Monterey-Salinas Transit District

Innovative Clean Transit (ICT) Rollout Plan

December, 2021

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Document Control

Revision Number	Revision Date	Revised by	COO Approval

This ICT Rollout Plan will guide the transition to zero-emission buses for Monterey-Salinas Transit District (MST) 19 Upper Ragsdale Drive, Suite 200, Monterey, CA 93940

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A

Transit Agency Information

Introduction

Monterey-Salinas Transit District (MST) was created by state law AB644 and formed July 1, 2010. The district succeeds Monterey-Salinas Transit Joint Powers Agency formed in 1981 when the City of Salinas joined the Monterey Peninsula Transit Joint Powers Agency which was formed in 1972.

Current members of the district are the Cities of Carmel, Del Rey Oaks, Gonzales, Greenfield, King City, Marina, Monterey, Pacific Grove, Salinas, Sand City, Seaside, Soledad and the County of Monterey. A board of directors with a representative from each member jurisdiction governs the agency and appoints the general manager.

Our Mission: Advocating and delivering quality public transportation as a leader within our community and industry

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MST is not part of a Joint Group (13 CCR § 2023.1(d)(3).

Fixed Route Fast Facts
Population Served: 434,061
Service Area: 295 square miles
Fleet Size: 132
Operating Expenses FY 2020: $41,537,574
Capital Expenses FY 2020: $5,471,730
Passengers Carried: 3,082,463
Stops in Service Area: 1,011
Revenue Miles Traveled: 3,784,919
Routes: 34
Employees: 243

Para-transit Fast Facts
Fleet Size: 39
Operating Expenses FY 2020: $5,797,274
Capital Expenses FY 2020: $136,778
Passengers Carried: 195,762
Revenue Miles Traveled: 1,081,379

MST's service area spans 295 square miles and includes the cities of Carmel, Del Rey Oaks, Gonzales, Greenfield, King City, Marina, Monterey, Pacific Grove, Salinas, Sand City, Seaside, Soledad, and the County of Monterey. MST also provides transportation service to nearby regions that include San Jose, Santa Cruz, Paso Robles, and Templeton.

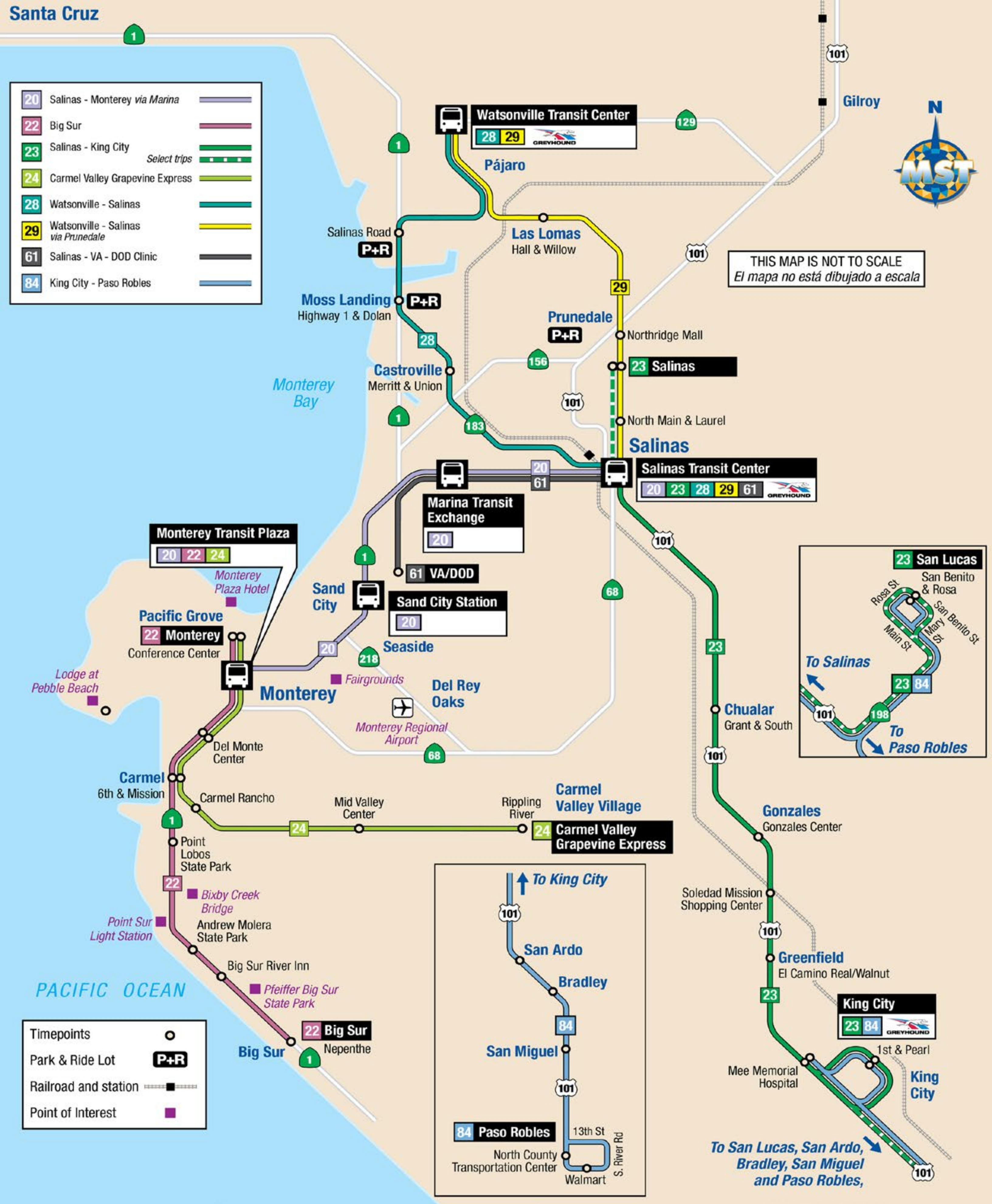
MST operates a total of 56 fixed routes, of which 50 are local routes and 6 are commuter and/or intercity routes. Route lengths vary from less than 1 mile to longer than 120 miles. Approximately 568 daily service hours are directly operated by MST and 272 are contracted with MV Transportation, Incorporated.

MST has two operational facilities for buses, one located at One Ryan Ranch Road in Monterey and the other at 443 Victor Way in Salinas. Both of these facilities are equipped with diesel and gasoline fueling stations.MST constructed a third operating facility in King City. The King City facility was not included in the scope of this study but should be evaulated for zero emissions opportunities. The King City operating facility will house MST's over-the-road coaches for MST's "high mileage" routes which are better suited for FCEB's due to the need for increased mileage and range. MST's contractor, MV Transportation Inc., currently operates from 4512 Joe Lloyd Way in Seaside. The Seaside location is fully equipped with gasoline fueling stations.

MST operates seven (7) diesel-powered trolleys at the Monterey Division, and MST currently has two electric buses on order from Gillig, Incorporated for production in 2021. MST also has 1 electric trolley that is charged en-route through a WAVE inductive charger near 201 Pearl Street, Monterey, CA 93940.

Community Role

Whether our community members are headed to work, school, shopping or meeting friends, Monterey-Salinas Transit District (MST) is there to connect them. MST provides bus service to the greater Monterey and Salinas areas as far south as Templeton and Big Sur and as far north as Santa Cruz and San Jose. We see ourselves as an important part of each community we serve, and strive to support our community and community members to be successful. Our goal is to provide residents and visitors with high-quality transit service.


Santa Cruz
20 Salinas - Monterey via Marina
22 Big Sur
23 Salinas - King City
Select trips
24 Carmel Valley Grapevine Express
28 Watsonville - Salinas
29 Watsonville - Salinas via Prunedale
61 Salinas - VA - DOD Clinic
84 King City - Paso Robles
Watsonville Transit Center
28 29
Pájaro
Gilroy
Salinas Road
P+R
Las Lomas
Hall & Willow
THIS MAP IS NOT TO SCALE
El mapa no está dibujado a escala
Moss Landing
Highway 1 & Dolan
Prunedale
Northridge Mall
23 Salinas
Castroville
Merritt & Union
Monterey Bay
North Main & Laurel
Salinas
Salinas Transit Center
20 23 28 29 61
Marina Transit Exchange
20
Monterey Transit Plaza
20 22 24
Monterey Plaza Hotel
61 VA/DOD
Sand City
Sand City Station
20
Pacific Grove
22 Monterey
Conference Center
Seaside
Lodge at Pebble Beach
Fairgrounds
Monterey
Del Rey Oaks
Monterey Regional Airport
Chualar
Grant & South
23 San Lucas
San Benito & Rosa
Rosa St
San Benito St
Mary St
Main St
To Salinas
To Paso Robles
Del Monte Center
Carmel
6th & Mission
Carmel Rancho
Mid Valley Center
Rippling River
Carmel Valley Village
24 Carmel Valley Grapevine Express
Gonzales
Gonzales Center
Point Lobos State Park
Bixby Creek Bridge
Point Sur Light Station
Andrew Molera State Park
To King City
San Ardo
Bradley
Soledad Mission Shopping Center
Greenfield
El Camino Real/Walnut
Big Sur River Inn
PACIFIC OCEAN
Pfeiffer Big Sur State Park
22 Big Sur
Nepenthe
Big Sur
San Miguel
King City
23 84
1st & Pearl
Mee Memorial Hospital
King City
Timepoints
Park & Ride Lot
Railroad and station
Point of Interest
84 Paso Robles
13th St
North County Transportation Center
Walmart
S. River Rd
To San Lucas, San Ardo, Bradley, San Miguel and Paso Robles,

B

Rollout Plan General Information

ICT Background

The California Air Resources Board (CARB) is the lead agency for climate change programs and is charged with protecting the public from harmful effects of air pollution and developing programs and actions to fight climate change. In December 2018, CARB adopted the Innovative Clean Transit (ICT) Regulation that requires all public transit agencies in the state to gradually transition to 100-percent zero-emission bus fleets by 2040.

Through the deployment of zero-emission technologies, the ICT regulation will provide significant benefits across the state, including:

- Reduce NOx and GHG emissions for all Californians, especially transit-dependent and disadvantage communities. The majority of these benefits will be in the State’s most populated and impacted areas where transit buses are most prevalent
- Increase penetration of the first wave of zero-emission heavy-duty technologies into applications that are well suited to their use to further achieve emission reduction benefits
- Save energy and reduce dependency on petroleum and other fossil fuels
- Expand zero-emission vehicle industry to bring high quality green jobs to local communities and trained workforce to California
- Provide other societal benefits by encouraging improved mobility and connectivity with zero-emission transportation modes and reduced growth in light-duty vehicle miles traveled

MST ICT Rollout

This document outlines a plan to guide Monterey-Salinas Transit District's transition from diesel and gasoline-powered vehicles to zero emission by 2040, without early retirement of diesel vehicles. MST anticipates the last purchase of a diesel vehicle will be in 2022, with a full shift to Zero Emissions Buses starting in 2023, depending on available funding.

The ICT Rollout Plan is a coordinating document to assist the planning, design, construction, acquisition, and implementation of zero emission technology. MST's adoption of zero emission technology will ultimately meet the ICT regulation requirements. The ICT Rollout Plan is approved by the Monterey-Salinas Transit District Board on December 13, 2021; a copy of the approved resolution in located in the attachments (13 CCR§ 2023.1(d)(2)).

The ICT Rollout Plan is divided into the following sections per the ICT requirements:

- A Transit Agency Information
- B Rollout Plan General Information
- C Technology Portfolio
- D Current Bus Fleet Composition and Future Bus Purchases
- E Facilities and Infrastructure Modifications
- F Providing Service in Disadvantaged Communities
- G Workforce Training
- H Potential Funding Sources
- I Start-up and Scale-up Challenges

The ICT Rollout Plan was created by Monterey-Salinas Transit District with assistance from HDR, Inc., a planning/engineering consultant.

C

Technology Portfolio

Technology Options

There are currently two commercially-viable zero emission bus technologies to transit agencies; battery-electric buses (BEB) and hydrogen fuel cell electric buses (FCEB). For Monterey-Salinas Transit District, BEBs are the preferred technology for the initial fleet conversion due to the consistency in vehicles, availability of fuel, cost of infrastructure, operation, and training. The key considerations used to identify a preferred scenario were cost, physical space and performance. FCEB technology remains a viable alternative for long-range routes and for routes of extended duration. FCEB technology is also considered for its operational flexibility during power outages or rolling black outs.

Primary Technology

Battery electric buses are identified as the preferred technology for Monterey-Salinas Transit District's's ZEV transition given today's BEB range, availability, and costs for vehicles and infrastructure. To further understand how this technology will affect current operations, MST recently completed a BEB/FCEB analysis to determine the vehicle options, infrastructure needs, operational considerations, and costs associated with each technology and a combination of the two. The effort included a route power analysis to determine the power usage of the fleet that accounts for weather (temperature), elevation change, and other power consumption elements. This analysis used existing schedules and routes to develop a realistic understanding of the power needs and potential range for each scheduled block, and which blocks may be too long for the current battery capacity.

Some existing routes will require more energy and distance than current battery-electric buses can deliver; therefore, **MST is planning to use FCEBs as an alternative on the routes/blocks that cannot be served by a BEB.** Because a single fuel type is preferred for a number of reasons, MST is prioritizing the purchase of BEBs for the near-term purchases, and planning for FCEBs for purchases for routes that BEBs cannot service starting in 2027. However, if BEB technology is able to meet the demands of a route or block, then the vehicle purchases starting in 2027 and beyond will prioritize BEB when viable, and FCEB as an alternative.

D

Current Fleet and Future Purchases

Bus Fleet

MST conducted a route power analysis that models the energy usage on a block-by-block basis of each route. The ability for the BEB vehicles to serve each route is determined on a number of different variables, including ambient temperature, route grade changes, passenger load, traffic, and stops.

Table 1 shows the existing MST bus fleet and Table 2 shows the fleet transition schedule. All of the MST ZEB fleet requirements will be met through the purchase of new vehicles.

Table 1: Existing bus fleet

Model Year	Fuel Type	Bus Length	Bus Qty.
2003	Diesel	30' Trolley	2
2003	Diesel	40' Bus	0
2007	Diesel	35' Bus	8
2008	Diesel	40' Bus	5
2009	Diesel	45' OTR	2
2010	Diesel	45' OTR	1
2011	Diesel	45' OTR	1
2013	Diesel	40' Bus	1
2015	Diesel	35' Bus	11
	Diesel	40' Bus	7
	Diesel	45' OTR	2
	Battery Electric	Trolley	1
2018	Diesel	35' Bus	9
	Diesel	40' Bus	17
	Battery Electric	30' Bus	2
2019	Diesel	35' Trolley	5
2019	Diesel	40' Bus	1
2021	Battery Electric	40' Bus	2
Total Fixed Route Fleet			**86**

Table 2: Fleet transition schedule

ICT Requirement	Year	ZEB				Conventional				Total Purchased
		Qty.	% of Total	Bus Length	Technology	Qty	% of Total	Bus Length	Fuel	
0%	2022					7	100%	40’	Diesel	7
	2023	4	100%	35’ Bus	Battery - Depot					7
		3		40’ Bus	Battery - Depot					
	2024	2	100%	35’ Bus	Battery - Depot					9
		7		40’ Bus	Battery - Depot					
	2025									
25%	2026									
	2027	11	100%	35’ Bus	FCEB*					18
		7		40’ Bus	FCEB*					
	2028									
100%	2029									
	2030	20	100%	40’ Bus	FCEB*					31
		11		35’ Bus	FCEB*					
	2031									
	2032									
	2033									
	2034	7	100%	40’ Bus	FCEB*					7

Notes:
*Fuel Cell Electric Buses are planned for purchase in these years, although Battery Electric Buses are the preferred option if the vehicles available at the time are able to achieve the range required.

All existing OTR vehicles are being transitioned to 40-foot buses.

The 2034 purchase round represents the last group of diesel vehicles transitioning to Zero Emissions Vehicles. All years following the 2034 purchase group will be ZEVs.

Para-transit Fleet

Table 3 shows the existing MST's para-transit fleet and Table 4 shows the para-transit fleet transition schedule. The 22-foot cutaway vehicles are over the 14,000 GVWR, and are the portion of the para-transit fleet that must comply with ICT requirements. MST has identified the following considerations related to transitioning the para-transit fleet to zero-emission vehicles:

- The purchase schedule of cutaway buses are contingent on the success of the fixed route buses. MST will evaluate and implement the effectiveness of the fixed route vehicles and determine the most appropriate course for purchasing and operating zero-emission para-transit vehicles.

- For cutaway purchases after 1/1/2026, vehicle fuel type will depend on status of zero-emission technology development. MST will purchase a ZEB vehicle in this category if the technology can meet its range requirements and vehicles have passed Altoona Testing. If not, MST will purchase gasoline-powered vehicles. MST will consider the purchase of zero-emission cutaways on and after 1/1/2026, once the technology becomes available to comply with the ICT.

Table 3: Existing para-transit fleet

Model Year	Fuel Type	Bus Length	Bus Qty.
2013	Gasoline	22' Cutaway	3
2015	Gasoline	22' Cutaway	8
2016	Gasoline	22' Cutaway	5
2018	Gasoline	22' Cutaway	7
2019	Gasoline	22' Cutaway	13
Total Para-transit Fleet			**36**

Table 4: Para-transit fleet transition schedule

ICT Requirement	Year	ZEB				Conventional				Total Purchased
		Qty.	% of Total	Bus Length	Technology	Qty	% of Total	Bus Length	Fuel	
0%	2022					9				9
	2023					12				12
	2024					5	100%	22' Cutaway	Gasoline	5
	2025					10	100%	22' Cutaway	Gasoline	10
25%	2026									
	2027									
	2028	9	100%	22' Cutaway	Battery - Depot					9
100%	2029	12	100%	22' Cutaway	Battery - Depot					12
	2030	5	100%	22' Cutaway	Battery - Depot					5
	2031	10	100%	22' Cutaway	Battery - Depot					10
	2032									

E

Facilities and Infrastructure Modifications

MST Bus Facilities

The 2023 and 2024 BEBs that MST intends to purchase are planned to be split between the Monterey and Salinas Garages, each requiring two shared 150kW chargers multiplexed to charge vehicles stationed at each garage.

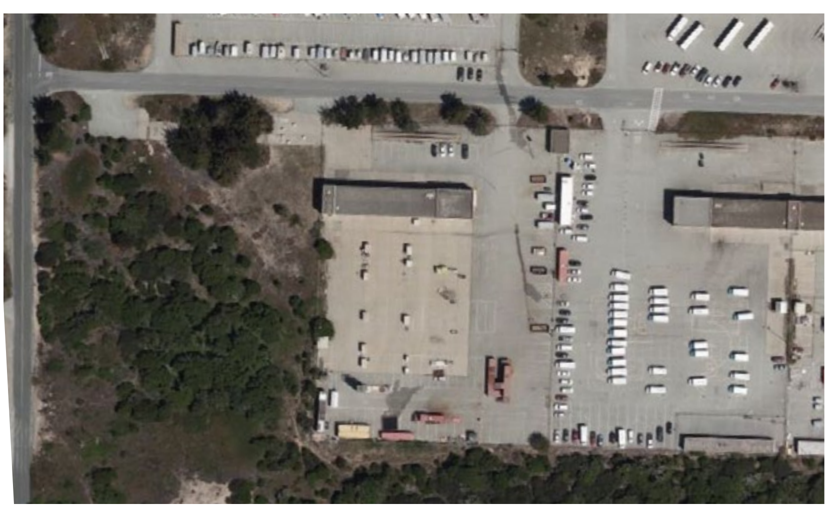
For now, long-term planning is focused on FCEBs, and determining the infrastructure needed and associated spatial requirements to support the infrastructure. The infrastructure needed is dependent on the type of hydrogen used, the generation strategy, and available funding. Broadly speaking, the infrastructure can be broken into three parts. First, there is the infrastructure required to produce hydrogen. This infrastructure may not be required if the hydrogen is purchased from a third party. Second, there is the infrastructure required to store the hydrogen until it is needed. This varies based on the type of hydrogen used. Finally, there is the infrastructure required to dispense the hydrogen. This infrastructure must be present at any location where hydrogen is dispensed regardless of where the hydrogen is produced. A breakdown of these components is shown in Table 6.

Table 5: Existing bus fleet

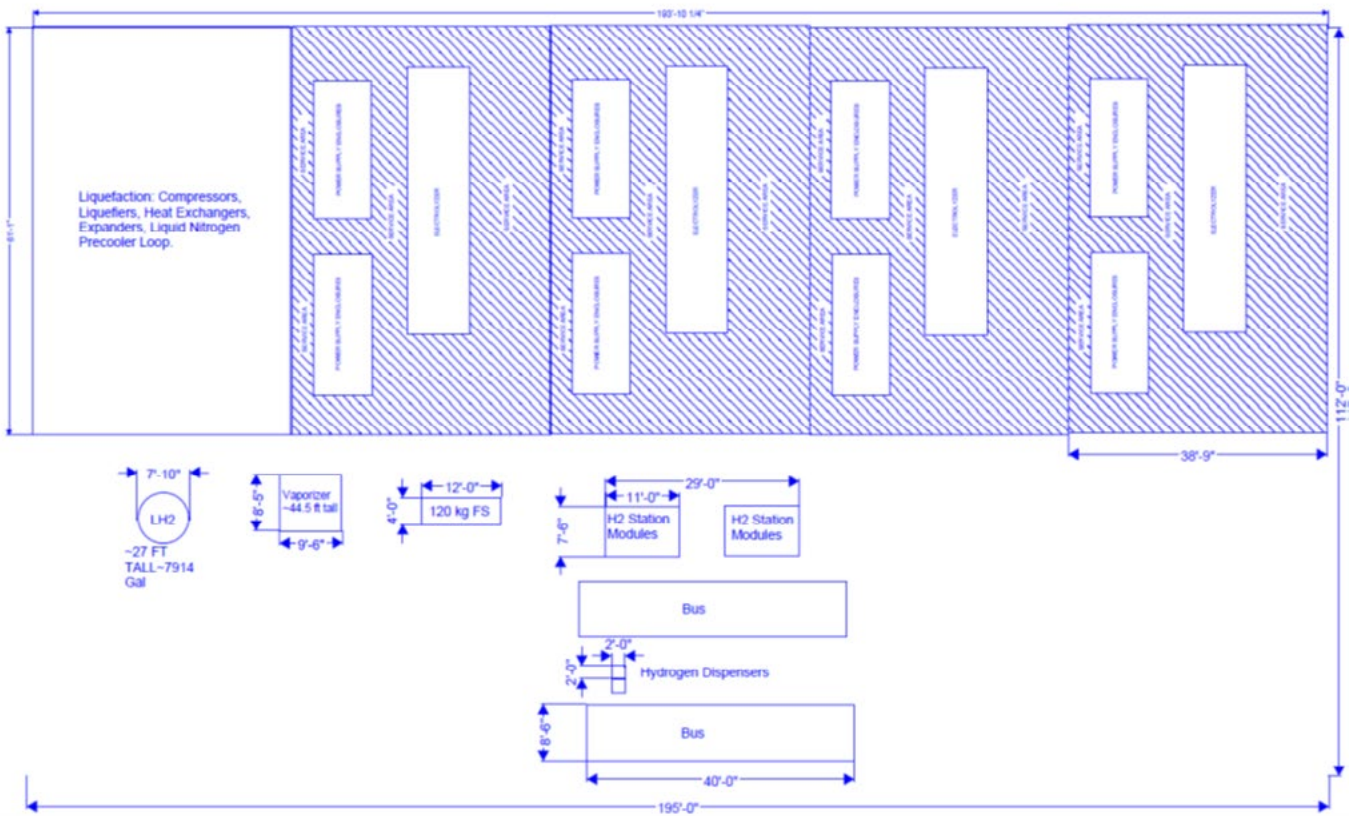
Facility	Address	Main function	Type(s) of infrastructure	Service capacity	Needs upgrade? (yes/no)	Estimated construction timeline
Monterey Garage	1 Ryan Ranch Rd, Monterey, CA 93940	Bus maintenance and storage	Charging Infrastructure, Liquid Hydrogen Infrastructure (if needed)	45 Vehicles	Yes	Completed by 2031
Salinas Garage	443 Victor Way, Salinas, CA 93907			31 Vehicles	Yes	Completed by 2031
Seaside Garage (privately operated)	4512 Joey Lloyd Way, Seaside, CA 93955	Para-transit vehicle maintenance and storage	Charging Infrastructure	81 Vehicles	Yes	Completed by 2031

Monterey Garage
(not to scale)
1 Ryan Ranch Rd.
Monterey, CA

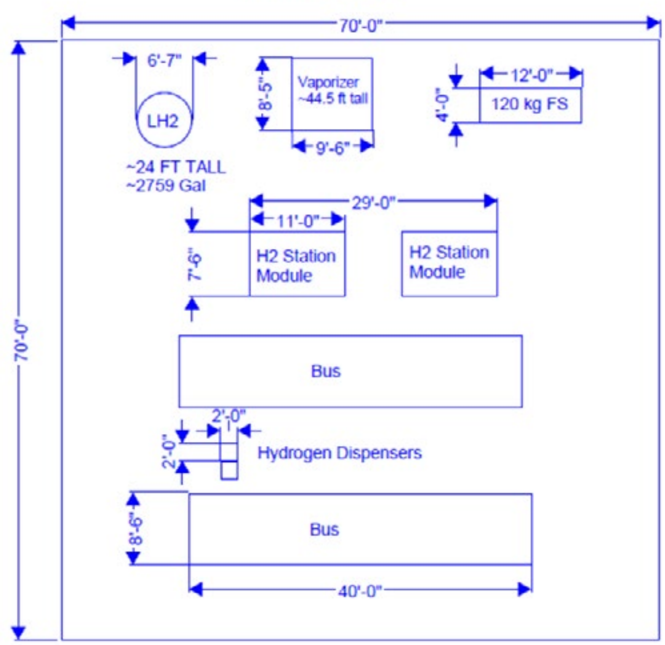
Salinas Garage
(not to scale)
443 Victor Way
Salinas, CA



Seaside Garage
(not to scale)
4512 Joey Lloyd Way
Seaside, CA



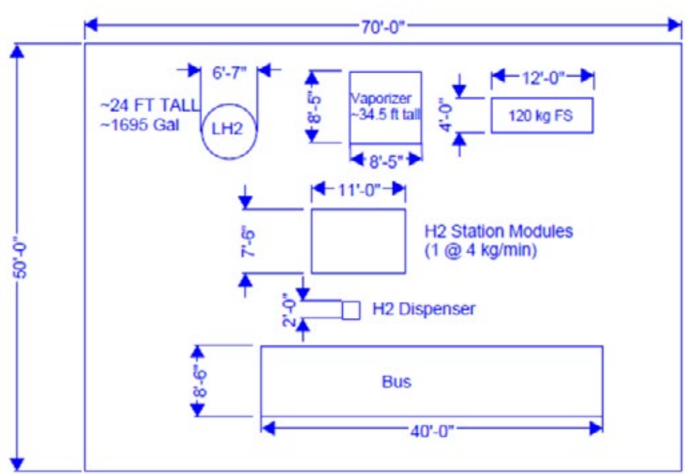
▲ ***Monterey Garage Hydrogen Footprint***
Basic layout shows hydrogen production for all three garages in the hatched area. If liquid hydrogen is trucked and tanked, the blue hatched area would not be required.



Salinas Garage Hydrogen Footprint ▶
Assumes liquid hydrogen trucked in from Monterey Garage or off-site hydrogen production site.

Table 6: Hydrogen infrastructure components by garage, assuming consolidated H2 production

	Equipment	Space	Power	Notes
Monterey Garage	Electrolyzers	9,920 ft2	8,920.8 kW	Water use is 750 gallons/hour Wastewater is 470 gallons/hour
	Liquefaction	2,480 ft2	2,354.1 kW	177 kg H2 per hour
	Liquid Hydrogen Storage	145 ft2	–	8,000-gallon capacity
	Cryogenic Pump	100 ft2	283.1 kW	
	Vaporizer	77 ft2	–	
	Fuel Storage	50 ft2	–	120 kg capacity to act as gaseous hydrogen storage buffer
	Station Modules	165 ft2	192 kW	
	Dispensers	8 ft2	9.6 kW	
	Site Total	**0.5 acres**	**11,759.6 kW**	
Salinas Garage	Liquid Hydrogen Storage	50 ft2	–	
	Cryogenic Pump	100 ft2	141.5 kW	
	Vaporizer	77 ft2	–	
	Fuel Storage	50 ft2	–	120 kg capacity
	Station Module	82.5 ft2	96 kW	
	Dispenser	4 ft2	4.8 kW	
	Site Total	**0.08 acres**	**242.3 kW**	
Seaside Garage	Liquid Hydrogen Storage	50 ft2	–	
	Cryogenic Pump	100 ft2	283.1 kW	
	Vaporizer	77 ft2	–	
	Fuel Storage	50 ft2	–	120 kg capacity
	Station Module	82.5 ft2	192 kW	
	Dispenser	4 ft2	9.6 kW	
	Site Total	**0.11 acres**	**484.7 kW**	



Seaside Garage Hydrogen Footprint
Assumes liquid hydrogen trucked in from Monterey Garage or off-site hydrogen production site.

F

Service in Disadvantaged Communities

Overview

Disadvantaged communities are identified by the California Environmental Protection Agency (CalEPA)* as the top 25% most impacted census tracts in CalEnviroScreen 3.0 - a screening tool used to help identify communities disproportionately burdened by multiple sources of pollution and with population characteristics that make them more sensitive to pollution.

There are ten SB535 disadvantaged communities within the MST service area, six in Santa Cruz County and four in Monterey County. The SB535 Disadvantaged Communities are identified by CalEnviroScreen (see Figure 11) are listed below by county:

Santa Cruz County SB535 Disadvantaged Communities:

- 6087110300
- 6087110400
- 6085501600
- 6085512310
- 6085512602
- 6085512603

Monterey County SB535 Disadvantaged Communities:

- 6053010101
- 6053014102
- 6053014500
- 6053000900

MST will actively seek funding to purchase sixteen battery-electric buses in 2024, deployed on the blocks that are viable for BEB technology to operate. Because the deployment of these vehicles is on a per-block, not per-route basis, many vehicles will serve more than one route.

Table 7 shows all the MST routes that intersect with the SB535 communities (several in the San Jose area were removed, as the route is traveling through a freeway). The right column shows the routes that use vehicles operating on the BEB blocks. The red highlight shows where BEB vehicles will operate on routes that serve SB535 communities. BEBs have been prioritized into blocks that are able to accommodate the range limitations of the technology, but many of the SB535 routes will not be affected. While it is the priority of MST to prioritize these routes, the technology limitations at this time will limit how many of the SB535 routes can be served. However, the vehicle purchases made in 2027 and beyond will have the range necessary to serve these routes, and many of the SB535 communities will be prioritized for ZEV buses.

Figures 1-5 show the location of MST routes overlaid with SB535 community boundaries.

Table 7: BEB/SB535 Routes

Routes Serving SB535 Communities	Initial BEB Routes
	8
	11
	12
	14
16	
19	
20	20
21	21
23	23
27	
28	
29	
40	
	41
48	
55	
56	56
61	
72	72
74	
78	
82	
86	
95	
	901
	902
	920

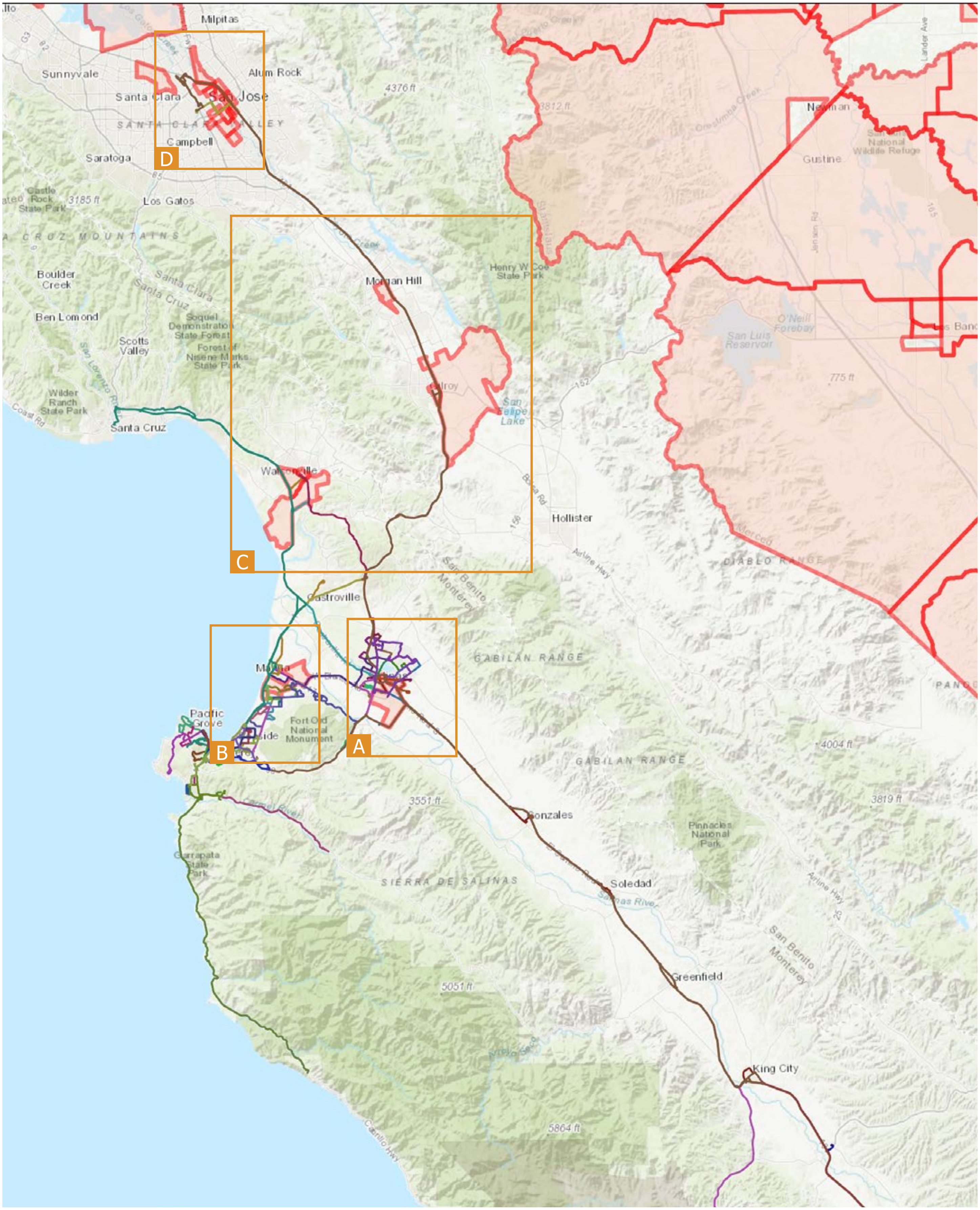


Figure 1: SB535 Disadvantaged Communities served by MST
Route data compiled by FTA National Transit Database 2019

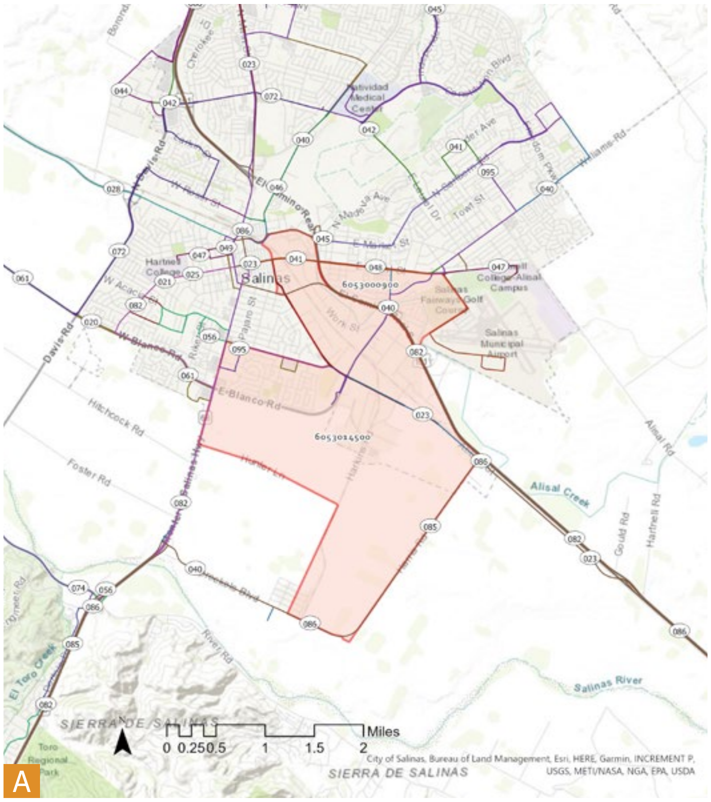


Figure 2: Salinas SB535 Communities

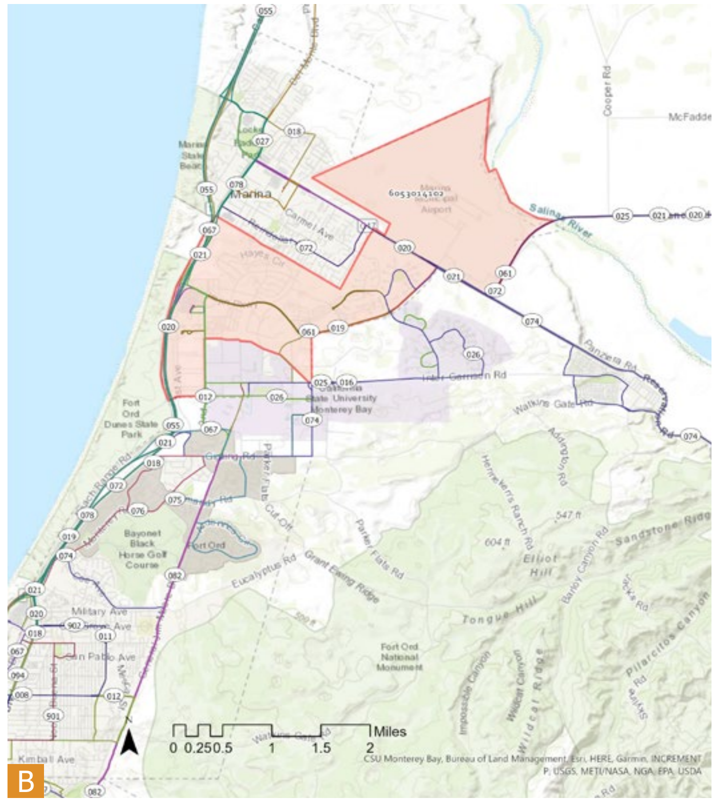


Figure 3: Marina SB535 Communities

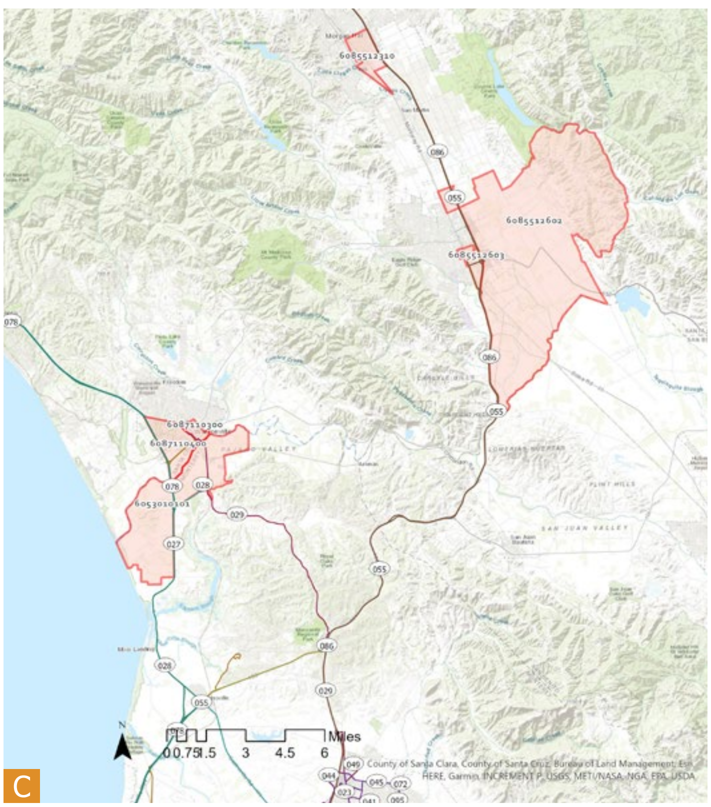


Figure 4: Pajaro Valley SB535 Communities

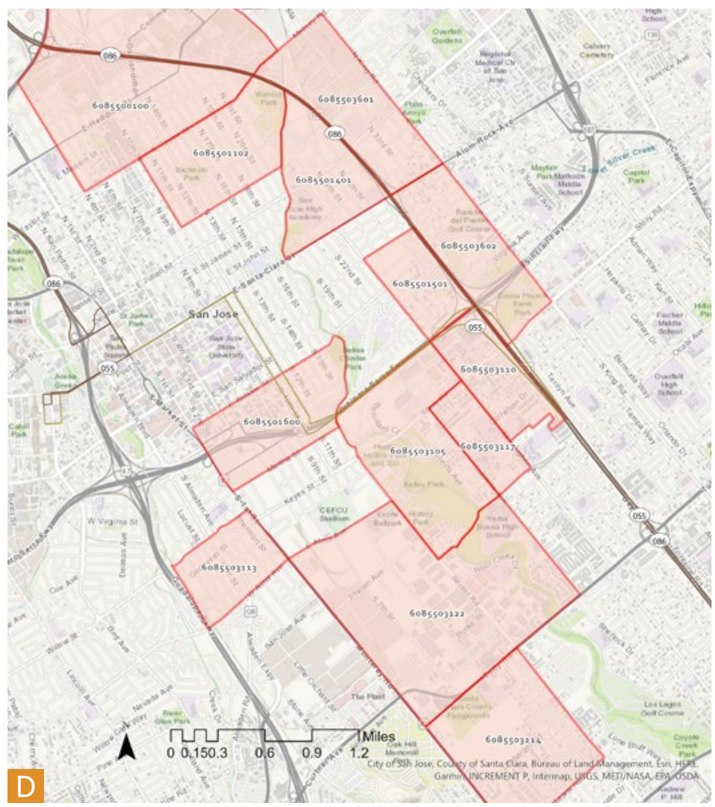


Figure 5: San Jose SB535 Communities

G

Workforce Training

Workforce Development

Making the transition to zero emission bus (ZEB) technology involves more than simply buying new buses. Training is required to ensure staff can operate and maintain these vehicles in a safe and efficient manner. Training must also meet any applicable regulatory requirements, such as the Driver Proficiency requirements of California 13 CCR § 1229. While BEBs and FCEBs share many of the same components, FCEBs will require additional training. Both vehicle types have unique components and support equipment that make them significantly different than the diesel buses in use. Training will be needed for both internal staff as well as several external parties who may interact with operations. Proper training is crucial for implementing a smooth, safe transition to these vehicle technologies.

Training Strategy

Trained and skilled BEB and FCEB mechanics are not readily available on the job market due to how new this technology is. This makes it difficult to hire maintenance staff that already have the required technical knowledge and skills for making a transition, and instead each agency will need to develop a strategy for training their existing maintenance staff and any new maintenance staff hired. Additional training is also required for most other staff, including drivers, dispatchers, supervisors, and many other roles within the organization. The strategy outlined here is based on the lessons learned from agencies that have already begun this transition.

The primary source of training initially will be the vehicle, charger, and fueling infrastructure original equipment manufacturers (OEMs), along with their subcomponent suppliers. These equipment providers have already developed training programs to assist with the deployment of these new types of vehicles. The learning curve for ZEB technology is steep, but it flattens as an agency gains experience and practice. Training from the OEM and subcomponent suppliers should be leveraged early on with the goal of building on this to develop internal training programs in the long run. OEM training is great for understanding the theory and technical specifications for buses, but training based on actual experience in maintenance and operations will be more applicable to a specific deployment.

Both academic and hands-on training are needed, but hands-on training is best for most topics and should be used whenever possible. This allows for an apprenticeship model, where mechanics can learn from an expert. The details of the training that are required from the OEM should be included as a part of the vehicle procurement process and made a part of the RFP and contract. This should cover training hours, aids, materials, special tools, and diagnostic equipment. Along with leveraging both internal and external training, it will also be important to have a strategy for tracking training progress. This system will be a valuable resource for knowing which employees have completed what training, tracking the overall training progress at the individual and group level, and identifying gaps in the skill set across the organization. Training should also be repeated as often as needed, for example quarterly, to maintain proficiency for existing staff and on-boarding of new staff.

Training Groups

Among the groups of people who require training are drivers, mechanics, and operations staff, as well as external parties. Each group has a unique set of training needs that must be addressed. Some topics, such as high-voltage safety, will be required by all groups, but other topics will be specific to only a subset of MST staff. The transition to ZEBs is more difficult for mechanics than it is for other staff, and more training will be required for this group than for any other.

One external group that will require special training for both BEBs and FCEBs are first responders. These vehicles present a unique set of hazards and require a response from emergency personnel that is different than with diesel buses. The vehicle OEM could be responsible for training first responders as a part of the vehicle procurement contract. MST has created a training program for first responders and is prepared to deliver this training to Monterey County first responders. Another external group that must be considered is the towing operator. The process of towing these vehicles is not the same as towing a diesel vehicle. There are certain steps that must be taken for both the safety of the tow truck driver as well as the safety of the vehicle. As soon as ZEBs are delivered, training should be scheduled with the vehicle OEM and the towing operator so that a test towing can be performed.

Training Topics

Basic training courses for familiarization with the vehicles, high voltage safety, and high pressure safety will be required for all groups identified above. This will cover topics such as recognizing high voltage and/or high pressure systems, the use of personal protective equipment (PPE), lockout/tagout procedures, emergency cut-off switches, and emergency response plans. This training will only take a few hours, and it can be completed as just-in-time training as required.

MST has the appropriate PPE for BEBs and has completed bus and infrastructure training through BEB manufacturers BYD and Gillig. MST has also completed training through the California Transit Training Consortium (CTTC).

Some of the components used in ZEBs are the same as components used in diesel buses and will require the same type of training that already exists. These include items such as the air system, mechanical brakes, power steering, axles, suspension, cooling system, low-voltage systems, controller area network (CAN), doors, and Americans with Disabilities Act (ADA) equipment. Other components are new and will require a new set of training; for BEBs this includes high voltage cables, high voltage junction boxes, high voltage battery energy storage systems (ESS), battery management systems (BMS), high voltage contractors, inverters, electric motors, and DC-DC converters. FCEBs have the same extra components as BEBs, but additionally include high pressure storage tanks and fuel cells. These new systems will require advanced training courses that will need to be completed by mechanics and supervisors. Maintenance staff will also need to be supplied with the proper diagnostic tools and equipment and trained in the use of these tools.

Drivers require training on how to efficiently operate the bus. They need to understand the difference between traditional mechanical brakes and regenerative braking, and how the brakes can feel different depending on the circumstance. Efficiency is also maximized when the optimal amount of acceleration and deceleration is used, and this must be balanced against keeping buses on schedule. Drivers must also be trained of the risks that come from operating a silent vehicle, including pedestrians and bicyclists that don't hear the vehicle coming or drivers not having the familiar audible clue that the vehicle is running. MST may consider providing incentives to encourage safe and efficient driving behaviors, in addition to the provided training.

Operations staff and planners will need to understand range limitations, seasonal impacts, and refueling/recharging times. Staff needs to know the proper response to different indicator lights, and know which notifications require immediate attention and which are informational or for diagnostics. For BEBs, the concept of state-of-charge (SOC) in place of fuel level must also be understood so operators, dispatchers, and schedulers can make the right decisions based on the SOC.

Chargers have their own set of training requirements in addition to the vehicles. This includes service, diagnostic, and repair training for maintenance personnel. Anyone responsible for vehicle charging (e.g., drivers, attendants) will also need training on the proper operation of the charger and the steps to connect and disconnect the charger and the vehicle. The level of training required will depend on the exact infrastructure that is used (e.g., pantographs vs. plug-in). Chargers present a new set of challenges for maintenance staff, particularly when both depot and en-route chargers are used since they may use different technologies and they won't be located at the same place.

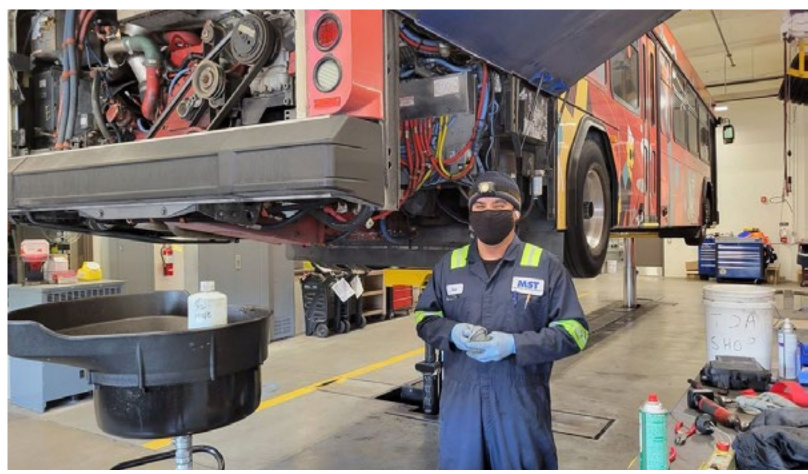
Hydrogen dispensing equipment will also require special training. The training will need to cover not only the operation of the dispensing equipment, but also service and maintenance. There are many auxiliary systems required to dispense hydrogen, including cryogenic storage tanks, vaporizers, and pumps that all must be dealt with following proper safety procedures.

The training required for external parties will be less intensive but is still very important. Emergency responders and third-party vendors such as towing operators will need to be familiar with high voltage and high pressure safety procedures, since there is the possibility they will need to interact with those systems on the vehicles. Emergency responders will also need specific training on the location and procedures for operating the high voltage disconnects on the battery packs. Other third-party vendors will need training specific to the operations they perform, such as the proper procedure to put the vehicle into "neutral" before towing.

Training Timing

Training needs to be completed before the new vehicles are deployed. Some training items may be scheduled just-in-time when vehicles are delivered. Introductory safety training, for example, will typically be less than an hour long and can be easily scheduled and performed on an as needed basis. However, other training that has a longer duration will need to be planned in advance of vehicle arrivals. For mechanics, it can be useful to train on the high-voltage and drivetrain systems of diesel hybrid buses if possible. These share several components with BEBs and FCEBs and can provide a training platform before these new technologies are available. Anything that allows for the initial training to be completed before the delivery of vehicles will accelerate the deployment timeline.

ZEB training will need to be a continuous and on-going part of normal operations. In addition to the initial orientation and safety training, special training may be needed for maintenance that occurs at different time periods including monthly, quarterly, annually, and even less frequent preventative maintenance. It is best for personnel to have recently completed the training they will need when they undertake these less frequent operations for the first time.
The size of the training program should also be scaled to match the size of the ZEB deployment. A small deployment may need fewer trained staff initially. The number of trained staff can be increased as the additional ZEBs are purchased. This provides the opportunity for those involved in the first round of training to become internal experts and develop customized training programs that are specific to MST that can be used for training the rest of the staff. The timing and ramp-up of training should correlate with the timing and ramp-up of the ZEB deployment.



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Potential Funding Sources

Funding

MST is intending to use a variety of funding sources to acquire zero-emissions vehicles and required infrastructure, including regional, state, and federal sources. Examples of funding sources are as follows:

- Transit and Intercity Rail Capital Program (TIRCP)
- Low Carbon Transit Operation Program (LCTOP)
- FTA Funds
  - » 5307 Funds
  - » Section 5339 Bus and Bus Facilities Program
  - » Low-No Program
- SB1 Local Partnership Program (LPP)
- Affordable Housing and Sustainable Communities Program (AHSC)
- Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP)
- Caltrans State of Good Repair (STA SOGR)

Other potential funding sources have been identified, but not included in the planned budget. These sources could be utilized at a future time to acquire either ZE vehicles or infrastructure.

- Volkswagen Environmental Mitigation Trust

Table 8: Anticipated Program Costs per Option

	BEB	Hydrogen Options: Centralized Generation – Electrolyzer	Hydrogen Options: Distributed Generation – Electrolyzer	Hydrogen Options: Truck and Tank – SMR
Infrastructure & Equipment Costs (in millions 2021 dollars)				
Vehicles	$59.75	$69.25	$69.25	$69.25
Chargers	$9.90			
Utility Infrastructure	$1.60			
Generation Plant		$22.40	$27.80	
Tanks and Dispensers		$9.50	$9.50	$9.50
Subtotal	**$71.25**	**$101.15**	**$106.55**	**$78.75**
O&M Cost (in millions 2021 dollars)				
Operating Costs	$23.32	$23.17	$23.17	$23.17
Vehicle Maintenance Costs	$5.05	$5.17	$5.17	$5.17
Plant Maintenance		$0.16	$0.49	
Fuel/Energy Costs	$1.44	$3.47	$3.47	$3.47
Subtotal	**$29.81**	**$31.97**	**$32.30**	**$31.81**

Start-up and Scale-up Challenges

The Road Ahead

The approach to building the zero emissions transition strategy is identified below. A key challenge is balancing the needs of MST with the limitations of emerging vehicle technologies, cost, complexity, and availability. The approach has four basic components as outlined below:

- Calculate how much energy is required to operate each vehicle block;
- Determine which of the existing blocks can be operate unchanged with today's vehicles;
- Identify the potential transition approaches for blocks that cannot be operated with today's vehicles;
- Create an infrastructure and procurement strategy that meet's MST's needs, ICT requirements, and is feasible with the technology available.

MST has learned there are still many unknowns and unexpected challenges to overcome. However, the strategy outlined below is intended to guide the agency through the transition period, allowing MST to use the technology that can provide the best level of service at the most competitive cost.

Strategy 1: Prioritize Battery Electric Buses (BEBs) for the near-term vehicle replacements, deployed on the routes/ blocks that can be served with vehicles available today.

Beginning in 2023 MST can prioritize vehicle replacements as BEBs, split evenly between the two depots. These vehicles would require the addition of two chargers located at each base (four total) and deployed on the routes/blocks that can accommodate a one-to-one replacement with diesel buses.

Strategy 2: Delay the final vehicle procurement decision for buses and cutaway vehicles starting in the 2027 and 2030 replacement rounds, allowing time for BEB technology to potentially increase in range and decrease in cost.

Delaying the decision can allow BEB technology to progress, and potentially allowing the technology to deploy on more routes. However, MST will need to identify the decision points that determine which technology will ultimately be used for the 2027 and 2030 vehicle purchases.

Strategy 3: Plan for Hydrogen Fuel Cell Electric Buses (FCEBs) as the alternative technology to BEBs for the 2027 and 2030 vehicle replacements.

The routes/blocks that cannot be served by a BEB should have a FCEB deployed instead. FCEBs will require additional infrastructure to deploy, and planning for that infrastructure can begin today. Planning for FCEB should recognize the following considerations:

- If possible, consolidate FCEBs into one base. This will lower the amount of infrastructure needed, reducing spatial requirements, redundancy, and cost.
- Plan for liquid hydrogen to be purchased from a third party. Hydrogen can potentially be manufactured on-site, but the energy, infrastructure, water source, space, and cost are prohibitive at this scale and location. Purchasing liquid hydrogen reduces the infrastructure to essentially storage tanks and dispensers.
- Fleet-wide transition to FCEB is not optimal, as the lower price of BEB vehicles and infrastructure should be considered. Additionally, FCEB vehicles and infrastructure should be given more time to mature before a full fleet transition should be considered.

Strategy 4: Monitor development of vehicle technology to best inform the decision on what to deploy in 2027 and beyond.

By monitoring the development of zero emissions technologies, MST can deploy the best possible technology available in terms of price, maturity, availability, reliability, fuel availability, and infrastructure needs.

It is important to note, the MST's ZEB Rollout Plan is a living document meant to guide the implementation of zero-emission bus fleets and help the agency work through many of the potential challenges to explore solutions. The Plan provides estimated timelines based on best available information for bus purchases, infrastructure upgrades, workforce training, or any other timelines in the Plan. MST may update the Plan as needed with the most current information and industry best practices.