania and Mission Bay alignments assume relocation of the railyard. Cost estimates were prepared for two potential sites band the higher of these two estimates was included in the total cost of both alignments.

The table below shows the total construction costs for each alignment.

$5.191 billion – Future with Surface Rail

$6.42 billion – Pennsylvania Avenue ($1.652 billion more than the Future with Surface Rail)

$10.196 billion – Mission Bay ($5.005 billion more than the Future with Surface Rail)

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ESTIMATED PROBABLE CONSTRUTION COST			
	DTX Future with Surface Rail (2026)	**Pennsylvania Avenue (2027)**	**Mission Bay (2030)**
Alignment Construction Probable Cost	$4,075	$6,842	$10,196
Grade Separation (escalated to mid-year construction 2024, completion 2026)	$1,116	$0	$0
TOTAL ($millions, escalated to mid-year of construction)	**$5,191**	**$6,842**	**$10,196**
Increase over DTX Future with Surface Rail (millions)		$1,651	$5,005

ALIGNMENT CONSTRUCTION PROBABLE COST ($2016 millions)			
	DTX Future with Surface Rail (2026)	**Pennsylvania Avenue (2027)**	**Mission Bay (2030)**
Direct Construction Costs	$1,016	$1,761	$2,185
Design/Construction Contingency %	15%	25%	35%
Design/Construction Contingency $	$152	$440	$765
subtotal construction costs	$1,168	$2,202	$2,950
ROW Acquisition	$200	$280	$400
Additional Enviromental Clearance	$0	$1.4	$1.9
Project Development/Management (32% of construction costs)	$374	$705	$944
Program Contingency (20%)	$348	$638	$859
TOTAL ($2016 millions)	$2,090	$3,825	$5,156
TOTAL escalated to estimated mid-construction year (2023, 2024, 2027)	$2,941	$5,652	$8,818
TTC fitout Costs (escalated, no program contingency)	$1,134	$1,191	$1,378
TOTAL ($millions escalated to mid-construction)	**$4,075**	**$6,842**	**$10,196**

	Construction Escalation (5%) - doesn't include TTC fitout		
to mid-year construction **2022**	$2,801	$5,126	$6,909
2023	$2,941	$5,383	$7,255
2024	$3,088	$5,652	$7,617
2025	$3,243	$5,934	$7,998
2026	$3,405	$6,231	$8,398
2027	$3,575	$6,543	$8,818
2028	$3,754	$6,870	$9,259
2029	$3,942	$7,213	$9,722
2030	$4,139	$7,574	$10,208
2031	$4,346	$7,953	$10,718

TTC FITOUT COSTS			
	DTX Future with Surface Rail	**Pennsylvania Ave**	**Mission Bay**
Direct Construction Costs ($2016 millions)	$806	$806	$806
TOTAL escalated to mid-year of construction (2023, 2024, 2027), completion 2026, 2027, 2030	**$1,134**	**$1,191**	**$1,378**

COST FOR GRADE SEPARATING ROADWAYS UNDER TRACKS AT INTERSECTIONS					
	Grade Sep #1: 7th/Mission Bay Drive	*Grade Sep #2: 16th/7th/ Mississippi*	**DTX Future with Surface Rail - Combined Grade Seps**	**Pennsylvania Ave**	**Mission Bay**
Environmental Clearance	*$3*	*$4*	$6	$0	$0
Construction costs (including 20% PM and 30% contingency)	*$513*	*$236*	$749	$0	$0
Total ($2016 millions)	*$515*	*$240*	$755	$0	$0
TOTAL escalated mid-year construction (2024), completion 2026			**$1,116**	**$0**	**$0**

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6.2 Overall Benefit/Cost Summary

In conjunction with the estimate of probable construction costs, the study team developed an Overall Benefit/Cost Summary. Specifically, the Overall Benefit/Cost Summary table combines:

- Estimated Project Costs (probable construction costs as presented above)
- City Revenue Bonding Potential (from development of 4th/King and surrounding area)
- Private Sector Benefits (primarily based on changes in land value)

The Overall Benefit/Cost Summary breakdown as shown in the table below is the leading section to the cost estimation analysis which can be found in *Appendix F: Basis for Comparative Cost Analysis*. The basis and calculations for the City Revenue Bonding Potential and the Private Sector benefits have been developed from an extensive economic analysis that can be found in *Appendix E: Rail Relocation Economic Analysis.*

The table below suggests an overall benefit/cost summary as follows:

$5.099 billion –Future with Surface Rail

$6.010 billion – Pennsylvania Avenue ($911 million more than the Future with Surface Rail)

$9.349 billion – Mission Bay ($4.250 billion more than the Future with Surface Rail)

It should be noted that other smaller monetary benefits were also explored but are not shown in the summary table above (e.g, lost parking revenue, etc.). While these items are part of a complete benefit cost summary, their impact is in the tens of millions and are relatively insignificant in considering overall costs. See Appendix E for a full accounting of benefits considered and costed.

Estimated Probable Construction Costs

	DTX Future with Surface Rail (2026)	Pennsylvania Avenue (2027)	Mission Bay (2030)
Alignment Construction Probable Cost	-$4,075	-$6,842	-$10,196
Grade Separation (escalated to mid-year construction 2024, completion 2026)	-$1,116	$0	$0
TOTAL ($millions, escalated to mid-year of construction 2023, 2024, 2027)	**-$5,191**	**-$6,842**	**-$10,196**
Increase over DTX Future with Surface Rail (millions)		$1,651	$5,005

City Revenue Bonding Potential

	DTX Future with Surface Rail	Pennsylvania Ave	Mission Bay
Railyard Site Development Fiscal Benefit Bonding Potential [1]	$0	$235	$235
Adjacent Property Value attributable to rail: Tax Increment Bonding Potential	$214	$214	$147
Railyard Site Land Secured Financing Bonding Potential - CFD on area 0.1% Assessed value	$0	$32	$32
Diminished Bonding Potential from Trenching	-$8	$0	$0
TOTAL BONDING POTENTIAL (millions of 2026 $)	**$206**	**$481**	**$414**

[1] *Assumes 25% of revenues dedicated to costs associated with development (e.g., increased sewer costs, etc)*

Private Sector Benefits(+)/Costs(-)

	DTX Future with Surface Rail	Pennsylvania Ave	Mission Bay
Railyard Land Value Conferred	$0	$352	$352
Diminished Property Value from Trenching intersections at Mission Bay Drive and 16th Street	-$114	$0	$0
Potential Rail Passenger Travel time Savings over 50 years	$0	$0	$82
TOTAL PRIVATE SECTOR BENEFITS/COSTS (millions of 2026$)	**-$114**	**$352**	**$434**

Overall Benefit/Cost Summary

	DTX Future with Surface Rail	Pennsylvania Ave	Mission Bay
Estimated Project Costs (escalated to estimated mid-year of construction 2023, 2024, 2027)	-$5,191	-$6,842	-$10,196
City Bonding Potential	$206	$481	$414
Private Sector +Benefits/-Costs (estimated to 2026$ millions)	-$114	$352	$434
TOTAL (millions)	**-$5,099**	**-$6,010**	**-$9,349**
Delta between alternatives (millions)		$911	$4,250

6.3 Economic Analysis

An economic analysis was conducted to estimate the impacts of likely development scenarios based on the different alignment alternatives. (See *Appendix D: Rail Relocation Economic Analysis*.) The purpose of the economic analysis was to establish an estimate of future City Revenue and potential for bonding against those revenues, as well as the effect on land values and other benefits/costs that might result from the different alignment alternatives. The economic study was delivered in three parts corresponding to the three technical memorandums that comprise Appendix E.

1. **Land Value Analysis** – This memo proposed residential/commercial development scenarios for parcels made available assuming tracks and railyard were all underground, then estimated the land value of "liberated" parcels accordingly. Valuations were only associated with rail reconfiguration and did not include any roadway or freeway parcels.
2. **Financing Opportunities and Value Capture** – This memo evaluated the potential for development intensification and "soft site" expansion that comes with alternative alignments; then associated value capture financing mechanisms such as community facilities districts,

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impact fees, benefit covenants, density bonuses, and other exactions charged to new and possibly even existing development.

3. **Secondary Cost Analysis** – This memo quantified the construction disruption costs, grade separation property impacts, and rider travel time savings.

The Benefit/Cost Summary table indicates that bonding potential from City revenues, along with land value from liberated property, are significant factors adding hundreds of millions of dollars in potential benefits to the Pennsylvania and Mission Bay alternatives over the DTX with surface rail. The secondary cost analysis documents some relevant, but less significant factors including:

1. **Construction of the DTX "Cut and Cover" project is expected to last six to seven years and would result in significant disruption costs.** Construction of this nature would require street closures of 12 city blocks for 6 months each. These closures would result in increased travel times for individuals moving to and from adjacent properties, as well as through the affected area. The RAB study team estimates that this additional travel time would represent approximately $88 million in productivity losses over the construction period (in Year 2026 dollars). In addition to this, the City of San Francisco would lose out on another $720,000 in on-street parking revenue during this construction period.
2. **There is considerable variation in travel times associated with possible grade separation scenarios for the DTX and Pennsylvania alternatives.** A scenario in which 16th Street becomes an underpass beneath Caltrain and HSR at the current surface grade would perform the best from a travel time savings standpoint when compared to its alternatives, and even improves upon existing travel times for motor vehicles. Alternatively, running HSR on the surface with the existing at-grade street configuration would result in substantial delays and productivity losses (see Appendix D).
3. **If the City elects to undergo a grade separation strategy that trenches intersections and allows HSR to run on the surface, some property owners will lose a portion of their site's accessibility and value.** The RAB study team estimates that in all, 57 such parcels would be affected by trenching along 16th Street, 7th Street, and Mission Bay Drive. The combined assessed property value loss for all of the affected parcels is estimated to total approximately $114 million. This diminished property value will decrease the City's bonding ability by approximately $8.3 million in 2026 dollars.
4. **Due to differences in the physical characteristics and alignment of the rail alternatives, the Mission Bay alternative will generate travel time savings and associated productivity gains compared to the DTX or Pennsylvania Avenue alternatives**. It is estimated that the Mission Bay alignment will result in travel time savings of 0.35 minutes and 0.3 minutes for Caltrain and HSR respectively. With this time savings applied to millions of annual riders, the annual aggregate time savings can be calculated. Annually, the RAB study team estimates that roughly 93,000 hours would be saved through the Mission Bay alignment compared to the Future with Surface Rail and Pennsylvania Avenue alternatives. This represents an annual value of times savings of $1.6 million, and more than $80 million when applied to a period of 50 years (in 2026 dollars).