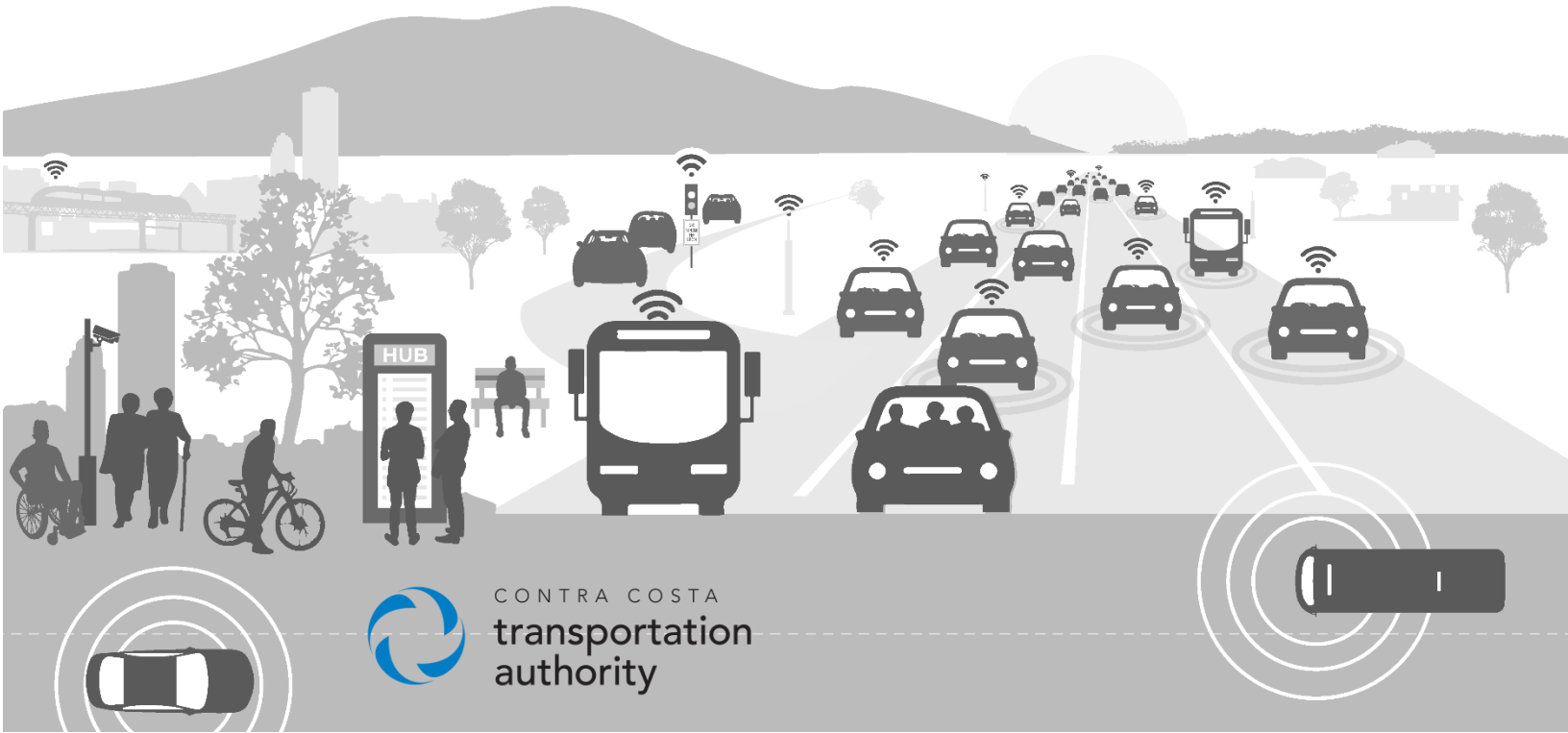
Multimodal Projects Discretionary Grant (MPDG)- Mega

Attachment A: Benefit Cost Analysis Narrative

INNOVATE 680

IMAGINE THE POSSIBILITIES



CONTRA COSTA transportation authority

BENEFIT COST ANALYSIS NARRATIVE

EXECUTIVE SUMMARY

A benefit-cost analysis (BCA) was conducted for the Contra Costa Transportation Authority (CCTA) Innovate 680 Program for submission to the U.S. Department of Transportation (USDOT) as a requirement for the National Infrastructure Project Assistance grants program (MEGA) as part of the Fiscal Year 2025-2026 Multimodal Project Discretionary Grant (MPDG) opportunity (Funding Opportunity Number: NIPA-25-26-MEGA). The analysis was conducted in accordance with the benefit-cost methodology as outlined by USDOT in the Benefit-Cost Analysis Guidance for Discretionary Grant Programs, released in December 2023. The Innovate 680 Program ("Combined Project") contains three distinct component projects, each of which demonstrates independent utility, and are as follows:

- I-680 Northbound Express Lane Completion Project – Phase 1 (Component Project 1)
- Advanced Technologies - Coordinated Adaptive Ramp Metering Project – Segments 1 and 3A (AT-CARM; Component Project 2)
- Shared Mobility Hubs (Component Project 3)

For each component project, a 20-year operating analysis period was evaluated in addition to the respective construction period. For component projects with multiple phases, benefits are accrued for a 20-year operating period following completion of the construction period of each individual phase. For projects with multiple components or phases, the analysis period is determined assuming a 20-year benefit accrual for each individual component/ phase.

Costs

The capital cost of Combined Project includes total expenditures encompassing all the major phases of the three component projects such as costs related to preliminary planning and environmental studies, engineering design studies, Right-of-Way (ROW) acquisition, construction, construction support, and systems integration. As shown in Table 1, the capital cost for the Combined Project is expected to be $283.7 million in undiscounted 2022 dollars through 2027. At a 3.1% real discount rate, these costs are $243.8 million.

Table 1. Combined Project, Project Costs by Category and Year, in Undiscounted Millions of 2022 Dollars

Cost Category	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total
Preliminary Engineering	$12.4	$2.4	$4.8	$11.6	$11.0	-	-	-	-	$42.2
ROW	-	-	-	$1.6	$3.1	-	-	-	-	$4.7
Construction	-	-	-	$8.4	$27.7	$98.8	$47.0	$38.0	$17.0	$236.9
Total	$12.4	$2.4	$4.8	$21.6	$41.8	$98.8	$47.0	$38.0	$17.0	$283.7
Total, 3.1% Discounted	$12.4	$2.3	$4.5	$19.7	$37.0	$84.8	$39.1	$30.7	$13.3	$243.8

Benefits

The total benefits from the Combined Project (Innovate 680 Program) during the analysis period are calculated to be $643.6 million in discounted 2022 dollars. The total capital costs, including engineering, construction, and ROWand land acquisition, are calculated to be $243.8 million in discounted 2022 dollars. The difference of the discounted benefits and costs equal a Net Present Value (NPV) of $399.8 million in discounted 2022 dollars, resulting in a Benefit-Cost Ratio (BCR) of 2.64. The Internal Rate of Return for the project is 12% with a Payback Period of 12 years. Table 2 summarizes the benefits and costs by categories and presents the results from the BCA.

Table 2. Combined Project, Benefit Cost Analysis Results, 2022 Dollars

BCA Metric	Project Lifecycle	
	Undiscounted	Discounted (3.1%)
Total Benefits	**$1,021,404,216**	**$643,634,535**
Travel Time	$844,844,049	$530,352,748
Emissions	$54,725,304	$38,527,881
Safety	$298,226,265	$179,845,069
Active Transportation	$1,793,679	$1,115,468
Health	$96,844	$60,223
Facility Amenities	$22,583,802	$14,043,304
Residual Value /Recapitalization cost	($53,293,522)	($30,762,275)
Change in O&M / R&R Costs	($147,572,206)	($89,547,883)
Total Costs	**$283,729,948**	**$243,838,295**
Net Present Value (NPV)	**$737,674,267**	**$399,796,240**
Benefit Cost Ratio (BCR)	**3.60**	**2.64**
Internal Rate of Return (IRR)	**12%**	
Payback Period (Years)	**12**	

The overall project benefit matrix for the Combined Project can be seen in Table 3.

Table 3. Combined Project, Project Impacts and Benefits Summary, Millions of 2022 Dollars

Benefit	Description	Monetized (Discounted 2022 $M)
Criterion #1: **Safety**	Combined project would integrate safety benefits from all component projects given express lane conversion, adaptive ramp metering, and improved smart mobility hubs are expected to act synergistically to reduce collisions (adjusting for overlapping countermeasures on any segments)	$179.8 M
Criterion #2: **State of Good Repair**	The service of life for the majority of scoped project improvements is 20 years aligning with the analysis period is 20 years. Thus, there would be no residual value. The net residual value would be negative as there would be a recapitalization cost for the AT-CARM Project – Segments 1 & 3A assuming a 10-year service life.	-$30.8 M

Benefit	Description	Monetized (Discounted 2022 $M)
Criterion #3: **Economic Impacts**	Travel time savings are quantified both at the corridor and county-level from the enhanced throughput and improved speeds offered by all the component projects, particularly the ELC and AT-CARM, and adjusted for 20 full years of operations (1.6 million person-hours reduced in opening year and 42.6 million hours across 20 years of operations)	$530.4 M
Criterion #4: **Climate Change/ Environment**	Incentive-based mode shift from SOV to HOV, increasing utilization of the transportation network, thereby increasing person-throughput and reducing congestion and its associated GHG (~142,000 tons of CO2), SOX (~1 ton), PM2.5 (~11 tons) and NOX (~88 tons) emissions. Vehicle speeds along the corridor are expected to improve while any induced VMT is mitigated through the Transportation Demand Management (TDM) Program, and Shared Mobility Hubs and as a result, emissions level is estimated to decrease over the project's duration.	$38.5 M
Criterion #5: **Equity/ Multimodal/ Quality of Life**	Enhanced facility amenities offer improved ride quality, comfort and rea-time information for various riders	$14.0 M
	Active transportation benefits for all bicyclists due to dedicate bicycle lanes (installation/extension)	$1.1 M
	Mortality reduction/health benefits for induced bicyclists from non-active transportation modes and within eligible age range	$0.1 M

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1. INTRODUCTION

A benefit-cost analysis (BCA) was conducted for the Contra Costa County Transportation Authority (CCTA) Innovate 680 Program for submission to the United States. Department of Transportation (USDOT) as a requirement for the National Infrastructure Project Assistance grants program (MEGA) as part of the Fiscal Year 2025-2026 Multimodal Project Discretionary Grant (MPDG) opportunity (Funding Opportunity Number: NIPA-25-26-MEGA). The Innovate 680 Program ("Combined Project") contains three distinct component projects, each of which demonstrates independent utility, and are as follows:

- I-680 Northbound Express Lane Completion Project – Phase 1 (Component Project 1)
- Coordinated Adaptive Ramp Metering Project – Segments 1 and 3A (Component Project 2)
- Shared Mobility Hubs (Component Project 3)

The following section describes the BCA framework, evaluation metrics, and report contents.

1.1 BCA Framework

A BCA is an evaluation framework to assess the economic advantages (benefits) and disadvantages (costs) of an investment alternative (or alternatives, if applicable). Benefits and costs are broadly defined and are quantified in monetary terms to the extent possible. The overall goal of a BCA is to assess whether the expected benefits of a project justify the costs from a national perspective. A BCA framework attempts to capture the net welfare change created by component projects and the Combined Project, including cost savings and increases in welfare (benefits), as well as disbenefits where costs can be identified (e.g., project capital costs), and welfare reductions where some groups are expected to be made worse off as a result of the proposed component projects and Combined Project.

The BCA framework involves defining a Base Case or "No-Build" Case, which is compared to the "Build" Case, where the grant request is awarded, and the component projects and Combined Project are built as proposed. The BCA assesses the incremental difference between the No-Build Case and the Build Case, which represents the net change in welfare. BCAs are forward-looking exercises which seek to assess the incremental change in welfare over a project lifecycle. The importance of future welfare changes is determined through discounting, which is meant to reflect both the opportunity cost of capital as well as the societal preference for the present.

The analysis was conducted in accordance with the benefit-cost methodology as recommended by the USDOT in the 2024 Benefit-Cost Analysis Guidance for Discretionary Grant Programs.[1] This methodology includes the following analytical assumptions:

- Defining existing and future conditions under the No-Build Case as well as under the Build Case;
- Assessing the independent utility of each component project if the overall application contains multiple separate projects linked together in a common objective;
- Estimating benefits and costs during construction and operation of each individual component project, including 20 years of operations, beyond the component project construction completion when benefits accrue;

- Aggregating benefits and costs for the Combined Project, where individual component project benefits and costs are accrued for a 20-year operating period beginning from their respective construction completion;
- Using USDOT recommended monetized values for reduced fatalities, injuries, property damage, state of good repair, travel time savings, congestion reduction, vehicle Operations & Maintenance (O&M) savings, emissions, active transportation, health, facility amenities, noise, while relying on best practices for monetization of other benefits;
- Presenting dollar values in real 2022 dollars. In instances where cost estimates and benefits valuations are expressed in historical or future dollar years, using an appropriate inflation factor to adjust the values; and,
- Discounting future benefits and costs with a real discount rate of 3.1% consistent with USDOT guidance.[1]

1.2 Report Contents

Section 2 of this report contains a description of the component projects and Combined Project, information on the general assumptions made in the analysis, and a description of the No-Build Case compared to the Build Case. Section 3 provides a summary of the anticipated project costs. Section 4 provides the anticipated demand projections for background traffic growth. Section 5 reviews the expected economic benefits the component projects and Combined Project would generate, including a review of the assumptions and methodology used to calculate the benefits. Section 6 reports the high-level results of the benefit-cost analysis. Section 7 reports the findings of the sensitivity test to key assumption inputs.

2. PROJECT OVERVIEW

2.1 Project Description

Interstate 680 (I-680) is a major north-south freeway connecting the Southern San Francisco Bay Area with Interstate 80 (I-80), which crosses the Central Valley including the Sacramento metropolitan area. I-680 passes through Santa Clara, Alameda, Contra Costa, and Solano counties. The I-680 corridor within Contra Costa currently experiences significant delays due to congestion, which is expected to deteriorate further if not remedied properly. The Contra Costa Transportation Authority (CCTA) is seeking to address the congestion along the corridor through the Innovate 680 Program, which includes a comprehensive series of projects that span roadway enhancements, advanced technological integrations, transit improvements, and other multimodal, technology-driven, innovative solutions, all aimed at mitigating congestion along the I-680 corridor. As shown in Figure 1, the Innovate 680 Program (the Combined Project) included in the BCA analysis contains three distinct component projects, each of which demonstrates independent utility, and are as follows:

- I-680 Northbound Express Lane Completion Project – Phase 1 (Component Project 1)
- Coordinated Adaptive Ramp Metering Project – Segments 1 and 3A (Component Project 2)
- Shared Mobility Hubs (Component Project 3)

Detailed project descriptions of each component are shown below.

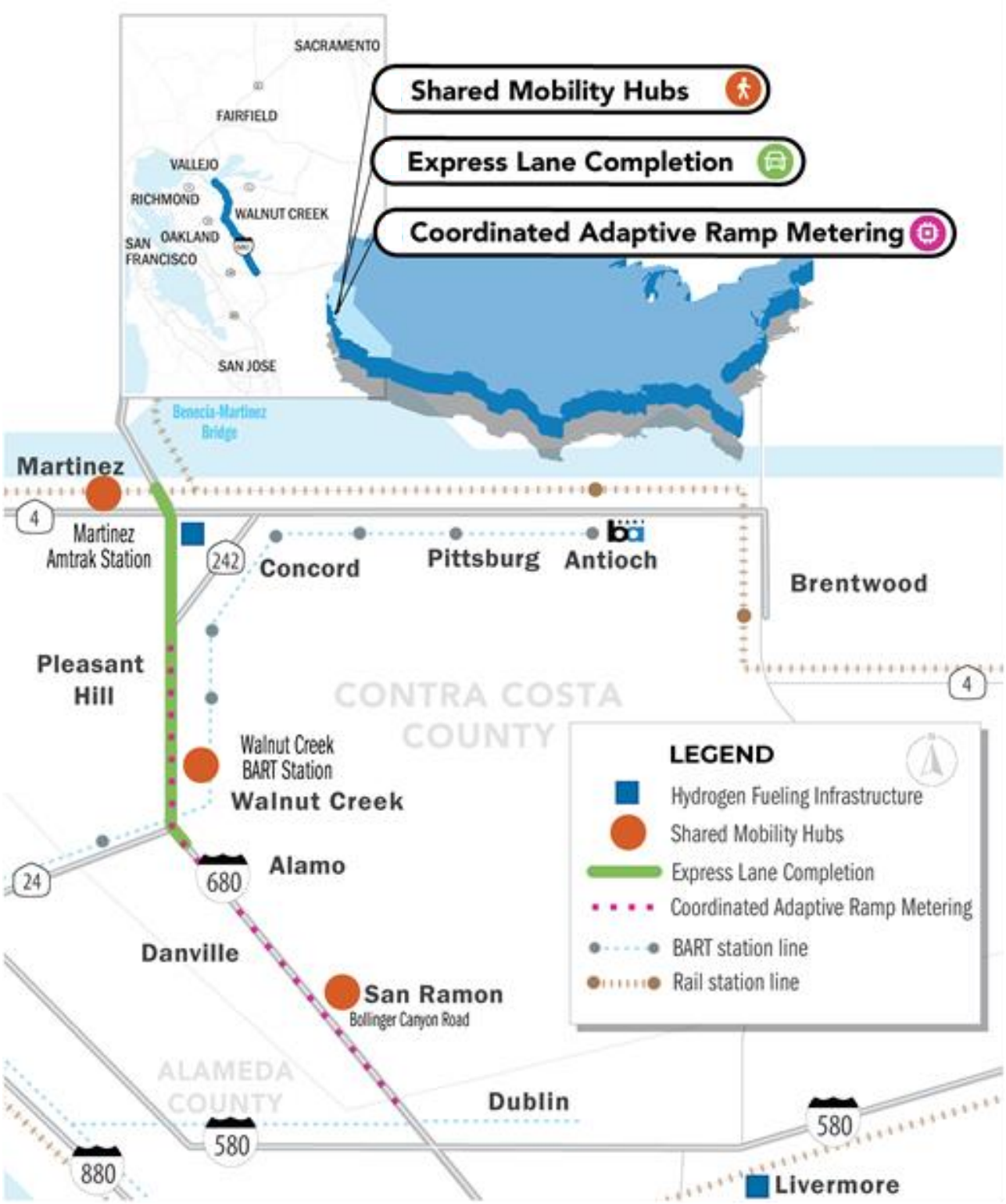

Figure 1. Innovate 680 Program (Combined Project)

2.1.1 I-680 Northbound Express Lane Completion Project – Phase 1 (Component Project 1)

One of the projects identified as part of the Innovate 680 Program is the I-680 Northbound (NB) Express Lane Completion (ELC) Project (Component Project 1), which is part of the Metropolitan Transportation Commission (MTC) Express Lanes network authorized by the California Transportation Commission (CTC). Under existing conditions, I-680 NB includes two types of managed lanes: (i) high-occupancy vehicle (HOV) lanes and (ii) express lanes. An existing express lane is currently in operation from south of Alcosta Boulevard to Livorna Road, and an HOV lane is also provided from north of the State Route 242 (SR-242) junction to south of Benicia-Martinez Bridge. Under existing conditions, a 7.5-mile gap exists between these two segments of the mainline from Livorna Road to the SR-242 junction, causing operational challenges along NB I-680. Addressing the existing I-680 NB mainline gap is expected to improve traffic operations and relieve traffic congestion on NB I-680 in Contra Costa County.

The Contra Costa Transportation Authority (CCTA), in cooperation with the California Department of Transportation (Caltrans) District 4 (D4) and the Metropolitan Transportation Commission (MTC) proposes Alternative 2 of the I-680 NB ELC Project, shown in Figure 2, which would be constructed in two phases. The I-680 NB ELC Project proposes to convert the existing HOV lane on I-680 NB from SR-242 to Marina Vista Avenue to an express lane and construct an express lane from Livorna Road to just north of I-680/SR-242 junction. The I-680 NB ELC Project – Alternative 2 – Phase 1 would include the following proposed improvements:

- Construction of braided ramps between the North Main Street/Lawrence Way Interchange and the Treat Boulevard Offramp. Braided ramps are ramps that cross over each other and are separated vertically by concrete pillars that elevate one or more of the ramps.
- Construction of a new northbound express lane from north of SR-24 to the SR-242 junction through restriping.
- Conversion of the existing northbound HOV lane from SR-242 to south of the Benicia-Martinez Bridge Toll Plaza to a High-Occupancy Toll (HOT) express lane.

Considering the capacity increase resulting from the I-680 NB ELC Project, compliance with the California Environmental Quality Act (CEQA) as stipulated by California Senate Bill 743 (SB 743) is required. Therefore, the project must implement measures to mitigate induced Vehicle-Miles Traveled (VMT) associated with Component Project 1. The identified VMT mitigation measures for Alternative 2 – Phase 1 include CCTA's commitment to funding O&M for the existing countywide Transportation Demand Management (TDM) Program, known as 511 Contra Costa, and the development and O&M of three proposed Shared Mobility Hubs (Component Project 3) to induce mode shift from Single Occupant Vehicles (SOVs) to HOVs, transit and other non-motorized modes. These commitments are to be maintained for a period of 20 years.

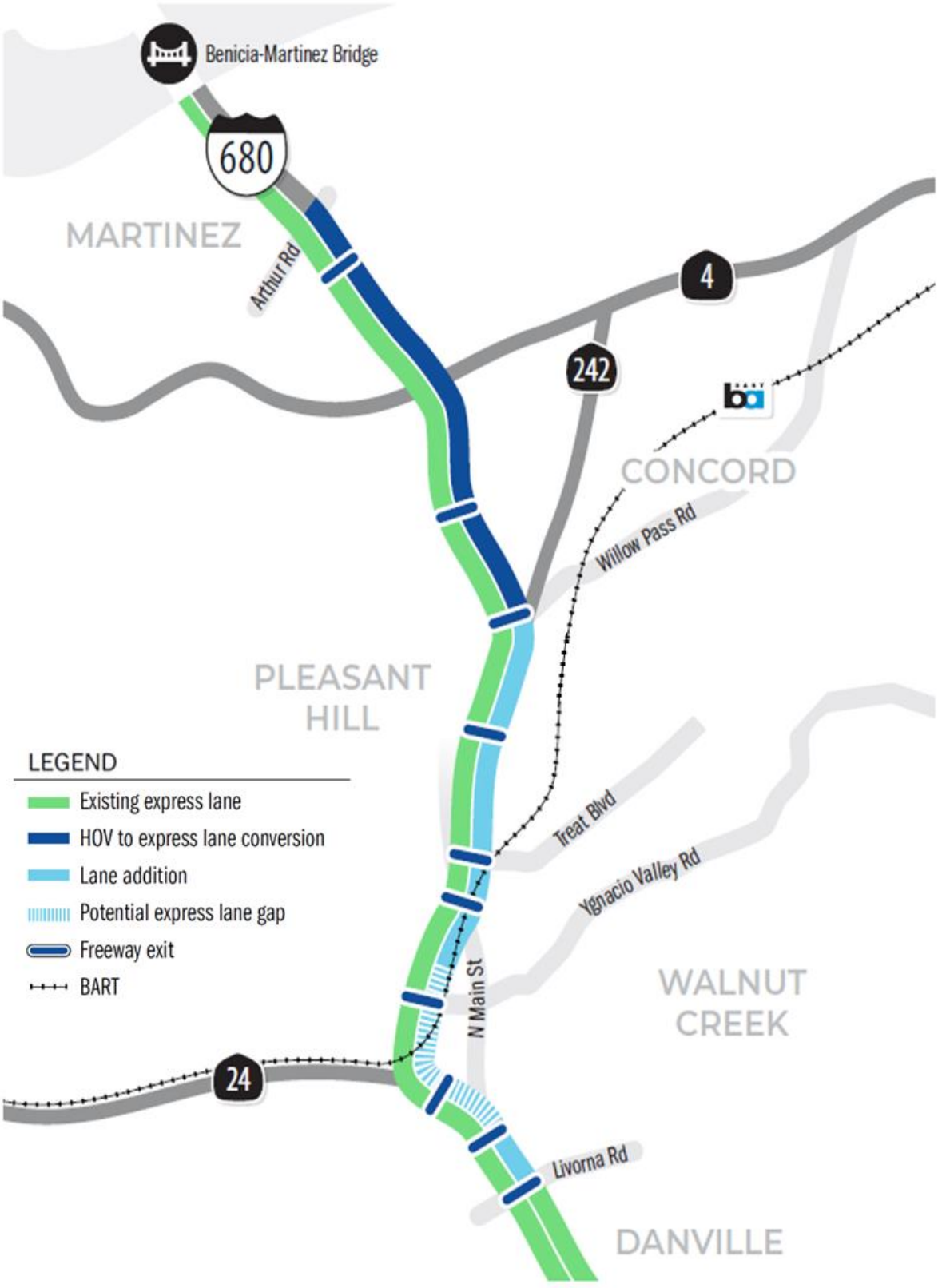

Figure 2. I-680 NB ELC Project Map

2.1.2 Coordinated Adaptive Ramp Metering Project – Segments 1 and 3A (Component Project 2)

The Contra Costa Transportation Authority (CCTA), in cooperation with the California Department of Transportation (Caltrans) District 4 (D4) and the Federal Highway Administration (FHWA), proposes to address congestion on Interstate 680 (I-680) and improve mobility in Contra Costa County by installing Coordinated Adaptive Ramp Metering (CARM) and mainline Intelligent Transportation Systems (ITS). The Advanced Technologies – Coordinated Adaptive Ramp Metering (AT-CARM) Project (Component Project 2) represents the inaugural initiative within the broader Innovate 680 Program, included in a comprehensive series of projects that span roadway enhancements, advanced technological integrations, and transit improvements, all aimed at mitigating congestion along the I-680 corridor.

As shown in Figure 3, the AT-CARM Project will implement an adaptive ramp metering system on I-680 Northbound (NB) for Segments 1 and 3A between Alcosta Boulevard and Olympic Boulevard, and between North Main Street/Lawrence Way and SR-242, respectively. A future phase will expand that to the southbound (SB) direction and the remaining NB segments of I-680 in Contra Costa County. The goal of CARM is to:

- Proactively manage both recurrent and non-recurrent congestion in a coordinated, real-time manner to improve productivity and reliability of the I-680 corridor.
- Balance freeway performance objectives and ramp queues.
- Improve the detection of incidents to support real-time CARM and other traffic operations strategies.
- Encourage collaboration with local agencies for further implementation of intelligent ITS and integrated real-time traffic operations strategies that address regional and local objectives.

The AT-CARM Project – Segment 1 includes reconfigurations at six entrance ramps – I-680/EB & WB Bollinger Canyon Road, I-680/EB & WB Crow Canyon Road, I-680/ Sycamore Valley Road and I-680/Olympic Boulevard. Concurrent with AT-CARM – Segment 1, the Caltrans SHOPP Ramp Metering Project (EA 04-1Q720) would be constructed. The different components of the Build Case for AT-CARM Project – Segment 1 are summarized in Table 4.

The AT-CARM Project – Segment 3A includes reconfigurations at two entrance ramps – I-680/ Oak Road/ Buskirk Avenue, and I-680/Willow Pass Road. Concurrent with AT-CARM – Segment 3, the I-680 NB ELC Project – Phase 1 (Component Project 1) would be constructed.

The AT-CARM Project will streamline access points to the I-680 NB mainline and provide enough storage behind the meter limit line to prevent queues from extending onto and impacting local street operations. ITS detection equipment and supporting electrical equipment, including Traffic Infra-Red Traffic Loggers (TIRTL), will also be installed at each northbound ramp and on the mainline between interchanges.

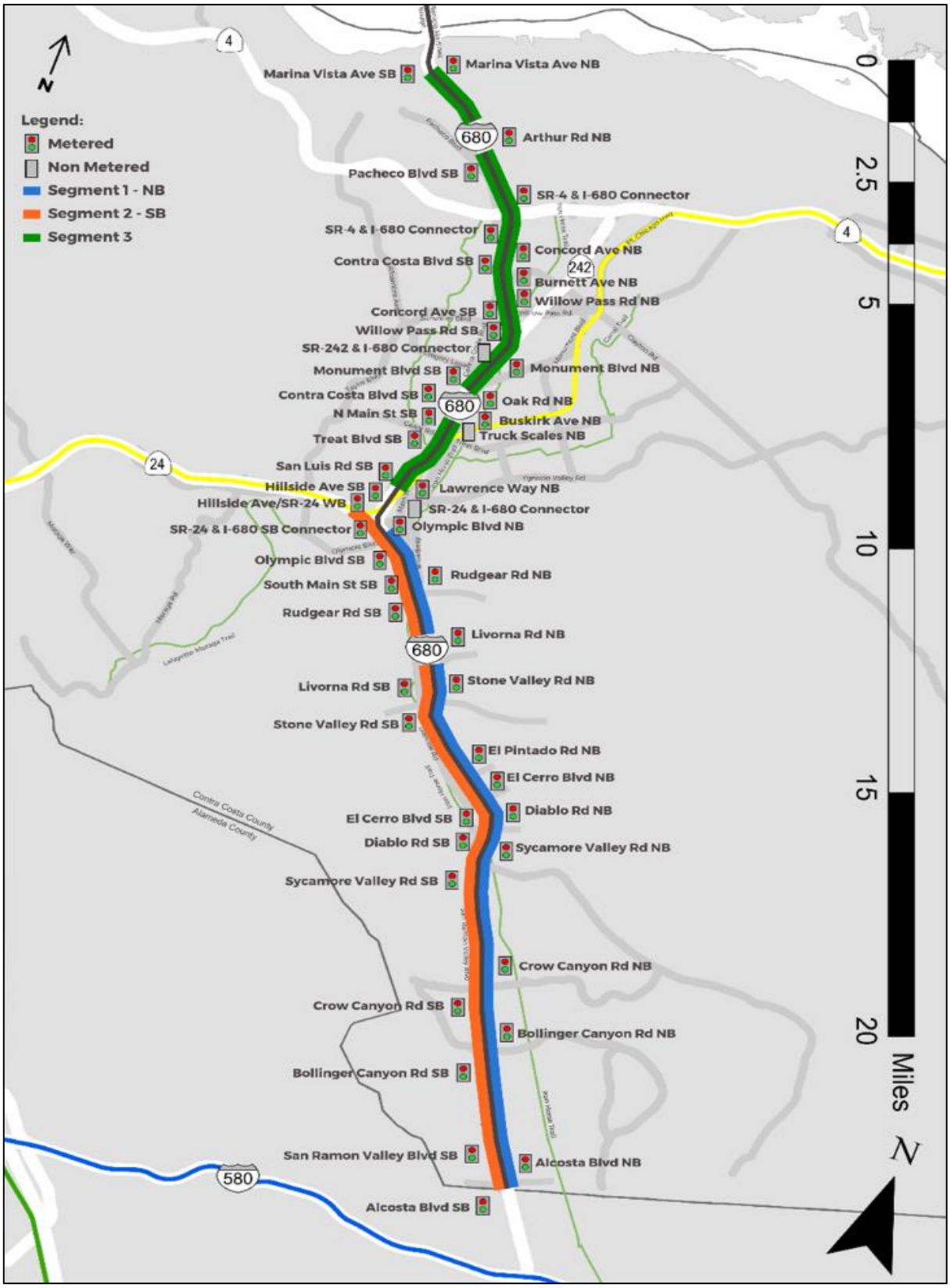

Figure 3. AT-CARM Project Map

Table 4. CCTA AT-CARM Segment 1 and Caltrans SHOPP Project Improvements: I-680 Northbound Ramps

LOCATION	RAMP TYPE	NO. LANES (EA1Q720)	SHOPP SCOPE OF WORK	CARM SCOPE OF WORK
Alcosta Boulevard	S	3	Install missing over ground equipment and restripe to 2 General-Purpose (GP) and 1 High Occupancy Vehicle (HOV) lane	▪ No physical improvements proposed
EB Bollinger Canyon Road	L	2	Widen ramp to 2 lanes (1GP + 1HOV) and install ramp meter equipment	▪ Reconfigure ramp, provide a total of 3 lanes behind the stop bar after merging the loop and diagonal on-ramps. ▪ Install necessary ITS equipment
WB Bollinger Canyon Road	S	3	Widen ramp to 3 lanes (2GP + 1HOV) and install ramp meter equipment	▪ Merge WB diagonal ramp with EB loop ramp
EB Crow Canyon Road	L	2	Re-stripe ramp to 2 lanes (1GP + 1HOV) and install above ground ramp meter equipment	▪ Reconfigure ramp, provide a total of 3 lanes behind the stop bar after merging the loop and diagonal on-ramps. ▪ Install necessary ITS equipment
WB Crow Canyon Road	S	3	Widen ramp to 3 lanes (2GP + 1HOV) and install ramp meter equipment. If forecasted volume is less than 900 vph, widening is not required.	▪ Merge WB diagonal ramp with EB loop ramp
Sycamore Valley Road	S	2	Re-stripe ramp to 2 lanes (1GP + 1HOV) and install above ground ramp meter equipment	▪ Reconstruct the CHP enforcement area to add a third lane behind the stop bar to provide 200 feet of additional storage capacity.
EB Diablo Road	L	2	Widen ramp to 2 lanes (1GP + 1HOV) and install ramp meter equipment	▪ No civil improvements proposed
WB Diablo Road	S	2	Widen ramp to 2 lanes (1GP + 1HOV) and install ramp meter equipment	▪ No civil improvements proposed
El Cerro Boulevard	S	2	Widen ramp to 2 lanes (1GP + 1HOV) and install ramp meter equipment	▪ No civil improvements proposed
El Pintado Road	S	2	Widen ramp to 2 lanes (1GP + 1HOV) and install ramp meter equipment	▪ No civil improvements proposed
Stone Valley	S	2	Widen ramp to 2 lanes (1GP + 1HOV) and install ramp meter equipment	▪ No civil improvements proposed
Livorna Road	S	2	Widen ramp to 2 lanes (1GP + 1HOV) and install ramp meter equipment	▪ No civil improvements proposed
Danville Boulevard / Rudgear Road	S	2	Widen ramp to 2 lanes (1GP + 1HOV) and install ramp meter equipment	▪ No civil improvements proposed
Olympic Boulevard	S	2	Widen ramp to 2 lanes (1GP + 1HOV) and install ramp meter equipment	▪ Reconstruct the CHP enforcement area to add a third lane behind the stop bar to provide 150 feet of additional storage capacity.

In terms of equipment, the AT-CARM Project (Component Project 2) would include cabinet controllers and communications infrastructure; mast arm signals with additional traffic signal heads per 2022 Caltrans Ramp Metering Design Manual (RMDM)[2] standards; additional traffic loops detectors (four at the stop bar, one at mid-queue and one at the back of the queue) per RMDM standards; and, advance warning signs with dynamic message boards in view of right- and left-turning lanes from arterial streets to the ramps, consistent with Manual on Uniform Traffic Control Devices (MUTCD) and California MUTCD standards.

The AT-CARM system will operate within the Bay Area Regional ITS Architecture (RITSA)[3] managed by the Metropolitan Transportation Commission (MTC), where Caltrans D4 and CCTA are identified as key stakeholders and the INNOVATE 680 program is identified as an underlying project. The AT-CARM – Segments 1 and 3A project is being developed cooperatively by Caltrans and CCTA to be consistent with the RITSA Operational Concepts for Traffic Management to satisfy Caltrans D4 responsibilities for:

- Implementing enhanced traffic management strategies.
- Maintaining field equipment.
- Managing and monitoring traffic on freeway on-ramps and Caltrans controlled highways.
- Managing and monitoring traffic on freeways including HOV and express lane management.
- Sharing freeway device control with other transportation agencies.
- Sharing traffic information with other transportation agencies.

The AT-CARM – Segment 1 Project is being developed in accordance with RITSA Functional Requirements for:

- Roadway traffic metering;
- Dynamic lane shoulder use on ramps;
- Roadway infrastructure monitoring;
- Data collection; and,
- ITS communications.

The conceptual systems architecture for AT-CARM – Segment 1 Project, as described in the I-680 AT-CARM Concept of Operations and illustrated in Figure 4, shows the system is being designed to interface with the existing Caltrans ITS Network including the ability for Caltrans D4 to receive all system-produced data. AT-CARM also represents a foundational element of the CCTA Countywide Connected Datacenter (CCD) and Decision Support System (DSS), which are both specifically defined in the RITSA. AT-CARM will support the regional ITS architecture through the collection, monitoring, and reporting of county-wide network performance data for Contra Costa County to enhance real-time situational awareness.

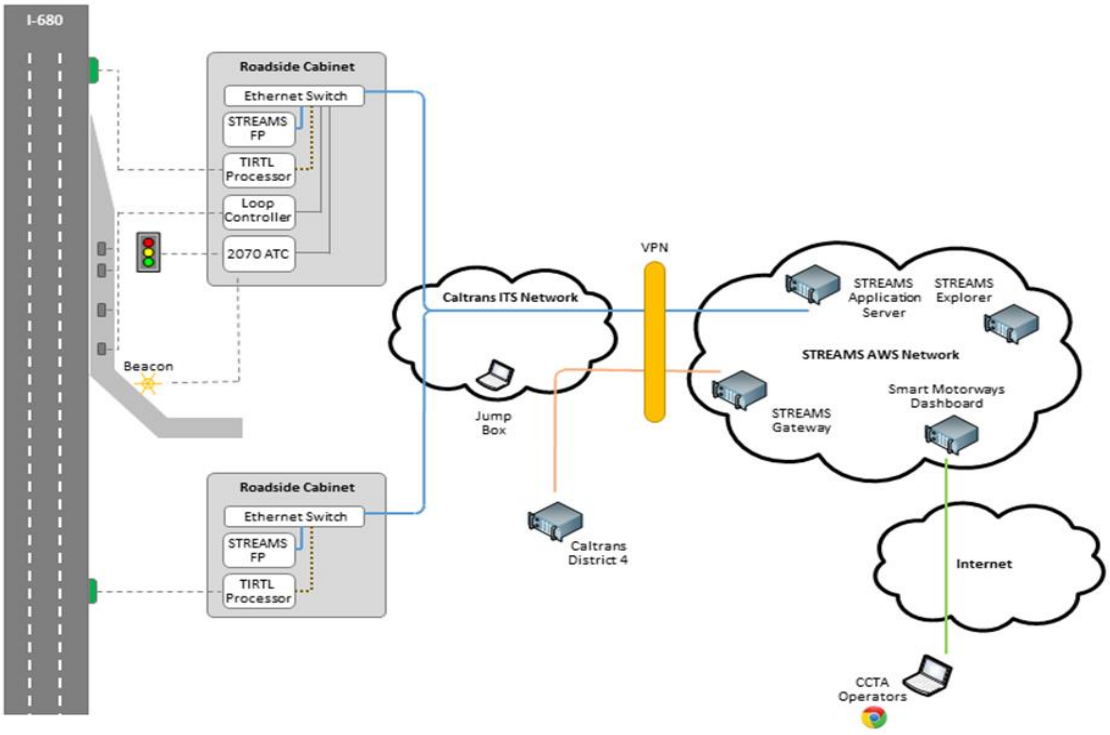

Figure 4. INNOVATE 680 AT-CARM – Segment 1 Project Conceptual Systems Architecture

2.1.3 Shared Mobility Hubs (Component Project 3)

As shown in Figure 5, three Shared Mobility Hubs (SMH) will be implemented along the I-680 at the limited stops of the zero-emission I-680 Express Bus Service, namely: Bollinger Canyon Road in San Ramon, the Walnut Creek BART Station, and the Martinez Amtrak Station. The express bus service addresses the existing rail gap on I-680 identified in the 2023 California State Rail Plan[4], providing the much-needed connection for travelers on Amtrak's national network, and the Capitol Corridor and San Joaquin routes with regional rail service such as the BART and Altamont Commuter Express (ACE) rail networks. The I-680 Express Bus Service will be operated with zero emission Hydrogen Fuel Cell Electric Buses (FCEB) by County Connection and Livermore Amador Valley Transit Authority (LAVTA) who are constructing hydrogen fueling and maintenance infrastructure at their respective sites to support the FCEBs.

These SMHs are crucial to support the new Express Bus Service. SMHs are places of connectivity where different travel options – biking, transit, carpooling, van pooling, ride-sourcing, and micro transit – come together, providing first/last-mile connection options to the Express Bus riders and other transit users that stop at the SMHs. In addition to providing an integrated suite of mobility services, the hubs offer a variety of amenities to incentivize mode shift and non-auto modes such as enhanced waiting areas, bike charging, and wi-fi. The first mile/last mile connectivity provided by these three SMHs will promote the regional impacts of the corridor transit options and help to make the zero emission Express Bus service successful. This coordinated suite of transit alternatives will be developed following the Regional Mobility Hub Implementation Playbook developed by MTC and is a model that can be replicated throughout the region. Additional details for each SMH are outlined below:

Bollinger Canyon Road SMH:

The SMH is located at Bishop Ranch, east of I-680/Bollinger Canyon Road interchange. Bishop Ranch is a large employment center with adjacent points of interests, including the City Center commercial center, Iron Horse Regional Trail that runs parallel to I-680, a large business campus that is the largest employment center in central Contra Costa County, and community services such as library, schools, and medical centers. Bishop Ranch is a mix of retail and commercial services with high-density residences currently under construction – the proposed SMH at Bishop Ranch #3 will provide mobility services to Bishop Ranch users and residents to create mode shift from SOV trips to multimodal trips.

Martinez Amtrak SMH:

The SMH will connect the new I-680 Express Bus riders to other bus connections, Capitol Corridor Amtrak line, and active transportation modes. The project proposes to enhance bicycle connections to the local bike network and the surrounding recreational trails at the Martinez Regional Shoreline Park. The SMH is located at the northern end of the I-680 corridor and serves as a regional intermodal hub for Northern California Amtrak and Capitol Corridor service and regional bus operators of County Connection, Tri Delta Transit, and Western Contra Costa County Transit (WestCAT). The Amtrak station is located at the west end of downtown Martinez, which is a designated DAC. The SMH is close to commercial buildings, Contra Costa Community College, residential neighborhoods, and regional parks. As the seat of Contra Costa County, downtown Martinez is also the home of the County Superior Court, County Administrative offices, and other governmental offices complexes which are major employers in the area.

Walnut Creek BART SMH:

The SMH will improve the BART station to support the new I-680 Express Bus service. The proposed mobility hub improvements focus on providing enhanced bicycle and pedestrian access to the station, through establishing new on-street and off-street connections, improving street crossings, and enhancing wayfinding and amenities both inside the station along the surrounding roadway network. These improvements will promote bicycle, pedestrian, and transit access to BART and support ridership growth potential from the Transit Oriented Development (TOD) project, while reducing reliance on parking for rider access.

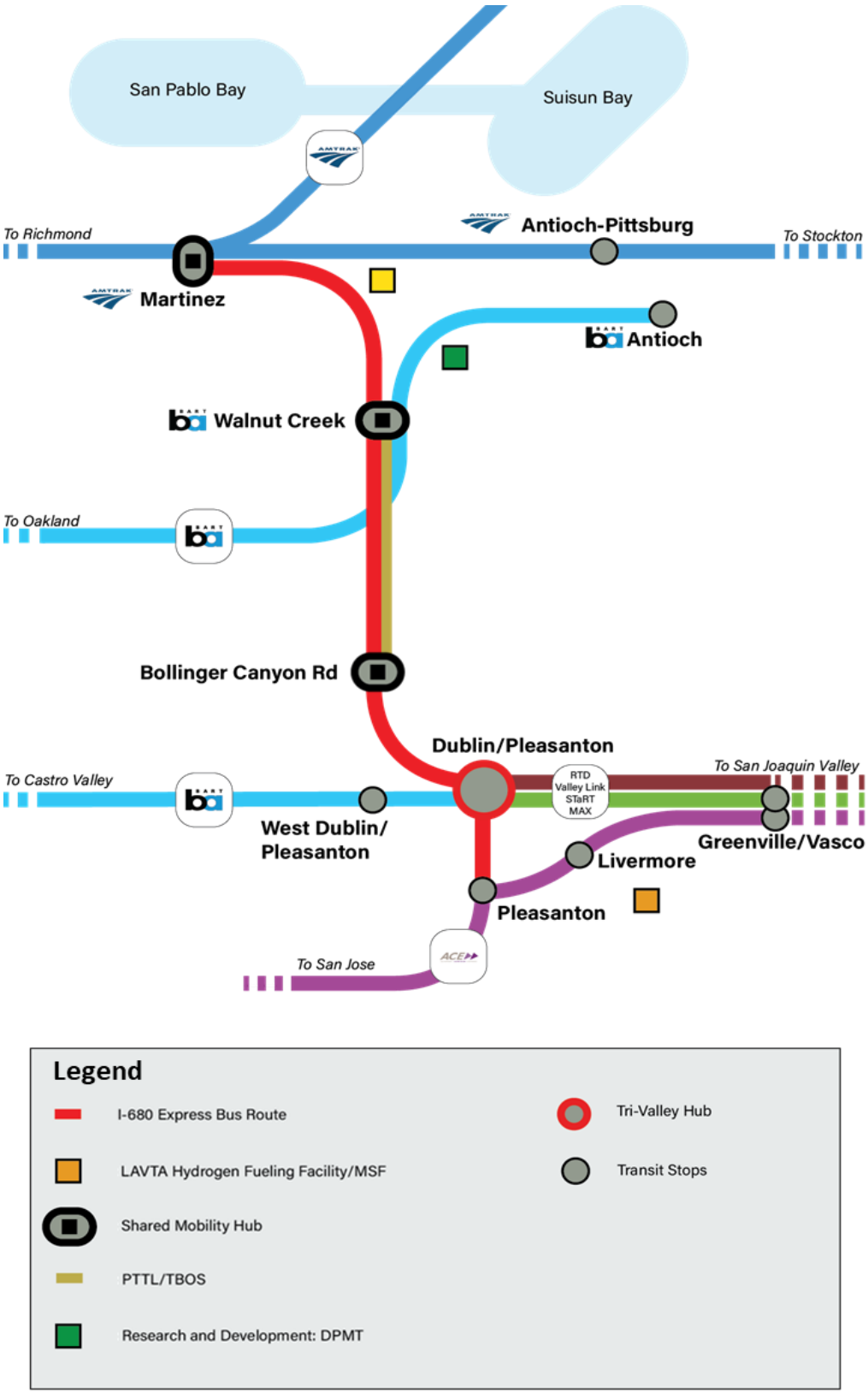

Figure 5. SMH Project Map

2.2 General Assumptions

The evaluation period for each of the individual component projects and the Combined Project vary based on their construction schedules. Per USDOT guidance, a suitable operating period for the three Innovate 680 Program project components would be a 20-year duration, as the Combined Project is aimed primarily at highway capacity expansion and addressing other operating deficiencies. The analysis period for the individual project components (including their sub-phases) are shown in Table 5 below. For the Combined Project evaluation, benefits and costs during the operating period are accrued only for the 20-year duration of each project component.

Table 5. BCA Analysis Periods for Component and Combined Project Evaluation

Project	Project Name	Phase	Project Development and Construction			Operations			Analysis Period		
			Start	End	Dur.	Start	End	Dur.	Start	End	Dur.
Component Project 1	**I-680 NB ELC Project**	**Phase 1**	2022	2030	9	2031	2050	20	2022	2050	29
Component Project 2	**AT-CARM Project**	**Segment 1**	2022	2027	6	2028	2047	20	2022	2047	26
		Segment 3A	2024	2030	7	2031	2050	20	2024	2050	26
Component Project 3	**Shared Mobility Hubs**	**Bollinger Canyon Road**	2024	2028	5	2028	2047	20	2024	2047	24
		Martinez Amtrak Station	2024	2028	5	2028	2047	20	2024	2047	24
		Walnut Creek BART Station	2024	2027	4	2028	2047	20	2024	2047	24
Combined Project	**Innovate 680 Program**	**N/A**	**2022**	**2030**	**9**	**2028**	**2050**	**23**	**2022**	**2050**	**29**

Dollar figures in this analysis are expressed in constant 2022 dollars (2022 $). Capital costs were provided by CCTA and were presented in 2024 dollars, which were then converted to 2022 dollars using data from the U.S. Bureau of Economic Analysis (BEA).[5] The real discount rate used for this analysis was 3.1%, consistent with USDOT guidance for 2024 grants[1] and OMB Circular A-94.[6]

2.3 No-Build Case and Build Case

The Base Case, or No-Build Case, is defined as the continual maintenance of the existing I-680 NB corridor facilities with no changes to the mainline, ramps, and to other infrastructure such as ITS technologies and transit facilities. As a result, there would be no changes in future conditions to anticipated safety, traffic, asset management and emissions metrics. The Base Case does not include other transportation projects considered as part of CCTA's Innovate 680 Program.

The Build Case would feature improvements to the I-680 corridor ramps and mainline, as well as facilities in the vicinity of the I-680 corridor in Contra Costa County, as described in Section 2.1. At the individual project component level, the Build Case assumes that the other project components that

are proposed as part of the Innovate 680 Program would not be developed. For the Combined Project, the Build Case assumes that all three project components would be developed. Other INNOVATE 680 Program transportation projects proposed by CCTA in addition to the three identified project components were not considered in the BCA analysis.

3. PROJECT COSTS

3.1 Capital Costs

The capital cost of the three component projects and Combined Project includes total expenditures encompassing all the major phases of the project such as costs related to preliminary planning and environmental studies, engineering design studies, ROW, construction, construction support, and ystems integration.

3.1.1 I-680 NB ELC Project – Phase 1 (Component Project 1)

As shown in Table 6, the capital cost for Component Project 1 is expected to be $174.2 million in undiscounted 2022 dollars through 2030. At a 3.1% real discount rate, these costs are $148.5 million.

Table 6. Component Project 1, Costs by Category and Year, in Undiscounted Millions of 2022 Dollars

Cost Category	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total
Preliminary Engineering	$12.1	$1.3	$1.1	$6.2	$9.7	-	-	-	-	$30.4
ROW	-	-	-	$1.6	$3.1	-	-	-	-	$4.7
Construction	-	-	-	-	-	$52.2	$39.4	$32.6	$14.9	$139.1
Total	$12.1	$1.3	$1.1	$7.8	$12.8	$52.2	$39.4	$32.6	$14.9	$174.2
Total, 3.1% Discounted	$12.1	$1.2	$1.0	$7.1	$11.3	$44.8	$32.8	$26.3	$11.6	$148.5

3.1.2 AT-CARM Project – Segments 1 & 3A (Component Project 2)

As shown in Table 7, the capital cost for Component Project 2 is expected to be $53.3 million in undiscounted 2022 dollars through 2030. At a 3.1% real discount rate, these costs are $45.9 million.

Table 7. Component Project 2, Project Costs by Category and Year, in Undiscounted Millions of 2022 Dollars

Cost Category	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total
Preliminary Engineering	$0.3	$0.6	$2.4	$1.1	$0.5	-	-	-	-	$4.9
ROW	-	-	-	-	-	-	-	-	-	-
Construction	-	-	-	-	$12.6	$23.3	$5.1	$5.4	$2.1	$48.4
Total	$0.3	$0.6	$2.4	$1.1	$13.0	$23.3	$5.1	$5.4	$2.1	$53.3
Total, 3.1% Discounted	$0.3	$0.6	$2.2	$1.0	$11.5	$20.0	$4.2	$4.3	$1.6	$45.9

3.1.3 Shared Mobility Hubs (Component Project 3)

As shown in Table 8, the capital cost for Component Project 3 is expected to be $56.2 million in undiscounted 2022 dollars through 2028. At a 3.1% real discount rate, these costs are $49.5 million.

Table 8. Component Project 3, Project Costs by Category and Year, in Undiscounted Millions of 2022 Dollars

Cost Category	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total
Preliminary Engineering	-	$0.5	$1.3	$4.2	$0.9	-	-	-	-	$6.9
ROW	-	-	-	-	-	-	-	-	-	-
Construction	-	-	-	$8.4	$15.1	$23.2	$2.5	-	-	$49.3
Total	-	$0.5	$1.3	$12.7	$16.0	$23.2	$2.5	-	-	$56.2
Total, 3.1% Discounted	-	$0.4	$1.3	$11.6	$14.2	$19.9	$2.1	-	-	$49.5

3.1.4 Innovate 680 Program (Combined Project)

As shown in Table 9, the capital cost for the Combined Project is expected to be $283.7 million in undiscounted 2022 dollars through 2027. At a 3.1% real discount rate, these costs are $243.8 million.

Table 9. Combined Project, Project Costs by Category and Year, in Undiscounted Millions of 2022 Dollars

Cost Category	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total
Preliminary Engineering	$12.4	$2.4	$4.8	$11.6	$11.0	-	-	-	-	$42.2
ROW	-	-	-	$1.6	$3.1	-	-	-	-	$4.7
Construction	-	-	-	$8.4	$27.7	$98.8	$47.0	$38.0	$17.0	$236.9
Total	$12.4	$2.4	$4.8	$21.6	$41.8	$98.8	$47.0	$38.0	$17.0	$283.7
Total, 3.1% Discounted	$12.4	$2.3	$4.5	$19.7	$37.0	$84.8	$39.1	$30.7	$13.3	$243.8

3.2 Operations & Maintenance (O&M) and Periodic Rehabilitation & Replacement (R&R) Costs

3.2.1 I-680 NB ELC Project – Phase 1 (Component Project 1)

Estimates for O&M and R&R costs were provided by the MTC's Bay Area Infrastructure Financing Authority (BAIFA). The I-680 NB ELC Project – Phase 1 is expected to result in R&R cost savings through removing the need for costly future R&R work, including civil assets, pavement resurfacing, luminaire replacement and electrical/ telecommunication utilities rehabilitation. However, compared to the No-Build Case, the Build Case would incur additional O&M and R&R related to the express lane toll operations, including the TDM Program, additional Roadside Toll Collection Systems (RTCS) equipment, additional electrical/ telecommunications infrastructure and allocated Regional Customer Service Center (RCSC) hard and soft costs. While O&M costs is incurred every year and R&R expenditures happen periodically, a summary of these costs at the interval of every five years is shown in Table 10.

Table 10. Component Project 1, Schedule of Operations and Maintenance and Repair/ Rehabilitation/ Replacement Costs (in Undiscounted 2022 Dollars)

Year	Build		No Build		Change Between Build and No Build	
	O&M	R&R	O&M	R&R	O&M	R&R

2025	-	-	-	-	-	-
2030	-	-	-	-	-	-
2035	$3,458,302	$941,162	-	-	$3,458,302	$941,162
2040	$3,773,482	$3,993	-	-	$3,773,482	$3,993
2045	$4,114,829	$3,320,242	-	-	$4,114,829	$3,320,242

3.2.2 AT-CARM Project – Segments 1 & 3A (Component Project 2)

Estimates for O&M and R&R costs were provided by CCTA. The AT-CARM Project – Segments 1 & 3A include implementation of ITS infrastructure and geometric changes to corridor ramps. Compared to the No-Build Case, the Build Case would incur additional operations costs comprising of agency staffing, utilities, training, data analysis, vendor fees and systems integrations costs. Similarly, R&R costs under the Build Case would include activities for electrical and ITS systems. While O&M costs is incurred every year and R&R expenditures happen periodically, a summary of these costs at the interval of every five years is shown in Table 11.

Table 11. Component Project 2, Schedule of Operations and Maintenance and Rehabilitation/ Replacement Costs (in Undiscounted 2022 Dollars)

Year	Build		No Build		Change Between Build and No Build	
	O&M	R&R	O&M	R&R	O&M	R&R
2025	-	-	-	-	-	-
2030	$5,634,436	-	-	-	$5,634,436	-
2035	$1,053,594	$2,794	-	-	$1,053,594	$2,794
2040	$1,053,594	-	-	-	$1,053,594	-
2045	$1,053,594	$825	-	-	$1,053,594	$825

3.2.3 Shared Mobility Hubs (Component Project 3)

Estimates for O&M and R&R costs were provided by CCTA. The three SMHs at Bollinger Canyon Road, Martinez and Walnut Creek include shelter, bike-sharing, electric vehicle (EV) charging, hydrogen fueling and real-time information infrastructure. Compared to the No-Build Case, the Build Case would incur additional operations costs comprising of O&M costs for these facilities. Similarly, R&R costs under the Build Case would include activities for physical and soft assets. While O&M costs is incurred every year and R&R expenditures happen periodically, a summary of these costs at the interval of every five years is shown in Table 12.

Table 12. Component Project 3, Schedule of Operations and Maintenance and Rehabilitation/ Replacement Costs (in Undiscounted 2022 Dollars)

Year	Build		No Build		Change Between Build and No Build	
	O&M	R&R	O&M	R&R	O&M	R&R
2025	-	-	-	-	-	-
2030	$566,879	-	-	-	$566,879	-
2035	$566,879	$28,401	-	-	$566,879	$28,401
2040	$566,879	-	-	-	$566,879	-
2045	$566,879	-	-	-	$566,879	-

3.2.4 Innovate 680 Program (Combined Project)

Estimates for O&M and R&R costs of the Combined Project were estimated by superimposing the anticipated O&M and R&R expenditures from the three component projects as these expenditures are largely independent with respect to their individual scope.

However, in the Combined Project scenario, there would be reduced TDM Program O&M expenditures because of incorporating the three Shared Mobility Hubs. As mentioned in Section 2.1.1, compliance with CEQA as stipulated by California SB 743 requires mitigation measures to reduce VMT. Per the I-680 Northbound Express Lane Completion: Analysis of VMT Mitigation Effectiveness study,[7] the inclusion of the three Shared Mobility Hubs would reduce VMT, therefore reducing CCTA's 20-year O&M cost commitment to the TDM program. While O&M costs is incurred every year and R&R expenditures happen periodically, a summary of these costs at the interval of every five years is shown in Table 13.

Table 13. Combined Project, Schedule of Operations and Maintenance and Rehabilitation/ Replacement Costs (in Undiscounted 2022 Dollars)

Year	Build		No Build		Change Between Build and No Build	
	O&M	R&R	O&M	R&R	O&M	R&R
2025	-	-	-	-	-	-
2030	$6,201,316	-	-	-	$6,201,316	-
2035	$4,734,463	$972,358	-	-	$4,734,463	$972,358
2040	$5,049,642	$3,993	-	-	$5,049,642	$3,993
2045	$5,390,989	$3,321,066	-	-	$5,390,989	$3,321,066

4. DEMAND PROJECTIONS

4.1.1 I-680 NB ELC Project – Phase 1 (Component Project 1)

The proposed improvements stemming from the I-680 NB ELC Project – Phase 1 can extend beyond the I-680 corridor limits and would likely have impact on region-wide mobility, particularly on the adjacent local streets and alternative routes. Thus, metrics concerning current conditions and anticipated future travel demand across Contra Costa County are extracted from the county-wide CCTA Travel Demand Model that incorporated design elements and related assumptions pertaining to both No-Build and Build conditions. The CCTA Travel Demand Model is a four-step trip-based model with ability to forecast trips by various modes. It was most recently updated in 2022 incorporating assumptions consistent with the current regional transportation plan (RTP) prepared by the Metropolitan Transportation Commission (MTC), Plan Bay Area 2050 (PBA 2050). It was validated against 2019 traffic counts conforming to pre-COVID conditions and best represents the emerging region-wide traffic patterns. The key metrics corresponding to No-Build and Build conditions extracted from the Travel Demand Model include Vehicle Miles Traveled (VMT) and Vehicle Hours of Travel (VHT) by mode (auto and trucks) and by peak period (AM Peak between 7 and 9 am; and PM Peak between 2 and 8 pm). The estimates are computed both for a model year (2027) and a design year (2047).

A detailed VISSIM Model was developed to capture the operational impacts across the corridor links more accurately including queuing delay in ramps and merging/weaving impacts for the broader Innovate 680 Program. This model was leveraged to produce similar metrics related to VHT and VMT corresponding to the No-Build and Build conditions for the I-680 NB ELC Project – Phase 1 (Component Project 1). The final estimates were computed by integrating corridor metrics from the VISSIM Model along with the region-wide metrics representing other Contra Costa County links from the Travel Demand Model. Table 14 and Table 15 present these projections extracted from the models for auto and trucks respectively.

Table 14. Component Project 1, Travel Performance Metrics - Auto

Metric/Year		AM Peak (7-9 am)		PM Peak (2-8pm)	
		No Build	Build	No Build	Build
VHT	2027	108,074	107,656	274,593	269,845
	2047	136,954	136,839	361,872	359,706
VMT	2027	3,403,307	3,403,307	8,872,041	8,872,041
	2047	3,809,535	3,809,535	10,094,751	10,094,751

Table 15. Component Project 1, Travel Performance Metrics - Trucks

Metric/Year		AM		PM	
		No Build	Build	No Build	Build
VHT	2027	1,750	1,748	5,244	5,137
	2047	2,220	2,213	6,747	6,670
VMT	2027	60,463	60,463	194,396	194,396
	2047	66,755	66,755	215,765	215,765

As shown from the VHT trends, the model estimates travel time savings for both modes, with significant savings during the PM Peak period resulting from reliable and faster travel for auto commuters. VMT is assumed to be similar between No-Build and Build conditions as CCTA is required to implement the TDM Program which is targeted to effectively mitigate any monetized impact resulting from the induced VMT due to the capacity increase from Component Project 1.

With the performance metrics established for the model year (2027) and design year (2047), VMT and VHT estimates for intermediate years were computed by interpolation based on the Compound Annual Growth Rates observed from the Travel Demand Model and VISSIM Model for respective mode, peak period, and No-Build/ Build conditions. An annualization factor of 260 is used to expand the weekday peak period changes to annual representations for both No-Build and Build conditions.

4.1.2 AT-CARM Project – Segments 1 & 3A (Component Project 2)

The AT-CARM Project – Segments 1 & 3A incorporates advancing sensing technologies that detects and controls the flow on mainlines by metering the ramps efficiently. It has the potential to maximize the corridor throughout (maximum sustainable flow rate), particularly during the identified peak periods, while optimizing the queuing on ramps by providing adequate storage and optimizing their discharge capacity. This results in reduction in travel time (VHT) across the corridor as vehicles tend to experience higher average speeds during peak periods while having no/minimal impact on VMT. Thus, the VISSIM Model representing No-Build conditions was utilized to extract key travel metrics

(VMT and VHT) corresponding to No-Build conditions. This model focuses exclusively on operational improvements at the corridor level and is considered closely aligned with the implementation objectives of the AT-CARM Project.

For Build conditions, travel times during peak periods were assumed to decrease by 2.0% and 10.0% in the opening year/model year (2027) and 1.0% and 5.0% in the design year (2047). The expected travel time reductions in the future are expected to be lower than existing conditions because of the growing corridor demand. These assumptions also represent conservative estimates based on comparable pilots, including the Colorado Department of Transportation (CDOT) SMART I-25 Performance Evaluation[8] which demonstrated a 2.0 and 14.3% reduction in average travel time during the AM and PM peak periods, respectively; and the VicDTP Monash M1 Freeway CARM Implementation Evaluation[9] which demonstrated a 27.6% reduction in average travel time during the PM peak period. Table 16 and Table 17 present these VHT and VMT projections extracted from the models for auto and trucks, respectively.

Table 16. Component Project 2, Travel Performance Metrics - Auto

Metric/Year		AM Peak (7-9 am)		PM Peak (2-8pm)	
		No Build	Build	No Build	Build
VHT	2027	5,561	5,450	19,823	17,841
	2047	7,222	7,150	30,643	29,111
VMT	2027	267,142	267,142	691,599	691,599
	2047	282,678	282,678	720,186	720,186

Table 17. Component Project 2, Travel Performance Metrics - Trucks

Metric/Year		AM Peak (7-9 am)		PM Peak (2-8pm)	
		No Build	Build	No Build	Build
VHT	2027	91	89	309	278
	2047	125	123	509	458
VMT	2027	3,827	3,827	8,887	8,887
	2047	3,960	3,960	9,296	9,296

With the performance metrics established for the model year (2027) and design year (2047), VHT and VMT estimates for intermediate years were computed by interpolation based on the growth rates observed from the VISSIM model for respective mode, peak period, and No-Build/ Build conditions. An annualization factor of 260 is used to expand the weekday peak period changes to annual representations for both No-Build and Build conditions.

4.1.3 Shared Mobility Hubs (Component Project 3)

The three Shared Mobility Hubs being implemented as part of Component Project 3 in the Innovate 680 Program offers improved facility amenities, bicycling lanes, and supporting amenities for promoting active transportation in the region and seamless integration with the I-680 Express Bus, local bus operators, Amtrak, and BART stations for multimodal connectivity. During the implementation phase, the SMHs are expected to induce modal shift, particularly from auto trips emanating from the region using the corridor to active transportation and transit resulting in net reduction of auto VMT from the No-Build conditions. The I-680 Northbound Express Lane

Completion: Analysis of VMT Mitigation Effectiveness study[7] conducted by CCTA to estimate the impact of the SMHs concluded that, on an average, the SMH Project would result in 0.1% reduction of daily VMT in comparison to the No-Build. The VMT for trucks is assumed not to be significantly impacted by the deployment of SMHs given these trips reflect freight transportation needs and would largely continue to use the same mode regardless of the status of the SMH Project. Table 18 presents the VMT projections for auto and trucks for No-Build and Build conditions.

Table 18. Component Project 3, VMT Projections for Auto and Trucks

Mode/Year		AM Peak (7-9 am)		PM Peak (2-8pm)	
		No Build	Build	No Build	Build
Auto	2027	3,403,307	3,399,052	8,872,041	8,860,950
	2047	3,809,535	3,804,773	10,094,751	10,082,133
Trucks	2027	60,463	60,463	194,396	194,396
	2047	66,755	66,755	215,765	215,765

In addition to reduced VMT, the induced modal shift is also expected to produce improved travel times for auto-commuters and new transit riders during the operations analysis period. However, given that VHT metrics for Component Project 3 are not available for travel time savings computation, congestion benefits were estimated via the VMT reduction. With the performance metrics established for the model year (2027) and design year (2047), VMT estimates for intermediate years were computed by interpolation based on the growth rates observed from the travel demand model for respective mode, peak period, and Build/No-Build conditions. An annualization factor of 260 is used to expand the weekday peak period changes to annual representations for both No-Build and Build conditions.

4.1.4 Innovate 680 Program (Combined Project)

The Combined Project entails the three component projects presented in this application that would offer synergistic impact on the I-680 NB corridor through improved mobility, enhanced safety, and increased multimodal connectivity, both at corridor level and county level. The anticipated increase in VMT from the I-680 NB ELC Project – Phase 1 would be effectively mitigated through the targeted TDM Program and reduction in auto trips from SMHs. Both the I-680 NB ELC Project and AT-CARM Project are expected to significantly improve ride quality of users by providing reliable, safe and fast travel, particularly for auto trips during peak periods, thereby improving mobility across the corridor and Contra Costa County. The corresponding travel performance metrics of the Combined Project were extracted from both the VISSIM Model and the Travel Demand Model. Table 19 and Table 20 present these projections extracted from the models for auto and trucks respectively.

Table 19. Combined Project, Travel Performance Metrics - Auto

Metric/Year		AM Peak (7-9 am)		PM Peak (2-8pm)	
		No Build	Build	No Build	Build
VHT	2027	113,635	113,106	294,416	287,686
	2047	144,176	143,988	392,515	388,817
VMT	2027	3,403,307	3,403,307	8,872,041	8,872,041
	2047	3,809,535	3,809,535	10,094,751	10,094,751

Table 20. Combined Project, Travel Performance Metrics - Trucks

Metric/Year		AM Peak (7-9 am)		PM Peak (2-8pm)	
		No Build	Build	No Build	Build
VHT	2027	1,841	1,837	5,553	5,415
	2047	2,345	2,336	7,256	7,128
VMT	2027	60,463	60,463	194,396	194,396
	2047	66,755	66,755	215,765	215,765

With the performance metrics established for the model year (2027) and design year (2047), VMT and VHT estimates for intermediate years were computed by interpolation based on the growth rates observed from the VISSIM Model and Travel Demand Model for respective mode, peak period, and No-Build/ Build conditions. An annualization factor of 260 is used to expand the weekday peak period changes to annual representations for both No-Build and Build conditions.

5. PROJECT BENEFITS

The overall project benefits for Component Project 1, Component Project 2, Component Project 3 and the Combined Project are summarized in the matrices shown in Table 21, Table 22, Table 23 and Table 24, respectively.

Table 21. Component Project 1, Project Impacts and Benefits Summary, Millions of 2022 Dollars

Benefit	Description	Monetized (Discounted 2022 $M)
Criterion #1: **Safety**	Conversion of an HOV lane to an Express Lane would result in a 20% reduction in collisions based on FHWA's Crash Modification Factor applicable to urban site conditions and collision of all types	$109.5 M
Criterion #2: **State of Good Repair**	The service of life for most scoped project improvements is 20 years aligning with the analysis period is 20 years. Thus, there would be no residual value	$0.0 M
Criterion #3: **Economic Impacts**	Travel time savings are quantified both at corridor and county-level from the enhanced throughput and improved speeds offered by conversion of HOV to express lane (1.8 million person-hours reduced in opening year and 26.2 million hours across 20 years of operation)	$314.9 M
Criterion #4: **Climate Change/ Environment**	Incentive-based mode shift from SOV to HOV, increasing utilization of the transportation network, thereby increase person-throughput and reducing congestion and its associated GHG (~98,000 tons of CO_2), SOx (0.6 tons) and NOx (70.1 tons) emissions. Vehicle speeds along the corridor are expected to improve while any induced VMT is mitigated through TDM Program and as a result, emissions level is estimated to decrease over the project's duration	$26.6 M

Table 22. Component Project 2, Project Impacts and Benefits Summary, Millions of 2022 Dollars

Benefit	Description	Monetized (Discounted 2022 $M)
Criterion #1: **Safety**	Application of adaptive ramp metering is expected to reduce collisions of all types by at least 8% based on FHWA's CMF for the proposed countermeasure for both Segments 1 and 3A	$69.6 M
Criterion #2: **State of Good Repair**	Recapitalization of coordinated adaptive ramp metering software and detection infrastructure occurs in 10-year cycles while the analysis period is extended to account for 20 full years of operations	-$30.8 M
Criterion #3: **Economic Impacts**	Reduced congestion through a 2% and 10% reduction in AM and PM peak period travel time, respectively, as a result of real-time and predictive traffic management, producing smoother traffic flow and higher average speeds; Benefits adjusted for the future year to account for growing corridor demand (1.2 million person-hours reduced in opening year and 15.4 million hours across 20 years of operation)	$183.0 M
Criterion #4: **Climate Change/ Environment**	GHG (around 29,600 tons CO2 reduction), NOX (17.7 tons), and SOx (0.2 tons) Emission reductions due to an increase in freeway speeds with the reduction of weaving movements across the corridor segments where CARM is implemented	$8.7 M

Table 23. Component Project 3, Project Impacts and Benefits Summary, Millions of 2022 Dollars

Benefit	Description	Monetized (Discounted 2022 $M)
Criterion #1: **Safety**	Application of enhanced access facilities including installation and extension of dedicated bicycle lanes lead to 27% reduction in collisions based on FHWA CMF database	$15.7 M
	Reduction of daily auto VMT also leads to additional reduction of crashes across the region due to fewer miles driven (external highway use)	$0.9 M
Criterion #2: **State of Good Repair**	Multimodal facilities resulting in reduction of daily auto VMT due to modal shift to transit and other active modes of transportation results in reduction of pavement damage	$0.1 M
	Estimated reduction in daily VMT leads to reduction in overall vehicle operations and maintenance costs across 20 full years of operations	$27.6 M
Criterion #3: **Economic Impacts**	Reduction of Daily auto VMT leads to congestion reduction benefiting the commuters in the corridor and the overall county	$7.3 M
Criterion #4: **Climate**	Reduced auto daily VMT together with increased speeds lead to corresponding reduction in GHG (23,700 tons of CO2), NOX (2.8 tons), and SOX (0.2 tons) emissions benefiting communities across the corridor	$5.5 M

Benefit	Description	Monetized (Discounted 2022 $M)
Change/ Environment	Reduced daily VMT also leads to regional-level emission reduction (external highway use)	$7.3 M
Criterion #5: **Equity/ Multimodal/ Quality of Life**	Enhanced facility amenities offer improved ride quality, comfort, and rea-time information for various riders	$14.0 M
	Active transportation benefits for all bicyclists due to dedicate bicycle lanes (installation/extension)	$1.1 M
	Mortality reduction/health benefits for induced bicyclists from non-active transportation modes and within eligible age range	$0.1 M
	Improvements in noise levels for the communities adjacent to the corridor due to reduction in daily auto VMT	$0.1 M

Table 24. Combined Project, Project Impacts and Benefits Summary, Millions of 2022 Dollars

Benefit	Description	Monetized (Discounted 2022 $M)
Criterion #1: **Safety**	Combined project would integrate safety benefits from all component projects given express lane conversion, adaptive ramp metering, and improved smart mobility hubs are expected to act synergistically to reduce collisions (adjusting for overlapping countermeasures on any segments)	$179.8 M
Criterion #2: **State of Good Repair**	The service of life of the most of the scoped project improvements, except for AT-CARM project, is 20 years aligning with the analysis period is 20 years. Thus, the overall project would have recapitalization investment based on Component Project -2	-$30.8 M
Criterion #3: **Economic Impacts**	Travel time savings are quantified both at corridor and county-level from the enhanced throughput and improved speeds offered by all the component projects, particularly the ELC and AT-CARM, and adjusted for 20 full years of operations (1.6 million person-hours reduced in opening year and 42.6 million hours across 20 years of operation)	$530.4 M
Criterion #4: **Climate Change/ Environment**	Incentive-based mode shift from SOV to HOV, increasing utilization of the transportation network, thereby increase person-throughput and reducing congestion and its associated GHG (~97,000 tons of CO2), SOx and NOx emissions. Vehicle speeds along the corridor are expected to improve while any induced VMT is mitigated through TDM Program, and Shared Mobility Hubs and as a result, emissions level is estimated to decrease over the project's duration.	$38.5 M
Criterion #5: **Equity/**	Enhanced facility amenities offer improved ride quality, comfort, and real-time information for various riders	$14.0 M

Benefit	Description	Monetized (Discounted 2022 $M)
Multimodal/ Quality of Life	Active transportation benefits for all bicyclists due to dedicate bicycle lanes (installation/extension)	$1.1 M
	Mortality reduction/health benefits for induced bicyclists from non-active transportation modes and within eligible age range	$0.1 M
	Improvements in noise levels for the communities adjacent to the corridor due to reduction in daily auto VMT	$0.1 M

5.1 Safety (Criterion #1)

Historical collision data from Caltrans' Traffic Accident Surveillance and Analysis System (TASAS) were used to obtain incident trends by severity along the I-680 NB corridor between Alcosta Boulevard and Waterfront Road for a five-year period, between January 1, 2017, and December 31, 2022, excluding the period between January 1, 2020, and December 31, 2020 due to atypical traffic patterns from the pandemic. The safety data along I-680 NB corridor is segmented as follows:

- Segment 1: Alcosta Boulevard to Crow Canyon Road; 3.99 miles
- Segment 2: Crow Canyon Road to Stone Valley Road; 6.22 miles
- Segment 3: Stone Valley Road to Ygnacio Valley Road; 4.23 miles
- Segment 4: Ygnacio Valley Road to SR-242; 4.22 miles
- Segment 5: SR-242 to SR-4; 2.48 miles
- Segment 6: SR-4 to Waterfront Road; 3.18 miles

During the five-year evaluation period, 3,395 collisions occurred across all highway segments. Of these collisions, there were 7 fatal (0.2%), 63 serious injury (1.9%), 1,033 minor injury (30.4%), and 2,292 Property Damage Only (67.5%). In addition, 93.8% of total collisions occurred on the mainline while the remaining 6.2% occurred on the ramps. The average collision frequency was 0.88 collisions per million VMT (MVMT).

In addition, data from Caltrans' TASAS at local intersections in the vicinity of the Shared Mobility Hubs were also included for the same time range. These intersections include on-ramps with I-680 located at Bollinger Canyon Road, Ygnacio Valley Road, and Martinez Avenue. During the five-year evaluation period, there were 256 collisions at these three intersections, of which there were 1 fatality (0.4%), 4 serious injury (1.5%), 68 minor injury (26.6%), and 183 Property Damage Only (71.5%) collisions.

In terms of monetization, the assumptions used in the estimation of safety benefits based on CMF and VMT reductions are summarized in Table 25 and Table 26,respectively.

Table 25. Safety Benefits Assumptions and Sources

Variable	Unit	Value	Source
Fatal Crash	2022$	$14,022,900	USDOT BCA Guidance December 2023 Table A-1
Injury Crash	2022$	$313,000	USDOT BCA Guidance December 2023 Table A-1
Property Damage Only Crash	2022$	$9,100	USDOT BCA Guidance December 2023 Table A-1

Table 26. Safety (External Highway Use) Benefits Assumptions and Sources

Variable	Unit	Value	Source
Auto Average Safety Cost	2022$ / VMT	$0.0170	derived from USDOT BCA Guidance December 2023 Table A-14
Truck Average Safety Cost	2022$ / VMT	$0.0160	derived from USDOT BCA Guidance December 2023 Table A-14

5.1.1 I-680 NB ELC Project – Phase 1 (Component Project 1)

For the analysis of Component Project 1, it was assumed that safety benefits would be captured along Segments 4, 5 and 6 which include the project limits of the I-680 NB ELC Project – Phase 1. By converting the existing HOV lane to a HOT lane, speed differentials between lanes would result in smoother traffic flow. Managing congestion and sustaining comparable speeds would reduce the likelihood of collisions caused by stop-and-go traffic. In addition, the reduction of weaving behavior because of physical changes and increased enforcement would further decrease the likelihood of collisions. A Crash Modification Factor (CMF) of 0.80 was used from FHWA's CMF Clearinghouse (CMF ID: 8805)[10] to estimate collisions in the Build Case because of Component Project 1.

At a 3.1% discount rate, the total safety benefit arising from collisions avoided of all severities is estimated to be $109.5 million. Table 27 presents the monetized benefit by severity for the project opening year and operating analysis period.

Table 27. Component Project 1, Safety Benefits, Millions of 2022 Dollars

Benefit	Project Opening Year			Project Lifecycle		
	Casualties	Undiscounted	Discounted (3.1%)	Casualties	Undiscounted	Discounted (3.1%)
Fatal Crashes Reduction	0	$2.5	$1.9	4	$52.4	$30.1
Injury Crashes	20	$6.2	$4.7	416	$130.1	$74.7
Property Damage Only (PDO) Crashes	42	$0.4	$0.3	881	$8.0	$4.6
Total	62	$9.1	$6.9	1,300	$190.6	$109.5

5.1.2 AT-CARM Project – Segments 1 & 3A (Component Project 2)

For the analysis of Component Project 2, it was assumed that safety benefits would be captured along Segments 1, 2, 3 and 4 which include the project limits of the AT-CARM Project – Segments 1 & 3A. By controlling access to the freeway, CARM can reduce the frequency and severity of accidents. It decreases incidents of abrupt braking and collisions related to merging, as vehicles enter the freeway at intervals that are optimized for traffic speeds in real time. The safety benefits assessed in this analysis include a reduction in fatalities and injuries, as well as a reduction in other property damage crash costs resulting directly from Component Project 2. A CMF of 0.92 was used from FHWA's CMF Clearinghouse (CMF ID: 11142)[11] to estimate collisions in the Build Case because of Component Project 2.

At a 3.1% discount rate, the total safety benefit arising from collisions avoided of all severities is estimated to be $69.6 million. Table 28 presents the monetized benefit by severity for the project opening year and analysis period.

Table 28. Component Project 2, Safety Benefits, Millions of 2022 Dollars

Benefit	Project Opening Year			Project Lifecycle		
	Casualties	Undiscounted	Discounted (3.1%)	Casualties	Undiscounted	Discounted (3.1%)
Fatal Crashes Reduction	0	$0.6	$0.5	2	$21.8	$13.4
Injury Crashes	8	$2.4	$2.0	275	$86.0	$52.9
Property Damage Only (PDO) Crashes	16	$0.1	$0.1	578	$5.3	$3.2
Total	24	$3.2	$2.7	854	$113.0	$69.6

5.1.3 Shared Mobility Hubs (Component Project 3)

For the analysis of Component Project 3, it was assumed that safety benefits would be captured at the three local intersections in the adjacent vicinity of the three Shared Mobility Hubs. By constructing protected bicycle lanes access at the local arterials, the severity and frequency of accidents would be reduced as conflicts with vehicular traffic become more restricted. The safety benefits assessed in this analysis include a reduction in fatalities and injuries, as well as a reduction in other property damage crash costs resulting directly from Component Project 3. A CMF of 0.735 was used from FHWA's CMF Clearinghouse (CMF ID: 10741)[12] to estimate collisions in the Build Case as a result of Component Project 3.

At a 3.1% discount rate, the total safety benefit arising from collisions avoided of all severities at local intersections is estimated to be $15.7 million. Table 29 presents the monetized benefit by severity for the project opening year and analysis period.

Table 29. Component Project 3, Safety Benefits, Millions of 2022 Dollars

Benefit	Project Opening Year			Project Lifecycle		
	Casualties	Undiscounted	Discounted (3.1%)	Casualties	Undiscounted	Discounted (3.1%)
Fatal Crashes Reduction	-	-	-	-	-	-
Injury Crashes	1	$0.4	$0.3	76	$23.9	$14.9
Property Damage Only (PDO) Crashes	3	$0.0	$0.0	149	$1.4	$0.8
Total	4	$0.4	$0.4	225	$25.3	$15.7

In addition, Component Project 3 would result in a reduction of VMT on the I-680 NB corridor across Segments 1 through 6 by reducing the modal share of autos. As discussed in Section 4.1.3, VMT on the I-680 corridor would decrease by 0.1%. At a 3.1 % discount rate, the total safety benefit arising from collisions avoided of all severities on the highway is estimated to be $0.90 million. Table 30 presents the monetized benefit by severity for the project opening year and analysis period.

Table 30. Component Project 3, Safety (External Highway Use) Benefits, Millions of 2022 Dollars

Benefit	Project Opening Year		Project Lifecycle	
	Undiscounted	Discounted (3.1%)	Undiscounted	Discounted (3.1%)
Safety - Auto	$0.0	$0.0	$1.5	$0.9

Safety - Truck	-	-	-	-
Total Safety (External Highway Use) Benefit	$0.0	$0.0	$1.5	$0.9

5.1.4 Innovate 680 Program (Combined Project)

For the analysis of Combined Project, it was assumed that safety benefits would be captured across all highway segments, as well as the local intersections near the Shared Mobility Hubs. For highway Segments 1, 2 and 3, a CMF of 0.92 was used because of Component Project 2. For highway Segments 5 and 6, a CMF of 0.80 was used because of Component Project 1. For highway Segment 4, a CMF of 0.741 was used which was calculated using the Dominant Common Residuals Method to estimate the combined effect of Component Projects 1 and 2, per FHWA's Highway Safety Benefit–Cost Analysis Guide.[13] For the local intersections near the Shared Mobility Hubs, a CMF of 0.735 was used as a result of Component Project 3. There would be no external highway use benefits due to VMT reduction, as the induced VMT from the I-680 NB ELC Project – Phase 1 is mitigated by the VMT reduction from the TDM Program and the SMHs, resulting in no change in VMT.

At a 3.1% discount rate, the total safety benefit arising from collisions avoided of all severities is estimated to be $179.8 million. Table 31 presents the monetized benefit by severity for the project opening year and analysis period.

Table 31. Combined Project, Safety Benefits, Millions of 2022 Dollars

Benefit	Project Opening Year			Project Lifecycle		
	Casualties	Undiscounted	Discounted (3.1%)	Casualties	Undiscounted	Discounted (3.1%)
Fatal Crashes Reduction	0	$0.7	$0.6	5	$65.8	$39.7
Injury Crashes	7	$2.3	$1.9	700	$219.1	$132.1
Property Damage Only (PDO) Crashes	15	$0.1	$0.1	1,464	$13.3	$8.0
Total	22	$3.1	$2.6	2,169	$298.2	$179.8

5.2 State of Good Repair (Criterion #2)

The construction and implementation of the proposed component projects and Combined Project would restore and replace existing core infrastructure components on the I-680 NB corridor mainline, ramps and local intersections. With the proposed improvements, anticipated R&R expenditures would be incurred further into the future as assets, such as civil, roadway surface and electrical/ telecommunications utilities, are either restored or replaced within the project limits. The lifecycle of these new assets may extend beyond the operational analysis period, resulting in a positive Residual Value. The Residual Value is calculated by assuming linear depreciation over its service life per USDOT guidance.[1]

In addition, projects that would exhibit operational efficiencies could also result in savings for O&M and R&R expenditures. For projects that would result in a VMT reductions, savings would be captured in the form of vehicle operating costs (including fuel) and pavement wear-and-tear. In terms of monetization, the assumptions used in the estimation of vehicle operating cost and pavement damage savings benefits are summarized in Table 32 and Table 33, respectively.

Table 32. Vehicle Operating Cost Savings Assumptions and Sources

Variable	Unit	Value	Source
Vehicle Operating Costs - Light Duty Vehicles	2022$ / VMT	$0.52	USDOT BCA Guidance December 2023 Table A-4
Vehicle Operating Costs - Commercial Trucks	2022$ / VMT	$1.32	USDOT BCA Guidance December 2023 Table A-4

Table 33. Pavement Damage Savings Assumptions and Sources

Variable	Unit	Value	Source
Auto Average Pavement Cost	2022$ / VMT	$0.0015	derived from FHWA, Cost Allocation Study, 2000
Truck Average Pavement Cost	2022$ / VMT	$0.1610	derived from FHWA, Cost Allocation Study, 2001

5.2.1 I-680 NB ELC Project – Phase 1 (Component Project 1)

The I-680 NB ELC Project – Phase 1 includes several components with varying lifecycles, ranging between 6 and 50 years. The BCA analysis period considers 20 years of operations, ending in 2050, in line with USDOT BCA guidance.[1] For conservative analysis purposes, it was assumed that the entire value of the asset would reach the end of its lifecycle in year 2050. As shown in Table 34, the residual value at the end of the analysis period would be zero. In addition, Component Project 1 would be VMT neutral, therefore there would be no further benefits/ disbenefits associated with vehicle operating costs and pavement damage.

Table 34. Component Project 1, Residual Value Benefits, Millions of 2022 Dollars

Benefit	Final Analysis Year	
	Undiscounted	Discounted (3.1%)
I-680 Express Lanes Phase 1 Remaining Capital Value In Final Year	-	-

5.2.2 AT-CARM Project – Segments 1 & 3A (Component Project 2)

The AT-CARM Project – Segments 1 & 3A includes several components with varying lifecycles, ranging between 4 and 20 years. The BCA analysis period considers 20 years of operations, ending in 2050. The lifecycle of ITS projects is 10 years per USDOT BCA guidance,[1] therefore it was conservatively assumed that the entire original capital cost would be recapitalized in year 2040. In final year 2050, it was assumed that the entire value of the asset would reach the end of its lifecycle in year 2050. At a 3.1% discount rate, the net residual value at the end of the analysis period is estimated to be -$30.8 million in discounted 2022 dollars, as shown in Table 35, which includes the recapitalization cost in year 2040. In addition, Component Project 2 would be VMT neutral, therefore there would be no further benefits/ disbenefits associated with vehicle operating costs and pavement damage.

Table 35. Component Project 2, Residual Value Benefits, Millions of 2022 Dollars

Benefit	Final Analysis Year	
	Undiscounted	Discounted (3.1%)
Coordinated Adaptive Ramp Metering Remaining Capital Value In Final Year	($53.3)	($30.8)

5.2.3 Shared Mobility Hubs (Component Project 3)

The Shared Mobility Hubs include several components with varying lifecycles, ranging between 8 and 50 years. The BCA analysis period considers 20 years of operations, ending in 2047, in line with USDOT BCA guidance.[1] For conservative analysis purposes, it was assumed that the entire value of the asset would reach the end of its lifecycle in year 2050. As shown in Table 36, the residual value at the end of the analysis period would be zero.

Table 36. Component Project 3, Residual Value Benefits, Millions of 2022 Dollars

Benefit	Final Analysis Year	
	Undiscounted	Discounted (3.1%)
Shared Mobility Hubs Remaining Capital Value In Final Year	$0.00	$0.0

As discussed in Section 4.1.3, VMT on the I-680 corridor would decrease by 0.1%. This effect would produce vehicle operating cost and pavement damage savings. At a 3.1% discount rate, the total vehicle operating cost and pavement damage savings is estimated to be $27.6 million and $0.1 million, respectively. Table 37 and Table 38 present these monetized benefits for the project opening year and analysis period.

Table 37. Component Project 3, Vehicle Operating Cost Savings Benefits, Millions of 2022 Dollars

Benefit	Project Opening Year		Project Lifecycle	
	Undiscounted	Discounted (3.1%)	Undiscounted	Discounted (3.1%)
Vehicle O&M Costs - Auto	$1.3	$1.0	$44.4	$27.6
Vehicle O&M Costs - Truck	-	-	-	-
Total	$1.3	$1.0	$44.4	$27.6

Table 38. Component Project 3, Pavement Damage Savings Benefits, Millions of 2022 Dollars

Benefit	Project Opening Year		Project Lifecycle	
	Undiscounted	Discounted (3.1%)	Undiscounted	Discounted (3.1%)
Pavement Damage - Auto	$0.0	$0.0	$0.13	$0.08
Pavement Damage- Truck	-	-	-	-
Total Reduced Pavement Damage	$0.0	$0.0	$0.13	$0.08

5.2.4 Innovate 680 Program (Combined Project)

The Net Residual Value of the Combined Project was estimated by superimposing the Net Residual Values from the three component projects given that these elements are largely independent by component project with respect to their individual scope. Given that the Net Residual Value of Component Projects 1 and 3 are zero, the Net Residual Value would be equal to that of Component

Project 2. At a 3.1% discount rate, the net residual value at the end of the analysis period is estimated to be -$30.8 million in discounted 2022 dollars, as shown in Table 39, which includes the recapitalization cost of Component Project 2 in year 2040. There would be no additional benefits due to VMT reduction, as the induced VMT from the I-680 NB ELC Project – Phase 1 is mitigated by the VMT reduction from the TDM Program and the SMHs, resulting in no change in VMT.

Table 39. Combined Project, Residual Value Benefits, Millions of 2022 Dollars

Benefit	Final Analysis Year	
	Undiscounted	Discounted (3.1%)
Combined Project Remaining Capital Value In Final Year	($53.3)	($30.8)

5.3 Economic Impacts, Freight Movement, and Job Creation (Criterion #3)

The implementation and operation of the proposed component projects and Combined Project would result in economic benefits to the corridor and the county. Economic benefits would be captured in the form of travel time savings and congestion reduction for both autos and trucks. These benefits are monetized through estimates of the value of time of commuters/ travelers and freight. Table 40 and Table 41 present the unit values used in the computation and monetization of travel time benefits and congestion benefits, respectively, per USDOT guidance.[1]

Table 40. Travel Time Savings Assumptions and Sources

Variable	Unit	Value	Source
Value of Travel Time Savings - All Purposes, Local	2022$ per person-hour	$19.60	USDOT BCA Guidance December 2023 Table A-2
Value of Travel Time Savings - All Purposes, Intercity	2022$ per person-hour	$27.39	Estimated
Value of Travel Time Savings - Trucks	2022$ per person-hour	$33.50	USDOT BCA Guidance December 2023 Table A-3
Value of Travel Time Savings - Bicyclists/ Pedestrians/ Waiting/ Standing/ Transfer Time	2022$ per person-hour	$35.80	USDOT BCA Guidance December 2023 Table A-2

Table 41. Congestion Reduction Benefits Assumptions and Sources

Variable	Unit	Value	Source
Auto Average Congestion Cost	2022$ / VMT	0.1380	Derived from USDOT BCA Guidance December 2023 Table A-14
Truck Average Congestion Cost	2022$ / VMT	0.3450	Derived from USDOT BCA Guidance December 2023 Table A-14

For BCA analysis purposes, economic impacts associated with real estate development, enhancement of recreational and tourism opportunities, freight and supply-chain growth at the nearby Oakland Airport and Port of Oakland and job creation were not quantitatively evaluated.

5.3.1 I-680 NB ELC Project – Phase 1 (Component Project 1)

Converting an HOV lane to a HOT lane increases capacity of the lane as single-occupancy vehicles (SOVs) are permitted to access the facility. As SOVs shift from the general purpose (GP) lane to the HOT lane, it decreases the volume-capacity (v/c) ratio of the GP lanes, resulting in an increase in

travel speeds and decrease in travel times. In addition, it creates an incentive for carpooling and decrease the number of vehicles on the road. Finally, the Dynamic Pricing Algorithm (DPA) allows to adjust toll rates in real-time to maintain a steady flow of traffic in the HOT lanes, especially during peak hours, ensuring that travel times remain relatively constant and predictable. There would be no induced VMT because of the capacity increase since the TDM Program would be implemented per California SB 743 CEQA Amendment.

Component Project 1 would offer travel time savings benefits, particularly during peak hours. VHT results for both the No-Build Case and Build Case were extracted from the VISSIM and Travel Demand models, as shown in Table 14 and Table 15. Travel time savings benefits are expected to be higher given the focus of the analysis is limited to AM and PM peak period for quantification of benefits.

Given these assumptions, at a 3.1% discount rate, the travel time savings benefits quantified for Component Project 1 amount to $314.9 Million in discounted 2022 dollars for the project analysis period. Table 42 shows the disaggregation of travel time savings between autos and trucks.

Table 42. Component Project 1, Travel Time Savings Benefits, Millions of 2022 Dollars

Benefit	Project Opening Year			Project Lifecycle		
	Hours (Millions)	Undiscounted	Discounted (3.1%)	Hours (Millions)	Undiscounted	Discounted (3.1%)
Travel Time Savings - Auto	1.82	$35.7	$27.1	25.75	$504.8	$305.4
Travel Time Savings - Truck	0.03	$0.9	$0.7	0.48	$16.2	$9.5
Total	1.85	$36.6	$27.8	26.24	$521.0	$314.9

5.3.2 AT-CARM Project – Segments 1 & 3A (Component Project 2)

CARM systems adjust the rate at which vehicles enter the freeway based on current traffic conditions, helping smooth the flow of traffic on the mainline. CARM systems can adapt in real-time to changing traffic conditions, making them more effective than static ramp metering systems. This flexibility allows for the efficient use of available roadway capacity, adjusting as needed without the need for manual intervention.

Component Project 2 would offer travel time savings benefits, particularly during peak hours, by preventing the freeway from becoming overloaded. Smoother traffic flow and reduced congestion lead to more reliable and predictable travel times, resulting in an increase in average speeds. This is beneficial for commuters and commercial transportation alike, contributing to overall economic efficiency. The estimated VHT for Component Project 2 are shown in Table 16 and Table 17. Travel time savings benefits are expected to be higher given the focus of the analysis is limited to AM and PM peak period for quantification of benefits. The project would also lead to improved reliability and provide smoother travel conditions throughout the day, which are not quantified. Compared to the No-Build Case, Component Project 2 would be net VMT neutral, therefore it would not generate any additional congestion reduction benefits.

Given these assumptions, at a 3.1% discount rate, the travel time savings benefits quantified for Component Project 2 amount to $183.0 Million in discounted 2022 dollars for the project analysis period. Table 43 shows the disaggregation of travel time savings between autos and trucks.

Table 43. Component Project 2, Travel Time Savings Benefits, Millions of 2022 Dollars

Benefit	Project Opening Year			Project Lifecycle		
	Hours (Millions)	Undiscounted	Discounted (3.1%)	Hours (Millions)	Undiscounted	Discounted (3.1%)
Travel Time Savings - Auto	0.60	$11.8	$9.8	14.50	$284.1	$178.4
Travel Time Savings - Truck	0.01	$0.2	$0.2	0.23	$7.6	$4.6
Total	0.61	$12.0	$10.0	14.72	$291.7	$183.0

5.3.3 Shared Mobility Hubs (Component Project 3)

Introducing the Shared Mobility Hubs would induce mode shift from SOVs to transit and other non-motorized modes, such as walking and biking. This mode shift would result in a decrease in VMT on the I-680 corridor and therefore a reduction in congestion. The Shared Mobility Hubs are included in the I-680 NB ELC Project – Phase 1 VMT mitigation strategy to reach acceptable VMT levels, per California SB 743 CEQA Amendment. As discussed in Section 4.1.3, Component Project 3 would result in a VMT reduction of 0.1% on the I-680 NB corridor. The estimated VMT for Component Project 3 are shown in Table 18. Congestion reduction benefits are expected to be higher given the focus of the analysis is limited to AM and PM peak period for quantification of benefits.

Given these assumptions, at a 3.1% discount rate, the congestion reduction benefits quantified for Component Project 3 amount to $7.3 Million in discounted 2022 dollars for the project analysis period. Table 44 shows the disaggregation of travel time savings between autos and trucks.

Table 44. Component Project 3, Congestion Reduction Benefits, Millions of 2022 Dollars

Benefit	Project Opening Year		Project Lifecycle	
	Undiscounted	Discounted (3.1%)	Undiscounted	Discounted (3.1%)
Congestion - Auto	$0.3	$0.3	$11.8	$7.3
Congestion - Truck	-	-	-	-
Total Congestion Reduction	$0.3	$0.3	$11.8	$7.3

5.3.4 Innovate 680 Program (Combined Project)

Estimates for travel time benefits of the Combined Project were estimated by superimposing Component Project 1 and 2. The estimated VHT for the Combined Project were derived from the VISSIM and Travel Demand Models, and are shown in Table 19 and Table 20. There would be no congestion reduction benefits from the Component Project 3 VMT reduction, as the induced VMT from the I-680 NB ELC Project – Phase 1 is mitigated by the VMT reduction from the TDM Program and the SMHs, resulting in no change in VMT.

Given these assumptions, at a 3.1% discount rate, the travel time savings benefits quantified for the Combined Project amount to $530.4 Million in discounted 2022 dollars for the project analysis period. Table 45 shows the disaggregation of travel time savings between autos and trucks.

Table 45. Combined Project, Travel Time Savings Benefits, Millions of 2022 Dollars

Benefit	Project Opening Year			Project Lifecycle		
	Hours (Millions)	Undiscounted	Discounted (3.1%)	Hours	Undiscounted	Discounted (3.1%)
Travel Time Savings - Auto	1.24	$24.2	$20.2	41.86	$820.5	$515.6
Travel Time Savings - Truck	0.02	$0.6	$0.5	0.73	$24.3	$14.8
Total	1.25	$24.8	$20.6	42.59	$844.8	$530.4

5.4 Climate Change, Resilience, and the Environment (Criterion #4)

As demonstrated in Section 5.3, the implementation of each component project and Combined Project would generate environmental and sustainability benefits relating to the overall speed increases and congestion reduction. VMT and VHT metrics for autos and trucks shown in Section 4, Tables 11 through 17 were used to estimate I-680 NB corridor speeds and VMT. Auto and truck emission rates are based on U.S. Environmental Protection Agency MOVES data from the FHWA Bridge Investment Program (BIP) Benefit-Cost Analysis Tool.[14]

Four forms of emissions were identified, measured, and monetized, including: nitrous oxides (NO_x), 2.5-micron or less particulate matter ($PM_{2.5}$), sulfur oxides (SO_x), and carbon dioxide (CO_2). The assumptions used in the estimation of emissions and monetization of emissions reduction benefits (based on unit values $ per metric ton) are summarized in Table 46, per USDOT BCA guidance[1].

Table 46. Emissions Reduction Benefits Assumptions and Sources

Variable	Unit	Value	Source
Cost of CO2 emissions	2022$ per metric ton	$228 (in 2023) - $233 (in 2053)	US DOT BCA Guidance, December 2023
Cost of NOx emissions	2022$ per metric ton	$19,800 (in 2023) - $22,000 (in 2053)	US DOT BCA Guidance, December 2023
Cost of PM2.5 emissions	2022$ per metric ton	$951,000 (in 2023) - $1,069,000 (in 2053)	US DOT BCA Guidance, December 2023
Cost of SOx emissions	2022$ per metric ton	$52,900 (in 2023) - $61,500 (in 2053)	US DOT BCA Guidance, December 2023
Emissions per VMT	Grams per VMT	Varies by year, vehicle type, speed, and emission type	California Air Resources Board EMFAC Database, 2021

As a result of congestion reduction (i.e. VMT reduction), external highway use CO_2 and non-CO_2 emissions are quantified and monetized. Table 47 presents the unit values used in the computation and monetization of emission reduction (external highway use) benefits per USDOT BCA guidance[1].

Table 47. Emissions Reduction Benefits Assumptions and Sources

Variable	Unit	Value	Source
Cost of CO2 emissions - Auto	2022$ per VMT	0.107	USDOT BCA Guidance December 2023 Table A-14 (WSP calc)
Cost of CO2 emissions - Truck	2022$ per VMT	0.303	USDOT BCA Guidance December 2023 Table A-14 (WSP calc)
Cost of Non-CO2 emissions - Auto	2022$ per VMT	0.012	USDOT BCA Guidance December 2023 Table A-14
Cost of Non-CO2 emissions - Truck	2022$ per VMT	0.035	USDOT BCA Guidance December 2023 Table A-14

For BCA analysis purposes, environmental impacts associated with EV charger construction, retrofit and replacement of diesel buses with zero-emission Hydrogen Fuel Cell Electric Buses (FCEB), transit-oriented development and climate change resiliency were not quantitatively evaluated.

5.4.1 I-680 NB ELC Project – Phase 1 (Component Project 1)

At 3.1% discount rate, the quantifiable portion of the total emission benefits resulting from Component Project 1 is estimated to be $26.6 for the analysis period in discounted 2022 dollars. Table 48 presents the emissions benefits by air pollutant category based on average vehicle speeds. There would be no induced VMT because of the capacity increase since the TDM Program would be implemented per California SB 743 CEQA Amendment, therefore it would not generate any additional emissions.

Table 48. Component Project 1, Emissions Reduction Benefits, Millions of 2022 Dollars

Benefit	Project Opening Year			Project Lifecycle		
	Tons	Undiscounted	Discounted (3.1%)	Tons	Undiscounted	Discounted (3.1%)
NOx Emissions Reduction	7.49	$0.2	$0.1	70.11	$1.5	$0.9
PM2.5 Emissions Reduction	1.06	$1.1	$0.9	8.47	$9.1	$5.3
SOx Emissions Reduction	0.04	$0.0	$0.0	0.59	$0.0	$0.0
CO2 Emissions Reduction	6,604.76	$1.7	$1.4	97,924.49	$30.0	$20.3
Total Emissions Reduction	6,613.36	$3.0	$2.4	98,003.66	$40.6	$26.6

5.4.2 AT-CARM Project – Segments 1 & 3A (Component Project 2)

At 3.1% discount rate, the quantifiable portion of the total emission benefits resulting from Component Project 2 is estimated to be $8.7 million for the analysis period in discounted 2022 dollars. Table 49 presents the emissions benefits by air pollutant category based on average vehicle speeds.

Compared to the No-Build Case, Component Project 2 would be net VMT neutral, therefore it would not generate any additional emissions.

Table 49. Component Project 2, Emissions Reduction Benefits, Millions of 2022 Dollars

Benefit	Project Opening Year			Project Lifecycle		
	Tons	Undiscounted	Discounted (3.1%)	Tons	Undiscounted	Discounted (3.1%)
NOx Emissions Reduction	0.66	$0.0	$0.0	17.67	$0.4	$0.2
PM2.5 Emissions Reduction	0.17	$0.2	$0.1	3.39	$3.6	$2.3
SOx Emissions Reduction	0.01	$0.0	$0.0	0.18	$0.0	$0.0
CO2 Emissions Reduction	1,102.78	$0.3	$0.2	29,607.25	$8.8	$6.2
Total Emissions Reduction	1,103.63	$0.5	$0.4	29,628.50	$12.8	$8.7

Furthermore, the implementation of CARM as part of Component Project 2 would result in lower platooning frequency which would effectively result in smoother traffic flow. In addition to the average speed increase resulting from the anticipated travel time reduction, which is quantified in the BCA, the smoother traffic flow would also result in lower frequency of stop-and-go driving patterns that contribute to higher fuel consumption and emissions, therefore decreasing emissions even further.

5.4.3 Shared Mobility Hubs (Component Project 3)

At 3.1% discount rate, the quantifiable portion of the total emission benefits resulting from Component Project 3 is estimated to be $5.5 million for the analysis period in discounted 2022 dollars. Table 50 presents the emissions benefits by air pollutant category based on average vehicle speeds.

Table 50. Component Project 3, Emissions Reduction Benefits, Millions of 2022 Dollars

Benefit	Project Opening Year			Project Lifecycle		
	Tons	Undiscounted	Discounted (3.1%)	Tons	Undiscounted	Discounted (3.1%)
NOx Emissions Reduction	0.27	$0.0	$0.0	2.76	$0.1	$0.0
PM2.5 Emissions Reduction	0.02	$0.0	$0.0	0.70	$0.7	$0.5
SOx Emissions Reduction	0.00	$0.0	$0.0	0.15	$0.0	$0.0
CO2 Emissions Reduction	751.24	$0.2	$0.2	23,712.51	$6.9	$5.0
Total Emissions Reduction	751.54	$0.2	$0.2	23,716.13	$7.7	$5.5

As mentioned in Section 4.1.3, the SMHs would result in a VMT reduction. At 3.1% discount rate, the quantifiable portion of the total emission benefits resulting from Component Project 3 is estimated to be $7.3 million for the analysis period in discounted 2022 dollars. Table 51 presents the emissions benefits by air pollutant category based on reduced VMT.

Table 51. Component Project 3, Emissions Reduction (External Highway Use) Benefits, Millions of 2022 Dollars

Benefit	Project Opening Year			Project Lifecycle		
	VMT	Undiscounted	Discounted (3.1%)	VMT	Undiscounted	Discounted (3.1%)
CO2 Emissions Reduction - Auto	2,408,649	$0.3	$0.2	85,451,583	$9.1	$6.7
CO2 Emissions Reduction - Truck	-	-	-	-	-	-
Non-CO2 Emissions Reduction - Auto	2,408,649	$0.0	$0.0	85,451,583	$1.0	$0.6
Non-CO2 Emissions Reduction - Truck	-	-	-	-	-	-
Total Emissions Reduction	4,817,299	$0.3	$0.3	170,903,167	$10.2	$7.3

5.4.4 Innovate 680 Program (Combined Project)

Estimates for emissions reduction benefits of the Combined Project were estimated by superimposing Component Project 1 and 2. There would be no emission reduction benefits from the Component Project 3 VMT reduction, as the induced VMT from the I-680 NB ELC Project – Phase 1 is countered by the VMT reduction from the TDM Program and the SMHs, resulting in no change in VMT.

At 3.1% discount rate, the quantifiable portion of the total emission benefits resulting from the Project is estimated to be $38.5 for the analysis period in discounted 2022 dollars. Table 52 presents the emissions benefits by air pollutant category based on average vehicle speeds.

Table 52. Combined Project, Emissions Reduction Benefits, Millions of 2022 Dollars

Benefit	Project Opening Year			Project Lifecycle		
	Tons	Undiscounted	Discounted (3.1%)	Tons	Undiscounted	Discounted (3.1%)
NOx Emissions Reduction	3.49	$0.1	$0.1	87.95	$1.9	$1.2
PM2.5 Emissions Reduction	0.14	$0.1	$0.1	10.77	$11.5	$7.2
SOx Emissions Reduction	0.00	$0.0	$0.0	0.88	$0.1	$0.0
CO2 Emissions Reduction	650.37	$0.2	$0.1	142,148.18	$41.2	$30.1
Total Emissions Reduction	654.01	$0.4	$0.3	142,247.79	$54.7	$38.5

As mentioned in Section 5.4.2, the implementation of CARM as part of Component Project 2 would result in lower platooning frequency which would effectively result in smoother traffic flow. In addition to the average speed increase resulting from the anticipated travel time reduction, which is quantified in the BCA, the smoother traffic flow would also result in lower frequency of stop-and-go driving patterns that contribute to higher fuel consumption and emissions, therefore decreasing emissions even further.

5.5 Equity, Multimodal Options, and Quality of Life (Criterion #5)

The implementation and operation of the proposed component projects and Combined Project would result in equity, multimodal options and quality of life benefits in Contra Costa County. These benefits would be captured via transit subsidy and support programs (such as 511 Contra Costa), enhancement of transit options and connectivity to Amtrak, BART and bus (see Figure 5), and new and improved walking and cycling infrastructure. Table 53, Table 54, Table 55 and Table 56 present the unit values used in the computation and monetization of facility amenity benefits, noise, active transportation and health, respectively, per USDOT guidance.[1]

Table 53. Facility Amenities Benefit Assumptions and Sources

Variable	Unit Value (2022$/ trip)	Source
Clocks	$0.07	USDOT BCA Guidance December 2023 Table A-10
Electronic Real-Time Information Displays	$0.90	USDOT BCA Guidance December 2023 Table A-10
Retail/Food Outlet Availability	$0.06	USDOT BCA Guidance December 2023 Table A-10
Staff Availability	$0.19	USDOT BCA Guidance December 2023 Table A-10
Step-free Access to Station/Stop	$0.21	USDOT BCA Guidance December 2023 Table A-10
Step-free Access to Vehicle	$0.07	USDOT BCA Guidance December 2023 Table A-10
Surveillance Cameras	$0.33	USDOT BCA Guidance December 2023 Table A-10
Temperature Controlled Environment	$0.65	USDOT BCA Guidance December 2023 Table A-10
Timetables	$0.05	USDOT BCA Guidance December 2023 Table A-10
Bike Facilities	$0.10	USDOT BCA Guidance December 2023 Table A-10
Car Access Facilities	$0.12	USDOT BCA Guidance December 2023 Table A-10
Taxi Pickup/Dropoff	$0.05	USDOT BCA Guidance December 2023 Table A-10

Table 54. Noise Reduction Benefit Assumptions and Sources

Variable	Unit	Value	Source
Auto Average Noise Cost	2022$ / VMT	$0.0019	USDOT BCA Guidance December 2023 Table A-14 (calc)
Truck Average Noise Cost	2022$ / VMT	$0.0437	USDOT BCA Guidance December 2023 Table A-14 (calc)

Table 55. Health Benefit Assumptions and Sources

Variable	Unit	Value	Source
Walking (ages 20-74)	2022$ / induced-trip	$7.63	USDOT BCA Guidance December 2023 Table A-13
Cycling (ages 20-64)	2022$ / induced-trip	$6.80	USDOT BCA Guidance December 2023 Table A-13

Table 56. Active Transportation Benefit Assumptions and Sources

Variable	Unit	Value	Source
Cycling Path with At Grade Crossings	2022$ / cycle-mile	$1.57	USDOT BCA Guidance December 2023 Table A-9
Cycling Path with no At Grade Crossings	2022$ / cycle-mile	$1.97	USDOT BCA Guidance December 2023 Table A-9
Dedicated Cycling Lane	2022$ / cycle-mile	$1.86	USDOT BCA Guidance December 2023 Table A-9
Cycling Boulevard/“Sharrow”	2022$ / cycle-mile	$0.29	USDOT BCA Guidance December 2023 Table A-9
Separated Cycle Track	2022$ / cycle-mile	$1.86	USDOT BCA Guidance December 2023 Table A-9

The Shared Mobility Hubs (Component Project 3) being presented as part of the Innovate 680 Program would improve quality of life for commuters and the overall region by enhancing facilities and amenities for multimodal connectivity between transit and other modes of active transportation. This is expected to induce modal shift from non-active modes and offer health benefits for eligible population. This section substantiates the assumptions behind quantification and monetization of such benefits and the overall Innovate 680 Program.

5.5.1 I-680 NB ELC Project – Phase 1 (Component Project 1)

The I-680 NB ELC Project – Phase 1 offers additional capacity for motorized transportation thereby offering increased throughput, reduced travel time for autos and trucks, and reduced emissions. Component Project 1 itself does not offer any direct equity, multimodal and quality of life benefits. However, the associated TDM Program, also known as 511 Contra Costa, offers electric bike (e-bike) rebate, bike storage subsidy, transit fare subsidy and paratransit programs. While these programs enhance equity, multimodal options and quality of life, these are not monetized and quantified in the BCA analysis.

5.5.2 AT-CARM Project – Segments 1 & 3A (Component Project 2)

The AT-CARM Project – Segments 1 & 3A implements a significant corridor-level operational improvement and has tangible benefits through reduction in travel time, increased speeds, and resulting reduction in emissions. Component Project 2 itself does not offer any direct equity, multimodal and quality of life benefits. However, it should be noted that Transit Signal Preemption (TSP) is a system proposed to be integrated to Component Project 2, offering some indirect benefits towards enhancing multimodal options, specifically the I-680 Express Bus. Nonetheless, the scope of work for Component Project 2 does not include substantial improvements related to active transportation and hence such benefits are not quantified/monetized.

5.5.3 Shared Mobility Hubs (Component Project 3)

The SMH proposed at three locations include significant facility enhancements that would ultimately benefit all the commuters by offering reliable travel-related information, bike facilities, access improvements for cars and taxi pickup/drop off points, among others. While existing annual ridership data from Amtrak and BART ridership reports provided baseline trip user estimates, a conservative growth rate of 0.5% was used to predict future demand at these two locations.

For the Bollinger Canyon SMH, CCTA's Shared Mobility Hubs Final Report[15] feasibility study provided daily user estimates and these estimates are expected to grow at 0.8% based on expected park and ride demand at this location. In summary, the total benefits corresponding to facility improvements proposed as part of the Component Project 3 is expected to yield $14.0 million across 20 full years of operation as shown in Table 57.

Besides offering facility improvement benefits for overall commuters, the SMH project offers additional benefits particularly to bicyclists with dedicated bicycle lanes at all these locations and health benefits for induced cycle trips within eligible age range. The baseline bike mode share at all these SMH locations is extracted using Streetlight's 2022 Active Transportation Trends analysis resulting in 6%, 5%, and 2.2% at Martinez Amtrak, Walnut Creek BART, and Bollinger Canyon location, respectively. The improved amenities offered by Component Project 3 is expected to induce

additional bicyclists in the region and a conservative assumption of 10% of current bicycle share is applied to compute the induced demand. With the increasing traffic in the corridor and growing economy in the region, the anticipated modal shift to active transportation could be higher than the current assumption. In summary, the overall active transportation benefits for bicyclists amount to $1.1 million in discounted 2022 dollars over 20 full years of operation as shown in Table 57.

In addition, the induced bike trips arising from Component Project 3 will have health benefits particularly for the proportion of the population shifting from non-active mode and in eligible age range. While local survey provided the share of expected bike trips (67%) in eligible age range (20-64), the national average from USDOT is used to adjust for the proportion shifting from non-active mode. In summary, the health benefits due to mortality reduction for eligible induced bicyclists is estimated to be $62 thousand in discounted 2022 dollars over 20 full years of operation as shown in Table 57.

Finally, the reduced daily auto VMT from SMH also produces benefits due to reduction in noise levels that are quantified to an overall benefit of $0.101 million in discounted 2022 dollars as shown in Table 57.

Table 57. Component Project 3, Quality of Life Benefits, Millions of 2022 dollars

Benefit	Project Opening Year		Project Lifecycle	
	Undiscounted	Discounted (3.1%)	Undiscounted	Discounted (3.1%)
Facility Improvements - Shared Mobility Hubs	$0.64	$0.54	$22.58	$14.04
Active Transportation – Bicyclists	$0.051	$0.043	$1.79	$1.11
Mortality reduction – induced bike trips	$0.003	$0.002	$0.096	$0.062
Noise Improvements	0.004	0.003	$0.162	$0.101

5.5.4 Innovate 680 Program (Combined Project)

The quality-of-life benefits for the Combined Project is expected to be emanating from the Shared Mobility Hubs. The quality-of-life benefits for the Combined Project are shown in Table 58.

Table 58. Combined Project, Quality of Life Benefits, Millions of 2022 dollars

Benefit	Project Opening Year		Project Lifecycle	
	Undiscounted	Discounted (3.1%)	Undiscounted	Discounted (3.1%)
Facility Improvements - Shared Mobility Hubs	$0.64	$0.54	$22.58	$14.04
Active Transportation – Bicyclists	$0.051	$0.043	$1.79	$1.11
Mortality reduction – induced bike trips	$0.003	$0.002	$0.096	$0.062
Noise Improvements	0.004	0.003	$0.162	$0.101

Additional benefits include the associated TDM Program, also known as 511 Contra Costa which offers electric bike (e-bike) rebate, bike storage subsidy, transit fare subsidy and paratransit programs as part of Component Project 1; and opportunity for TSP integration as part Component Project 2.

While these programs and technologies enhance equity, multimodal options and quality of life, these are not monetized and quantified in the BCA analysis.

6. SUMMARY OF RESULTS

6.1 Evaluation Measures

The benefit-cost analysis converts potential gains (benefits) and losses (costs) from the component projects and Combined Project into monetary units and compares them. The following common benefit-cost evaluation measures are included in this BCA:

- Net Present Value (NPV): NPV compares the net benefits (benefits minus costs) after being discounted to present values using the real discount rate assumption. The NPV provides a perspective on the overall dollar magnitude of cash flows over time in today's dollar terms.
- Benefit Cost Ratio (BCR): The evaluation also estimates the benefit-cost ratio; the present value of incremental benefits is divided by the present value of incremental costs to yield the benefit-cost ratio. The BCR expresses the relation of discounted benefits to discounted costs as a measure of the extent to which a project's benefits either exceed or fall short of the costs.
- Internal Rate of Return (IRR): The IRR is the discount rate which makes the NPV from the Project equal to zero. In other words, it is the discount rate at which the Project breaks even. Generally, the greater the IRR, the more desirable the Project.
- Payback Period: The payback period refers to the period of time required to recover the funds expended on a Project. When calculating the payback period, the time value of money (discounting) is not considered.

6.2 BCA Results

This section presents the consolidated results of the BCA analysis for each of the individual component project as well as the Combined Project. Results are presented in undiscounted dollars and discounted dollars at 3.1 % as prescribed by USDOT. All benefits and costs were estimated in constant 2022 dollars over an evaluation period extending 20 years of full operation, per USDOT guidance for the component projects as well as the Combined Project.

6.2.1 I-680 NB ELC Project – Phase 1 (Component Project 1)

The total benefits from the Component Project 1 during the analysis period are calculated to be $394.8 million in discounted 2022 dollars. The total capital costs, including engineering, construction, and right-of-way (ROW) and land acquisition, are calculated to be $148.5 million in discounted 2022 dollars. The difference of the discounted benefits and costs equal a Net Present Value (NPV) of $246.4 million in discounted 2022 dollars, resulting in a Benefit-Cost Ratio (BCR) of 2.66. The Internal Rate of Return for the project is 10% with a Payback Period of 13 years. Table 59 summarizes the benefits and costs by categories and presents the results from the BCA.

Table 59. Component Project 1, Benefit Cost Analysis Results, 2022 Dollars

BCA Metric	Project Lifecycle	
	Undiscounted	Discounted (3.1%)
Total Benefits	**$653,323,942**	**$394,842,769**
Travel Time	$520,966,327	$314,938,087
Emissions	$40,587,219	$26,560,324
Safety	$190,581,452	$109,475,204
Change in O&M / R&R Costs	($98,811,056)	($56,130,845)
Total Costs	**$174,209,440**	**$148,462,634**
Net Present Value (NPV)	**$479,114,501**	**$246,380,135**
Benefit Cost Ratio (BCR)	**3.75**	**2.66**
Internal Rate of Return (IRR)	**10%**	
Payback Period (Years)	**13**	

6.2.2 AT-CARM Project – Segments 1 & 3A (Component Project 2)

The total benefits from the Component Project 2 during the analysis period are calculated to be $201.0 million in discounted 2022 dollars. The total capital costs, including engineering, construction, and ROW and land acquisition, are calculated to be $45.9 million in discounted 2022 dollars. The difference of the discounted benefits and costs equal a Net Present Value (NPV) of $155.1 million in discounted 2022 dollars, resulting in a Benefit-Cost Ratio (BCR) of 4.38. The Internal Rate of Return for the project is 21% with a Payback Period of 10 years. Table 60 summarizes the benefits and costs by categories and presents the results from the BCA.

Table 60. Component Project 2, Benefit Cost Analysis Results, 2022 Dollars

BCA Metric	Project Lifecycle	
	Undiscounted	Discounted (3.1%)
Total Benefits	**$321,194,347**	**$200,974,981**
Travel Time	$291,731,789	$183,011,554
Emissions	$12,826,592	$8,742,900
Safety	$113,016,452	$69,582,971
Residual Value /Recapitalization cost	($53,293,522)	($30,762,275)
Change in O&M / R&R Costs	($43,086,965)	($29,600,170)
Total Costs	**$53,293,522**	**$45,901,631**
Net Present Value (NPV)	**$267,900,826**	**$155,073,350**
Benefit Cost Ratio (BCR)	**6.03**	**4.38**
Internal Rate of Return (IRR)	**21%**	
Payback Period (Years)	**10**	

6.2.3 Shared Mobility Hubs (Component Project 3)

The total benefits from the Component Project 3 during the analysis period are calculated to be $72.0 million in discounted 2022 dollars. The total capital costs, including engineering, construction, and ROWand land acquisition, are calculated to be $49.5 million in discounted 2022 dollars. The difference of the discounted benefits and costs equal a Net Present Value (NPV) of $22.5 million in discounted 2022 dollars, resulting in a Benefit-Cost Ratio (BCR) of 1.46. The Internal Rate of Return

for the project is 4% with a Payback Period of 19 years. Table 61 summarizes the benefits and costs by categories and presents the results from the BCA.

Table 61. Component Project 3, Benefit Cost Analysis Results, 2022 Dollars

BCA Metric	Project Lifecycle	
	Undiscounted	Discounted (3.1%)
Total Benefits	**$113,019,510**	**$71,993,564**
Emissions	$7,705,501	$5,528,772
Safety	$25,258,997	$15,702,459
Vehicle O&M (includes fuel)	$44,434,823	$27,600,300
Pavement Damage	$130,212	$80,880
Congestion	$11,792,319	$7,324,695
Noise	$162,358	$100,847
Safety (External Highway Use Cost)	$1,452,677	$902,318
Non-CO2 Emission Cost (External Highway Use Cost)	$1,025,419	$636,930
CO2 Emission Cost (External Highway Use Cost)	$9,143,319	$6,689,870
Active Transportation	$1,793,679	$1,115,468
Health	$96,844	$60,223
Facility Amenities	$22,583,802	$14,043,304
Change in O&M / R&R Costs	($12,560,441)	($7,792,501)
Total Costs	**$56,226,986**	**$49,474,031**
Net Present Value (NPV)	**$56,792,524**	**$22,519,533**
Benefit Cost Ratio (BCR)	**2.01**	**1.46**
Internal Rate of Return (IRR)	**4%**	
Payback Period (Years)	**19**	

6.2.4 Innovate 680 Program (Combined Project)

The total benefits from the Combined Project (Innovate 680 Program) during the analysis period are calculated to be $643.6 million in discounted 2022 dollars. The total capital costs, including engineering, construction, and ROWand land acquisition, are calculated to be $243.8 million in discounted 2022 dollars. The difference of the discounted benefits and costs equal a Net Present Value (NPV) of $399.8 million in discounted 2022 dollars, resulting in a Benefit-Cost Ratio (BCR) of 2.64. The Internal Rate of Return for the project is 12% with a Payback Period of 12 years. Table 62 summarizes the benefits and costs by categories and presents the results from the BCA.

Table 62. Combined Project, Benefit Cost Analysis Results, 2022 Dollars

BCA Metric	Project Lifecycle	
	Undiscounted	Discounted (3.1%)
Total Benefits	**$1,021,404,216**	**$643,634,535**
Travel Time	$844,844,049	$530,352,748
Emissions	$54,725,304	$38,527,881
Safety	$298,226,265	$179,845,069
Active Transportation	$1,793,679	$1,115,468
Health	$96,844	$60,223
Facility Amenities	$22,583,802	$14,043,304
Residual Value /Recapitalization cost	($53,293,522)	($30,762,275)

BCA Metric	Project Lifecycle	
	Undiscounted	Discounted (3.1%)
Change in O&M / R&R Costs	($147,572,206)	($89,547,883)
Total Costs	**$283,729,948**	**$243,838,295**
Net Present Value (NPV)	**$737,674,267**	**$399,796,240**
Benefit Cost Ratio (BCR)	**3.60**	**2.64**
Internal Rate of Return (IRR)	**12%**	
Payback Period (Years)	**12**	

7. SENSITIVITY TESTING

The BCA analysis relies on many assumptions that, while based on the best available knowledge, are uncertain. A sensitivity analysis was performed to evaluate the impact of adjusting key assumptions on the NPV and BCR. As presented in Table 63, the Combined Project's benefits are relatively robust against uncertainties related to Value of Time (VOT), travel time savings, capital cost, value of statistical life and CMF. In all the scenarios tested, the Combined Project's benefits still outweigh its costs, demonstrating the overall value and contribution of the Combined Project to the region.

Table 63. Combined Project, Benefit Cost Analysis Sensitivity Analysis, 2022 Dollars

Sensitivity Variable	Sensitivity Value	New BCR	New NPV	% Change in NPV	Source / Notes
Base results	Build (3.1% Discount Rate)	2.64	$399,796,240	-	No Change to the Model
Value of Travel Time	Lower Bound of Range Recommended by USDOT	2.01	$245,580,192	-39%	Automobile: $12.7. WSP Computation from BUILD BCA Guidance
	Upper Bound of Range Recommended by USDOT	3.09	$508,875,883	27%	Automobile: $21.58. WSP Computation from BUILD BCA Guidance
Capital Cost Estimate	25% increase	2.11	$338,836,666	-15%	25 % increase chosen based on range displayed in the Summary of Cost Estimate.
O&M Cost Estimate	25% increase	2.55	$377,409,269	-6%	25 % increase chosen based on range displayed in the Summary of Cost Estimate.
Value of Statistical Life	Lower Bound of Range Recommended by USDOT	2.34	$327,858,212	-18%	40% lower VSL. WSP Computation from BUILD BCA Guidance
	Upper Bound of Range Recommended by USDOT	2.93	$471,734,267	18%	40% higher VSL. WSP Computation from BUILD BCA Guidance

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