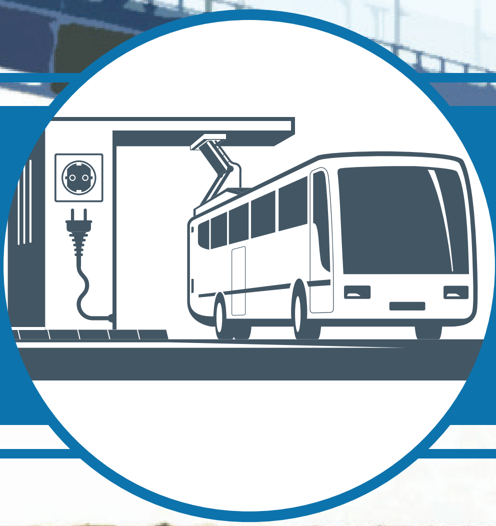


Cape Cod Regional Transit Authority

ZEV Fleet Transition Plan

Rev. 2 | November 7, 2023

11/7/2023	2		Emily Marble	Daniel Lang		
Date	**Rev.**	**Status**	**Prepared By**	**Checked By**	**Approved By**	**Approved By**
HATCH						**Client**

Table of Contents

1. Executive Summary

Cape Cod Regional Transit Authority (CCRTA) is a mid-sized regional transit authority providing transit service and paratransit service to 15 towns over 400 square miles on Cape Cod, Massachusetts. CCRTA, in consultation with the Cape Cod Commission, has committed to reduce its emissions and its fossil fuel dependence and is in the planning stages of transitioning its fossil-fueled mixed fleet to battery electric vehicles (BEVs). The Authority is dedicated to the mission; driving initiatives and regional collaboration to combat climate change and growing the acceptance of zero emission technology and supporting infrastructure on Cape Cod.

Over the past few years, CCRTA has begun acting on this mission with several key initiatives. Hyannis Transportation Center (HTC), which is owned by CCRTA, is the Authority's primary terminal and site to administrative and executive offices. In 2019, CCRTA installed 20 chargers at HTC for both staff and public use, which kickstarted the Authority's electrification plans. In 2023 CCRTA ordered 20 electric paratransit vans through the Massachusetts Department of Transportation (MassDOT) Mobility Assistance Program (MAP) procurement in further demonstration of their commitment to zero emission technologies. Those vehicles are scheduled to be delivered in fiscal year 2024. Charging infrastructure for those vehicles has been installed at the Authority's Operations and Maintenance Facility (the Depot).

Also in 2023, Hatch Associates Consultants, Inc. (Hatch) was contracted to support the Authority in the development of a zero-emission vehicle (ZEV) fleet transition plan and regional support study. As CCRTA looks ahead to full fleet electrification, a thorough analysis was conducted by Hatch to develop a transition strategy for the Authority that considered Environmental Justice (EJ) communities on Cape Cod. This report summarizes a fleet management plan, resource allocation, policy impacts, facility plans, utility partnerships, workforce development needs, emission reduction estimates, and resiliency recommendations that were determined by Hatch's analysis.

The analysis and subsequent Hatch recommendations serve to provide CCRTA with fleet and infrastructure asset configurations that will provide a feasible transition to battery electric drivetrain technologies while supporting the Authority's operational requirements and financial constraints. The equipment and infrastructure configurations recommended for CCRTA call for a total fleet size of 143 vehicles of which 127 are Battery Electric Vehicles (BEVs). The BEV fleet will be a mixed fleet consisting of battery electric buses (BEBs), cutaways, trolleys, and caravans. Procurement of 16 gasoline cutaways will be required to ensure viable operation for CCRTA's demand-response services, which have travel distances which exceed the capabilities of current BEV technology. Hatch also recommends CCRTA purchase four additional vehicles; a minimal increase in fleet size, to further offset BEV range limitations.

To support the recommended BEVs, CCRTA plans to procure, install, and commission 116 charging systems at the Depot that will have the capacity to support overnight charging of up to 146 vehicles simultaneously. In addition, recommendations call for early on-route charging infrastructure at HTC. The Authority plans to procure, install, and commission five on-route charging systems at HTC for use during service hours.

Industry best practice recommends partnership with electrical utilities to advance charging system installation goals. To follow this practice, CCRTA has maintained coordination with Eversource, the local utility. Through Eversource's Make Ready Incentive Program, the Authority has begun conceptual design work for the supporting charging infrastructure required at both the Depot and HTC. CCRTA is also working with the utility regarding existing power and future capacity requirements at these sites, and future, potential charging locations.

The proposed fleet transition strategy requires initial capital spending to reduce recurring cost and achieve other strategic goals. Overall, CCRTA will need to plan for a total of $79 million over the course of the 12-year transition period. This need is common to many transit projects and is representative of the transit industry, with nearly all bus and rail systems requiring capital investments up front to save money in other areas (traffic congestion, air pollution, etc.) and achieve broader societal benefits over the long term.

As mentioned, the primary motivation behind CCRTA's efforts to transition to BEVs is to achieve emissions reductions compared to their existing fossil-fueled operations. As part of this analysis, an emissions projection was generated for the proposed future battery electric fleet. The results of this emissions projection estimate that the new fleet will provide up to a 66% reduction in emissions compared to CCRTA's pre-electrification operations.

Beyond fleet, infrastructure, and emissions considerations, CCRTA is well positioned for continued development of staff skills necessary to maintain and operate BEVs over the transition period. This fall, CCRTA began conversations with two Cape Cod technical schools and the local community college regarding potential collaboration opportunities for curriculum, training, and hands-on learning. In addition, the Authority has been working to secure training for both operators and technicians in advance of the delivery of the 20 MAP vehicles.

In conclusion, BEVs can feasibly support CCRTA's operations. ZEV technology will reduce emissions and support achievement of the Authority's strategic goals over the long term. CCRTA is encouraged to continue with BEV procurement and infrastructure upgrades according to the timeline and strategy described in this transition plan while continuing efforts to monitor and apply for new funding opportunities through state and local entities to cover the increase in upfront capital cost that is not covered by the federal government's FTA and Low-No grants.

2. Introduction

CCRTA committed to transition a large portion of its fossil fuel powered fleet to ZEV technology by 2030. The overarching goal of this transition is to decrease the Authority's carbon footprint by reducing greenhouse gas (GHG) emissions. Regional plans such as the Cape Cod Regional Policy Plan (RPP), the Comprehensive Economic Development Strategy (CEDS), the Cape Cod Climate Action Plan, and the Regional Transportation Plan (RTP) all support steps required to expand ZEV access and use. In addition, the Massachusetts Clean Energy and Climate Plan for 2025 and 2030 calls for accelerating the electrification of fleet vehicles and investment in charging infrastructure.

Additionally, the Federal Transit Administration (FTA) currently requires that all agencies seeking federal funding for "Zero-Emissions" bus projects under the grants for Buses and Bus Facilities Competitive Program (49 U.S.C. § 5339(b)) and the Low or No Emission Program (49 U.S.C. § 5339(c)) have completed a transition plan for their fleet. Specifically, the FTA requires that each transition plan address the following:

- Demonstrate a long-term fleet management plan with a strategy for how the applicant intends to use the current request for resources and future acquisitions.
- Address the availability of current and future resources to meet costs for the transition and implementation.
- Consider policy and legislation impacting relevant technologies.
- Include an evaluation of existing and future facilities and their relationship to the technology transition.
- Describe the partnership of the applicant with the utility or alternative fuel provider.
- Examine the impact of the transition on the applicant's current workforce by identifying skill gaps, training needs, and retraining needs of the existing workers of the applicant to operate and maintain zero-emissions vehicles and related infrastructure and avoid displacement of the existing workforce.

In response to the Governor's Roadmap and the FTA requirements, CCRTA and its consultant, Hatch, have developed this fleet transition plan. In addition to the FTA requirements, this transition plan also addresses details on items like: CCRTA's future operations plans, current vehicle technology options, requirements for building electrical capacity, emissions impacts of the fleet transition, resiliency, and financial implications for the Authority.

3. Existing Conditions

The authority currently owns and operates both a revenue and non-revenue service fleet of 149 diesel and gasoline powered vehicles. These vehicles service both fixed and demand-response routes. Vehicles include standard 29' and 35' low-floor transit buses, mixed-sized cutaway vans, caravans, trolleys for seasonal service, and staff vehicles consisting of SUV's and one electric sedan. The authority also owns and maintains Council on Aging (COA) vehicles consisting of cutaways and caravans as well as taxis, however CCRTA does not operate these vehicles; these were not included in Hatch's analysis. As mentioned previously, the Authority has 20 Ford E-Transit 350 vans on order with expected delivery in fiscal year 2024. This group of vehicles will be CCRTA's first group of electric vehicles (EVs) however they were not included in Hatch's analysis due to the timing of the order. See Table 1 for a summary of CCRTA's current fixed route and demand response fleet.

CCRTA operates eight fixed service routes year-round and ten fixed service routes during the summertime with a mixed fleet of buses, cutaways, caravans, and seasonal trolleys. During winter months, the authority operates six days per week (Monday through Saturday) on seven of its eight fixed service routes with 'The Shuttle' operating on Friday, Saturday, and Sundays, only. During the summertime, from Memorial Day to Labor Day, CCRTA adds two fixed-route trolley services and expands all services to seven days per week. In May, CCRTA began a pilot program for the summer of 2023 to expand the Flex service to accommodate Provincetown restaurant and bar staff. This pilot program included "shoulder season" expansion, with this service starting prior to Memorial Day, and running past Labor Day. Except as noted otherwise, the remainder of this study considers seven-day service for all fixed-routes, during peak tourist season (summertime).

CCRTA provides a daily, public demand-response service called Dial-A-Ride Transportation (DART). DART is CCRTA's ride by appointment transportation service. DART runs across all of the Cape's 15 towns six days per week (Monday through Saturday), with limited service on Sunday. Daily hours of operation vary by town. Under the DART umbrella, CCRTA also provides an application-based, on-demand service called SmartDART. This service is currently available in Sandwich, Falmouth, Yarmouth, Barnstable, and Dennis. CCRTA has plans for potential SmartDART services in additional towns as well. CCRTA vehicles currently servicing both DART and SmartDART are the cutaways and vans.

Table 1 Current Fixed Route and Demand Response Fleet Summary

Vehicle Type	Fixed Route	Demand Response	Total
29' Bus	29		29
35' Bus	7		7
32' Trolley	5		5
21' Cutaway		31	31
23' Cutaway		3	3
26' Cutaway	8	34	42
28' Cutaway	14		14
Van		8	8

4. Vehicle Technology Options

As discussed in Section 3, CCRTA's revenue service fleet is composed of standard 29' and 35' low-floor transit buses, mixed-sized cutaway vans, caravans, and trolleys for seasonal service. Since CCRTA operates a mixed fleet, in the context of zero emission transition planning, it may pose a constraint on the number of possible vendors available to CCRTA.

For BEBs, battery capacity can be varied on many commercially available bus platforms to provide varying driving range. There is not as much flexibility with battery capacity in smaller transit vehicles, and electric trolleys have comparatively limited battery capacity. Beyond range, all categories of EVs may have limitations related to size, weight, and passenger capacity that fossil-fueled versions do not have. For example, because of the weight of the battery, electric vans can typically accommodate eight ambulatory passengers and only one wheelchair (as opposed to two wheelchairs on a gasoline van) while staying under Gross Vehicle Weight Rating (GVWR) limits.

Batteries are low-density means of energy storage that do not provide the same vehicle range as gasoline or diesel fuel. In addition, seasonal factors affecting range become much more significant after a transition to EVs. Even when diesel heaters are installed in battery electric buses, as was assumed in this study, icy road conditions and cold temperatures degrade the performance of the vehicles. In the case of cutaways and smaller vehicles typically used by CCRTA, auxiliary heaters are not an option. Although practices to extend range like pre-conditioning the vehicles before leaving the Depot are recommended, winter conditions will present challenges to EV operation. CCRTA's operating model will need to account for these limitations as service must operate year-round.

Table 2 summarizes the advertised battery capacity and the corresponding usable battery capacity for the vehicle types that were analyzed as part of this study. Two types of safety margins were subtracted from the nominal battery capacities of the BEVs. First, the battery was assumed to be six years old (i.e., shortly before its expected replacement at the midlife of a bus or trolley, or the retirement of a cutaway or van). As batteries degrade over time, their capacity decreases, so the battery capacity was reduced by 20% to account for this. Second, the BEV was assumed to need to return to the garage before its level of charge falls below 20%. This is both a manufacturer's recommendation (batteries have a longer life if they are not discharged to 0%) and an operational safety buffer to prevent BEVs from becoming stranded on the road. Combining these two margins yields a usable battery capacity of 64% of the nominal value. Finally, as the industry is advancing quickly and technology continues to improve, a 3% yearly improvement in battery capacity was assumed.

Table 2 Vehicle Battery Capacity and Usable Capacity Assumptions

Vehicle Class	Advertised Battery Capacity (kWh)	Usable Battery Capacity (kWh)	Usable Range (miles)
Bus	492	314.88	156
Cutaway	157	100.48	79-114[1]
Trolley	127	81.28	54
Vans	120	76.80	91

Although the market is changing quickly, and within the next few years more diverse electric bus, mini-bus, and van models are likely to be introduced, Hatch recommends that CCRTA consider broadening its specifications where possible to allow the largest possible range of vendors to participate; expanding the pool of competing vendors by considering such vehicles will likely save CCRTA money and could increase parts commonality with the fixed-route fleet.

[1] The usable range for electric cutaways is represented with a mileage range because CCRTA operates seasonal services with cutaway vehicles; some routes using cutaways are operated during the summertime only. Those vehicles operated during the warmer months have longer range than those operated during the wintertime.

To maintain a fair comparison, however, this analysis assumes that the existing fleet will be replaced during its expected retirement year with the same vehicle type as operated now. Although the recommended final fleet size is marginally higher than CCRTA's fleet size today, the increased reliability of EVs and expected 12-year and 7-year replacement cycle (compared with some of CCRTA's existing vehicles which are operating well past their retirement years) will contribute to improved vehicle reliability and reduced spare factor.

Refer to Appendix A for a complete list of existing CCRTA vehicles by type and class, and the electric conversion equivalent. This list provides purchase cost of the electric equivalent as well as seating capacity. Note that this list is not a comprehensive list of what is available on the market, nor is Hatch recommending certain manufacturers or vendors. This list is to provide CCRTA with market options to guide vehicle specification and procurement.

5. Infrastructure Technology Options

Like BEVs, several market options for charging infrastructure exist dependent on the type of vehicle, and the vehicle's service level requirements. There are two primary types of chargers that are applicable to CCRTA's fleet – Level 2 chargers, which are common in consumer applications, and DC fast chargers, most often applied toward heavy-duty vehicles. These differ in several key respects, primarily the type of power supplied.

Power distributed by electrical utilities, both at high voltages in long-distance transmission lines and low voltages in conventional wall outlets, is alternating current (AC), while batteries on vehicles use direct current (DC). Smaller vehicles, that require lower power levels, generally accept both types of power and have onboard rectifiers to convert AC input to DC. Accepting AC power reduces the cost of charging equipment. For larger vehicles the required rectifier would be too heavy, so the conversion to DC is conducted within the charger. This has a significant impact on the power levels each type of charger supplies.

The charging power provided by Level 2 chargers can range from 3.1kW to 19.2kW. Typical consumer grade chargers incorporate 6.24 kW of power while commercial grade chargers are available at 19.2 kW charging rates. Examples of such a system are shown in Figure 1.

Figure 1: Example Commercial Level 2 Charging Systems (Source: FLO & Blink)

BEBs typically require DC fast chargers (DCFCs) as transit buses are usually not equipped with an on-board transformer that would allow them to be charged with Level 2 AC chargers.

DCFCs, which can provide up to 450 kWh of power, typically come in two types of configurations:

1. Centralized
2. De-centralized

A decentralized charger is a self-contained unit that allows charging one vehicle per charger. The charging dispenser is typically built into the charging cabinet. These are typically suited to small-scale charging applications. In contrast, in a centralized configuration, a single high-power charger can charge multiple vehicles through separate dispensers. The power is assigned to the dispensers dynamically based on the number of vehicles that are charging at the same time. These are best applied to large charging stations, such as those that would be installed in a bus depot for overnight charging.

Examples of both configurations are shown in Figure 2.

Figure 2: Example Charging Systems

Left – Charging Cabinet (System) and Three Dispensers (Charge Boxes)

Right – Overhead Pantograph Charger and Centralized Cabinets

(Source: ABB)

Different types of charging infrastructure will be needed dependent on the charging location's requirements and capacity. For CCRTA's operations, Hatch recommends installing 19.2 kW Level 2 chargers and 150 kW three-dispenser DCFCs at the Depot for overnight charging. CCRTA's cutaway vehicles can be charged with Level 2 chargers or DCFCs, dependent on their specific service routes and the amount of time they have to charge. The Authority's vans and other smaller vehicles would be charged with Level 2 chargers while the BEBs must be charged with DCFCs. In addition, Hatch recommends future DCFCs for three on-route locations where high-speed charging is necessary to meet CCRTA's operational needs. At the on-route locations, all of the CCRTA vehicles would be charged during the day using DCFCs. These charging stations and on-route charging specifications are discussed in more detail in Section 6.2.

There are many options for charging equipment and CCRTA will most likely want to go through proper evaluation prior to finalizing procurement orders with vendors. In addition, CCRTA will be required to procure equipment from Eversource's qualified product lists (QPL) that are qualified to be eligible for rebates under the Make Ready Incentive Program. Refer to Appendix B for Eversource's QPL.

6. Route Planning

6.1 Operational Simulation

Because of the energy density of fossil fuel, transit operations do not need to account for fossil fuel vehicle's limitations. Vehicles can operate on a single tank of fuel for several hundred miles – sufficient for all but the most extreme transit services – and refueling only takes several minutes when it is required. This is not true for EVs, which cannot travel the same distances and require substantially more time to recharge. Although CCRTA's primary mission is to provide reliable and efficient service to its passengers, as the authority electrifies its fleet, operations will have to change to accommodate the limitations imposed by today's EV technology.

A simulation was conducted to predict how EVs would perform on CCRTA's fixed routes and demand-response services and to assess how range limitations may affect operations. A simulation is necessary because vehicle range and performance metrics advertised by manufacturers are maximum values that ignore the effects of gradients, road congestion, stop frequency, driver performance, severe weather, and other factors specific to Cape Cod's operations.

CCRTA's network was analyzed on a route-by-route basis through the creation of "drive cycles" for several routes representing the authority's typical modes of fixed-route and demand-response operation, ranging from slower-speed urban routes to higher-speed routes through more rural areas. For each representative route, the full geography (horizontal and vertical alignment), transit infrastructure (location of key stops and transit hubs), and road conditions (vehicle congestion, traffic lights, stop signs, crosswalks, etc.) were modeled. The performance of BEVs was simulated in worst-case weather conditions to create a drive cycle. These CCRTA-specific drive cycles were used to calculate battery energy consumption per mile. This analysis provided information regarding the total battery energy consumed by a vehicle on each route. The vehicles utilized for simulation were electric transit buses, cutaways, and trolleys, as appropriate for the route and the same size or similar to the fossil fuel vehicles currently operated on each route.

6.1.1 Fixed Route

CCRTA's summer Friday fixed-route operations were modeled because they represent both the most intensive service and the highest level of traffic congestion. Note that the Flex 2023 pilot program discussed in Section 3 was not considered in the operational analysis. In each case, the vehicles were assumed to depart from their origin locations (either the Depot in Dennis or the seasonal "park-out" location in Provincetown) with a full battery and operate their entire schedule for the day. The remaining battery energy (accounting for the safety factors outlined above) was tracked over the course of the day. The remaining energy in each vehicle's battery at the end of the day is shown in Table 3, with blocks (sequences of trips operated by a given vehicle over the course of one day) suitable for electrification shown in black font and those unsuitable shown in red font.

Table 3 Fixed Route Block Energy Requirements

Route	Block	Mileage	kWh Req'd	Mileage Excess / Shortage	Vehicle Type
Sealine	120	148.62	296.16	9.27	Bus
	121	148.62	296.16	9.27	Bus
	122	148.62	296.16	9.27	Bus
	123	148.62	296.16	9.27	Bus
	124	148.62	296.16	9.27	Bus
	125	148.62	296.16	9.27	Bus
	126	83.51	164.64	74.38	Bus
	127	148.62	296.16	9.27	Bus
H2O	200	187.48	372.46	-28.51	Bus
	201	142.71	283.13	15.72	Bus
	202	187.48	372.46	-28.51	Bus
	203	187.48	372.46	-28.51	Bus
	204	177.48	354.46	-19.59	Bus
	205	142.71	283.13	15.72	Bus
	206	187.48	372.46	-28.51	Bus
	207	142.71	283.13	15.72	Bus
Provincetown Shuttle (Truro)	300	191.83	386.07	-35.24	Bus
	301	145.54	292.98	10.84	Bus
	303	130.63	260.24	27.05	Bus
Provincetown Shuttle (Beaches)	306	104.62	92.66	9.09	Cutaway
	308	104.62	92.66	9.09	Cutaway
Barnstable Villager	400	117.76	146.38	-36.14	Cutaway
	402	84.46	104.14	-2.88	Cutaway
	403	73.72	90.45	7.90	Cutaway
Hyannis Crosstown	410	90.57	111.90	-8.99	Cutaway
	411	49.33	59.52	32.25	Cutaway
Sandwich	500	140.29	171.57	-55.98	Cutaway
	501	153.72	192.10	-72.14	Cutaway
	502	153.72	192.10	-72.14	Cutaway
	503	140.29	171.57	-55.98	Cutaway
Flex	600	66.55	133.00	90.04	Bus
	602	217.28	437.06	-60.48	Bus
	603	112.84	226.09	43.96	Bus
	604	217.28	437.06	-60.48	Bus
	608	217.28	437.06	-60.48	Bus
	610/ 611	324.52	653.07	-167.42	Bus
	612/ 613	361.12	725.11	-203.08	Bus
Bourne	700	164.00	200.63	-78.86	Cutaway

Route	Block	Mileage	kWh Req'd	Mileage Excess / Shortage	Vehicle Type
	701	164.00	200.63	-78.86	Cutaway
	702	200.85	246.22	-114.76	Cutaway
	703	141.35	170.66	-55.26	Cutaway
	704	141.35	170.66	-55.26	Cutaway
	705	141.35	170.66	-55.26	Cutaway
CapeFlyer	**717**	77.00	100.30	0.14	Cutaway
Hyannis Trolley	**800**	67.00	98.23	-11.22	Trolley
	801	50.80	73.76	4.98	Trolley
Whoosh Trolley	**900**	136.64	196.89	-76.56	Trolley
	901	110.76	157.81	-50.68	Trolley

Following the same assumptions, the decline in battery energy levels over the course of the day is presented in Figure 3 below. The lines that cross zero and enter into negative battery energy levels represent the vehicles that cannot make it through the day on a single charge.

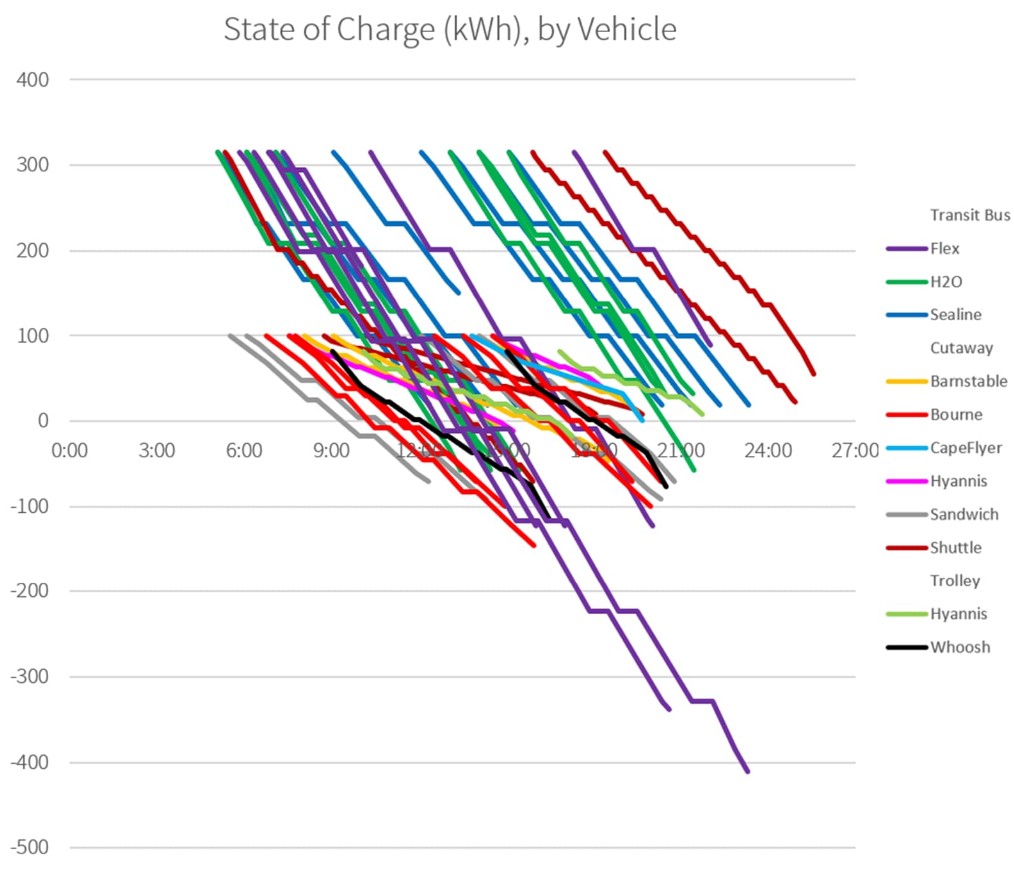


Figure 3 - Battery Energy Levels by Vehicle Over the Course of the Day

Simulation results showed that of the 48 blocks modeled, 27 would be unsuitable for a full day of EV service with no other operational changes. In particular, the longer-distance routes operating cutaways (Bourne and Sandwich), as well the Flex route, present challenges for operation due to insufficient range of the BEVs. The two fixed route blocks least amenable for BEV conversion are the two Flex route blocks that incorporate a "hot-seat" (mid-trip driver swap), because these vehicles remain in service for the entire duration of two, full driver shifts.

For the 21 blocks modeled that were found feasible for BEV operation, no operating changes are required for deployment of zero-emissions vehicles. For the remaining blocks, however, operational changes are necessary, as described in Section 6.2.

6.1.2 Demand-Response

Demand-response service is, inherently, more difficult to model because passenger demand is unpredictable and changes each day. To assess the suitability of EVs for CCRTA's DART operations, a representative sample of trips was modeled as described above. The calculated vehicle energy consumption per mile was multiplied by the mileage for each trip to determine how much energy would be required to complete the trip. The remaining battery energy at the end of the day was computed for each vehicle, as shown in Table 4 below. Trips that could be served by today's EVs are shown in black font, while those that could not are shown in red font.

Table 4 Demand Response Sample Trips Energy Requirements

Block	Mileage	kWh Available	kWh Required	Mileage Excess / Shortage
B16	87	100	95	5.05
B27	120	100	130	-27.33
B51	130	100	141	-37.34
B54	175	100	190	-82.51

Similar to the fixed-route services, operational changes will be needed to accommodate EV operation on the majority of demand-response blocks. These changes are discussed in the following section.

6.2 Operational Alternatives

When a new vehicle type is introduced without sufficient range to serve the blocks it is intended for, there are several operations strategies authorities can implement to maintain the same level of service. The simplest operating strategy – although not considered further in this report – is changing the vehicle type to one with higher range. For example, CCRTA could choose to replace a cutaway shuttle with a transit bus, which has three times as much battery capacity. Although this can provide a dramatic increase in vehicle range, there are several associated downsides. First, larger vehicles have higher capital and operating costs than smaller vehicles. CCRTA's current selection of vehicle types is generally optimized for the passenger loadings on each route, so using a larger-than-required vehicle would increase cost and result in the operation of mostly empty vehicles. Also, smaller vehicles can operate on routes that are too space-constrained for larger ones. For these reasons, changes to vehicle type were not considered to mitigate vehicle range limitations.

Aside from changing vehicle type, there are several other strategies that CCRTA can use to address the range limitations of EVs. High level options are:

+ Shortening blocks
+ Rearranging blocks to let vehicles charge at the Depot midday, and
+ Installing on-route charging so vehicles can charge throughout the day

Shortening blocks is the solution most like CCRTA's present operations. Today, most CCRTA vehicles operate for up to 8-10 hours to avoid excessively long driver shifts. Routes are generally served by two sets of blocks, with the first set operating between approximately 6am and 2pm and the second set from 2pm to 10pm. To accommodate EVs, this block structure could be revised, so that each block operates for only six hours (with a corresponding decrease in daily mileage). Although this solution would be simplest for dispatchers and operators, it would require introducing a third set of blocks to maintain a full day of operation. Accordingly, the number of required drivers would increase significantly, impacting CCRTA's labor costs and further stressing an already constrained labor pool. Therefore, this solution was not considered further.

A third potential solution involves rearranging blocks to provide charging windows at the Depot throughout the day. The primary advantage of such an approach is that, as with the previous strategy, charging infrastructure is only required at the Depot. Also, if optimally scheduled, the number of additional drivers required would be less than for the first alternative, because most shifts would still be eight hours long. However, because EVs require long charging windows, and because the Dennis operating facility is far away from most routes' terminals, sending vehicles to the Depot to charge mid-shift would be time-consuming. This would require a large number of additional vehicles, and drivers, to maintain service while other vehicles are charging at the Depot. Because of these inefficiencies and associated costs, this alternative was not considered further.

The final operating strategy – installation of on-route charging at route terminals – allows vehicles to remain in revenue service for a full eight-hour shift. Although on-route charging is insufficient to let vehicles maintain a constant state of charge throughout the day, it can provide enough additional battery energy for vehicles to avoid needing to return to the Depot early. If available layover times are sufficient, existing operations can be maintained with no scheduling changes. However, particularly in a traffic-congested area like Cape Cod, this reliance on layover time poses significant risks. Because vehicles will no longer be able to truncate their layover time to recover from schedule delay (for fear of running out of battery energy mid-route), dispatchers will need to carefully monitor vehicles' battery energy levels to determine how much charging is required, and schedules will need to be written with sufficient safety margin to allow some charging to occur even if the vehicle arrives at the terminal behind schedule. Despite these potential risks, on-route charging is the recommended operating strategy for CCRTA's fixed-route operations.

For demand-response services, there is a similar range of operational mitigations that can be used to overcome vehicle range limitations. As stated previously, most demand-response vehicles operate further than today's EVs can travel on a single charge. CCRTA could choose to shorten the trip length of each vehicle, distributing the same number of requested trips among a larger number of vehicles (and drivers). The Authority could also shuffle vehicles to and from the Depot throughout the day, perhaps during the driver's lunch break. However, each of these solutions would require additional capital and operating resources to deliver the same level of service. A third option, which would require fewer (or no) additional vehicles, would be to charge vehicles at locations around the Cape during their drivers' lunch breaks. This would give each vehicle additional range. While this would not be sufficient for full electrification of the demand-response fleet, it would allow a majority of the fleet to be converted to zero-emissions operation. The remaining vehicles could remain fossil fueled vehicles or could be replaced with EVs and have their trip lengths shortened as necessary. For the purposes of this study, on-route charging was selected for demand-response services as well, with some vehicles remaining fossil fuel powered to mitigate range issues on the longest runs.

6.2.1 On-Route Charging Locations

With on-route charging selected for both fixed-route and demand-response operations, a key decision is the selection of on-route charging locations across the Cape. This requires examining both fixed-route and demand-response operations.

For fixed-route operations, on-route charging is only appropriate at a small number of locations. Because stopping a vehicle mid-route, with passengers onboard, for charging is infeasible and inconvenient, charger installation is only practical at route terminals and overnight parking locations. Figure 4 below shows the main hubs on CCRTA's fixed-route network.

Demand-response operation, however, has no fixed terminals where on-route chargers can be installed, as each vehicle's combination of trips served differs from day to day. Across the CCRTA service area, however, there are several areas of concentrated demand-response ridership. This is due to the distribution of population; especially the transit-dependent population. Because these areas are likely to be near where drivers take their mid-shift lunch breaks, it is logical to consider these areas for installation of charging stations. The heatmap in Figure 4 below, created from the representative sample of demand-response trips used for this study, shows these high-ridership areas across the Cape.

The terminals for fixed route operations shown in Figure 4 on the left are:

- Provincetown
- Orleans
- Harwich
- Dennis
- HTC
- Mashpee
- Falmouth
- Bourne

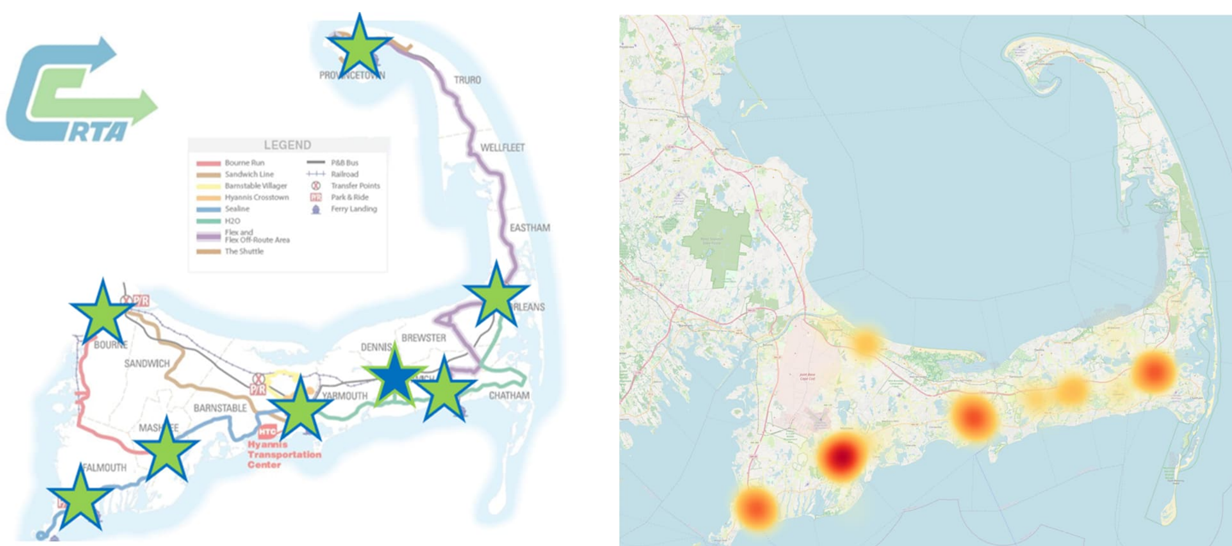


Figure 4 Fixed Route Operation Terminal Locations (left), Demand Response Trip Heat Map (Right)

Comparing the left and right image in Figure 4 shows that there is significant overlap between the terminals for fixed-route operation and the areas of highest demand-response ridership. This aligns closely with the densest areas on Cape Cod and allows the selection of several charging locations to serve the entire breadth of the Cape.

Hyannis

Hyannis, the primary hub for fixed-route operation and a key base for DART ridership, is an obvious place for a charging station. HTC is already owned by CCRTA and has the available real estate for installation of charging infrastructure. As mentioned, there are currently 20 Level 2 chargers (ten dual head Level 2 chargers) for both CCRTA, and public use located at the site. In addition, CCRTA applied for Eversource's Make Ready Incentive Program and has plans to expand charging infrastructure at the terminal which would enable on-route charging for both fixed route and DART vehicle use. Eversource's approved contractors, Maverick Electric Vehicle Services (Maverick), provided proposed design drawings for HTC which are discussed in more detail in Section 9.

Mashpee

Mashpee, as the largest hub of demand-response operation and the terminal of the Bourne fixed route, is another clear candidate for a charging station. However, unlike Hyannis, there is no CCRTA-owned land in the area; therefore, installation of any charging station will require negotiation with local landowners. Fortunately, Mashpee Commons – the large mall that serves as the area's commercial hub – has ample parking space available where chargers could be installed and is already the site of multiple charging stations for personal vehicles. Eversource confirmed the presence of existing transformers and services in the general vicinity that could be used to feed EV charging.

Provincetown

On the other end of the Cape, Provincetown is a strategically important node for CCRTA operations. Although it does not see high demand-response activity, it is far enough from other areas of the Cape that a demand-response vehicle would likely be unable to complete a full day of service that includes a round trip to Provincetown. Additionally, it is the terminal for the Flex and Shuttle routes and sees vehicles "parked out" overnight during the summer season. For these reasons, it is an important area for installation of a charging station for both midday and overnight use. For midday use, it is important that the chargers be located close to the terminal at MacMillan Pier, so that vehicles (particularly on the Flex route) can charge during short layovers. According to Eversource, there are several existing utility services in this area.

For overnight use, however, the charging station needs to be in a secure location and needs to be large enough to accommodate several vehicles charging at once, including spare vehicles that may remain there during the day. Because of the busy nature of downtown Provincetown, identifying a location that meets all of these requirements is challenging, and will require discussion with the Provincetown municipal government and the local community. For the purposes of this study, the town wastewater treatment plant on Route 6 was selected as a conceptual charging location; however, CCRTA is encouraged to review all possible locations in the area before beginning construction.

Falmouth

Falmouth and the Woods Hole area also see concentrated demand-response ridership and are the terminals of the Sealine and the Whoosh trolley. The trolley route, in particular, poses challenges for EV operation because CCRTA does not currently own or operate any charging infrastructure along this route and because electric trolleys have limited battery capacity. However, given the proximity to the Mashpee charging station and the seasonal, one-vehicle nature of the Whoosh service, it is likely uneconomical for CCRTA to build a separate charging station in the area. Instead, demand-response vehicles could deadhead to Mashpee when necessary to charge during the driver's lunch break, and the Whoosh trolley could use the Steamship Authority's nearby Palmer Avenue Parking Lot in Falmouth for charging. Eversource confirmed that existing infrastructure around the Palmer Lot is limited however there is possibility to bring new service to feed EV chargers. CCRTA is encouraged to negotiate with the Steamship Authority to arrange this access before electrifying the Whoosh route as well as coordinate for potential partnerships, access, and future, shared charging infrastructure.

These four charging locations, together with the Depot, are expected to provide adequate coverage across the Cape to support CCRTA operations. Although some operating changes will still be required, because of short layover times or to let DART vehicles deadhead to a charging location midday, such a charging network will help ensure CCRTA's smooth transition to an electric fleet.

6.2.2 Fixed-Route Operations with On-Route Charging

With the charging locations (Hyannis, Mashpee, Provincetown, and Falmouth) identified, the feasibility of electrifying CCRTA's fixed-route service could be reassessed. For this study, changes to passenger-facing schedules were not considered; all changes were assumed to only affect vehicle assignment to existing passenger trips.

With the charging locations listed above, each fixed route would have access to a charger near (for the trolley and Flex routes) or directly at (for all other routes) one of its terminals. Given this access, charging windows were allocated throughout the day to correspond to vehicles' layover times at those terminals. Deadhead time was considered when the chargers were not located directly at terminals, charging time reduction factors were considered to account for delays due to traffic congestion, and charge rate reduction factors were included to account for charging rate ramp-up and ramp-down, and other factors. Accounting for these reduction factors, charge rates of 60 kW and 150 kW were assumed for cutaways and transit buses, respectively, instead of the maximum possible rates of 80 kW and 220 kW respectively.

In some cases, simply replacing fossil fueled vehicles with the electric equivalents available today, and adding on-route charging during layovers, would still not allow a full day of operation. Several mitigation strategies were used in these cases. For those blocks where vehicles would have nearly enough energy to complete a full shift, the most practical option is to defer procurement of vehicles for those routes. Because CCRTA will not be replacing its entire fleet in one year, and because battery capacity has been improving at approximately 3% annually, it is often more practical to wait several years to replace vehicles on a certain route than to purchase additional vehicles (or chargers) to cover a small deficit in battery capacity. For this analysis, vehicles on the Sandwich, Flex, Barnstable Villager, and Whoosh routes were assumed to have battery capacities expected in 2025, 2027, 2030, and 2032 respectively, aligning with the estimated procurement timelines detailed below. For larger deficits in battery capacity, some shuffling of trips between blocks can increase electrification feasibility. For example, in the current schedule block #500 is scheduled to make one and a half round trips on the lengthy Sandwich route, with limited layover time at HTC. Accordingly, it is expected to be unable to complete its full shift. At the same time, block #402 is scheduled to operate on the Barnstable Villager route, which is less energy-intensive and has frequent layovers at HTC. Reassigning the first half-round trip on the Sandwich route from block #500 to block #402 can, therefore, make #500 feasible for EV operation without extending #402 beyond the maximum range of a cutaway vehicle. For the most substantial energy deficits, where such adjustments are insufficient, additional vehicles were assumed to be added to those routes, enabling all vehicles on those routes to dwell longer at the terminal and thus make more use of on-route charging. For the Sandwich, Bourne, and Flex routes, this analysis assumed two, one, and one additional vehicle respectively.

With these operating changes implemented, all fixed-route vehicles are able to complete a full shift of service, as shown in Figure 5:

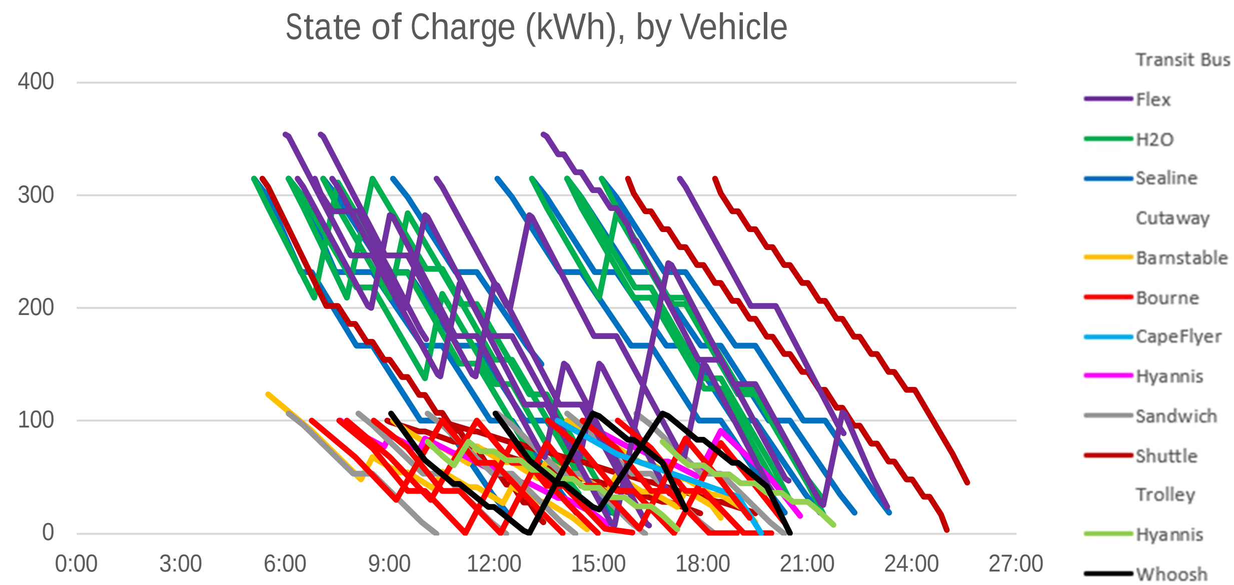


Figure 5 Battery Energy Levels by Vehicle Over the Course of the Day with On-Route Charging

To accommodate fixed-route operation, two chargers would be required at HTC and at Mashpee. Only one charger would be needed for daytime use at Provincetown, but two chargers (three dispensers each) would be required for overnight park-out during summer months. At Falmouth, use of one Steamship Authority-owned charger would be needed.

6.2.3 Demand Response Operations with On-Route Charging

Demand-response operations can be modeled similarly to fixed-route services. Once the duration of each representative block's lunch break is determined, the energy gained from charging during that break can be calculated, and the proportion of vehicles suitable for electrification estimated.

As for fixed-route service, the energy gained through charging must be conservatively estimated to account for required deadheading to and from the charging location, traffic congestion, and other sources of variability. For this analysis, a DC fast charging rate of 80 kW was assumed for half of the duration of the lunch break of each representative block. Table 5 below shows the remaining battery energy for each block after lunchtime recharging is accounted for.

Table 5 Demand Response Sample Trip Energy Requirements with On-Route Charging

Block	Mileage	kWh Available	kWh Required	Lunch Duration	kWh Gained During Lunch	Reduced kWh Required	Mileage Excess / Shortage
B16	87	100	95	49 min	33	62	35.47
B27	120	100	130	55 min	37	93	6.89
B51	130	100	141	96 min	64	77	21.64
B54	175	100	190	64 min	43	147	-42.88

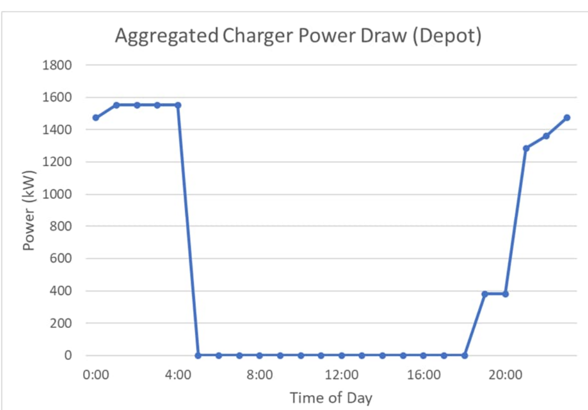
To accommodate demand-response operation, approximately three chargers each would be needed at both Hyannis and Mashpee, yielding a total of five chargers at each location. Table 6 shows the total required chargers by location, and type. These chargers are strategically laid out based on the needs of the operation. For example, dedicated single dispenser chargers are specified to ensure maximum charging during layovers and operator breaks. In comparison, high-power Level 2 chargers are recommended at the Depot for cutaway vans as regular, dual-head Level 2 chargers would not have sufficient power.

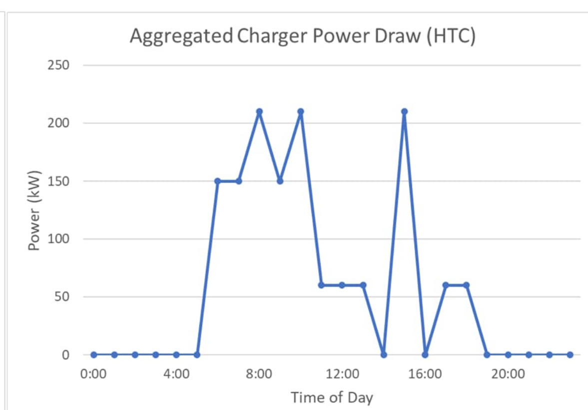
Table 6 Summary of Total Required Chargers

	Depot	HTC	Provincetown	Mashpee	Total
19.2 kW Level 2	101				101
150 kW DCFC (3 Dispensers)	15		2		17
100 kW DCFC (Single Dispenser)		3		5	8
300 kW DCFC (Single Dispenser)		2	1		3
Total	116	5	3	5	

7. Charging Schedule and Utility Rates

Developing a charging schedule is recommended practice while developing a transition plan as charging logistics can have significant effects on bus operations and costs incurred by the Authority. From an operational perspective, charging buses during regular service hours reduces vehicle availability and adds logistical complexity. Developing charging profiles also helps provide the peak load requirements for the site to determine the utility upgrade requirements and is used to calculate the utility costs. Therefore, the charging profiles were developed for each of the four locations based on the fleet composition and the operating schedules. Figure 6 below shows the charging profile for each of the four locations.





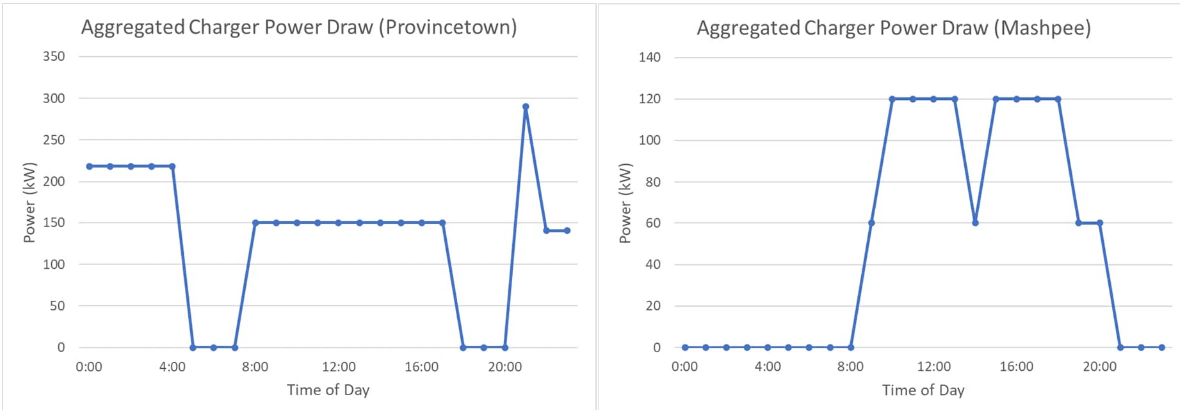


Figure 6 Charging Profiles by Location

The above charging profile was combined with the utility rates outlined in Table 7 to determine the cost of charging. This is the utility rate that will apply to CCRTA's EV charging operations under the Eversource Make Ready Program. Under this rate structure CCRTA pays a flat "customer charge" monthly, regardless of usage. The Authority also pays a single demand charge of $3.33 per kW for the single highest power draw (kW) that occurs during each month. Moreover, there will be a single transmission charge of $15.75 that is applied to the location's power draw (kW) during periods when Eversource's grid load is peaking, termed the 'coincidental peak'. Finally, CCRTA is charged an 'energy delivery charge' of $0.03052 per kWh. In addition to these delivery charges, CCRTA will be charged an 'electricity rate' of $0.1235 per kWh which is the cost of the energy consumed. At the time of this report, Nextera Energy services was CCRTA's energy supplier. Therefore, Hatch determined the 'electricity rate' from the most current utility bill provided by CCRTA. This rate is assumed to be the rate that Nextera currently charges CCRTA. These costs are recurring and are dependent on the amount of energy the Authority uses throughout the month.

Table 7 - Utility Delivery Rates

Customer Charge	$930.00 per month
Demand Charge	$3.33 per non-coincidental peak kW (calculated monthly)
Transmission Service Charge	$15.74 per coincidental peak kW (calculated monthly)
Delivery Charge	$0.03052 per kWh
Electricity Rate	$0.12350

Below is an estimate of expected operational costs associated with the proposed charging schedule, based on the above rates.

Depot

Daily kWh consumption = 9,562 kWh
Monthly Non-coincidental peak = 1301 kW
Monthly coincidental peak = 0 kW

$$Daily\ Charge = Daily\ kWh\ consumption \times (Energy\ Delivery\ Charge + Energy\ Cost)$$

$= 9{,}562\ kWh \times$ ($0.03052 + $0.1235)
= $1,472.74

$Monthly\ Charge$

$= (Monthly\ Non-coincidental\ Peak\ \times Distribution\ Charge)$
$+ (Monthly\ Coincidental\ Peak\ \times Transmission\ Charge)$
= (1,301 kW × \$3.33) + (0 kW × \$15.74)
= \$4,332.33

HTC
Daily kWh consumption = 699 kWh
Monthly Non-coincidental peak = 233 kW
Monthly coincidental peak = 233 kW

$Daily\ Charge =$
$Daily\ kWh\ consumption\ \times (Energy\ Delivery\ Charge + Energy\ Cost)$
= 699 kWh × (\$0.03052 + \$0.1235)
= \$107.66

$Monthly\ Charge$
$= (Monthly\ Non-coincidental\ Peak\ \times Distribution\ Charge)$
$+ (Monthly\ Coincidental\ Peak\ \times Transmission\ Charge)$
= (233 kW × \$3.33) + (233 kW × \$15.74)
= \$4,443.31

Provincetown
Daily kWh consumption = 2693 kWh
Monthly Non-coincidental peak = 323 kW
Monthly coincidental peak = 167 kW

$Daily\ Charge =$
$Daily\ kWh\ consumption\ \times (Energy\ Delivery\ Charge + Energy\ Cost)$
= 2693 kWh × (\$0.03052 + \$0.1235)
= \$414.78

$Monthly\ Charge$
$= (Monthly\ Non-coincidental\ Peak\ \times Distribution\ Charge)$
$+ (Monthly\ Coincidental\ Peak\ \times Transmission\ Charge)$
= (323 kW × \$3.33) + (167 kW × \$15.74)
= \$3,704.17

Mashpee
Daily kWh consumption = 807 kWh
Monthly Non-coincidental peak = 133 kW
Monthly coincidental peak = 133 kW

$Daily\ Charge =$
$Daily\ kWh\ consumption\ \times (Energy\ Delivery\ Charge + Energy\ Cost)$
= 807 kWh × (\$0.03052 + \$0.1235)
= \$124.29

$Monthly\ Charge$
$= (Monthly\ Non-coincidental\ Peak\ \times Distribution\ Charge)$
$+ (Monthly\ Coincidental\ Peak\ \times Transmission\ Charge)$
= (133 kW × \$3.33) + (133 kW × \$15.74)
= \$2,536.31

8. Asset Selection, Fleet Management and Transition Timeline

With operational and charging plans established, it was then possible to develop procurement timelines for infrastructure and vehicles to support those plans. CCRTA, like almost all transit agencies, acquires buses on a rolling schedule. This helps to keep a low average fleet age, maintain stakeholder competency with procurements and new vehicles, and minimize scheduling risks.

The vehicle procurement timeline outlined in Table 8 and Figure 7 takes into account vehicle age, current vehicle mileage, and CCRTA's Ten Year Strategic Plan and Supporting Five Year Capital Plan. It is recommended that CCRTA consolidate the procurement timeline as outlined below. There will be a spike in EV procurement in 2024 to kick start the transition. This is also due to the fact that there are a large number of CCRTA vehicles that are past due for replacement. The number of EVs recommended for procurement in 2024 does not take into account the 20 MassDOT MAP vehicles arriving for CCRTA use in fiscal year 2024.

Fossil fuel vehicle procurement in year 2024 and 2025 are highlighted to show the years where gasoline powered vehicles are required to support CCRTA's DART services. As discussed in Section 6, these gasoline vehicles are required to mitigate range issues on some of the longest DART runs. The feasibility of electrifying these vehicles, which make up the last 24% of DART vehicles, can be reconsidered during their subsequent procurement cycles and as battery technology improves.

Table 8 - Detailed Vehicle Replacement Schedule

	Fixed Route Gillig	Fixed Route Cutaway	Trolleys	DART Cutaway: CDL	DART Cutaway: non-CDL	Caravans
2023						
2024	1034, 1035, 1036, 6281, 6282, 6283, 6284, 6285, 6297, 8230, 8231, 8232	501, 502, 503, 504, 506		415*, 416, 417, 421, 422, 423, 425*, 429, 432*, 433*, 434*, 437, 438, 439*, 446, 473	449, 451, 452, 453*, 455*, 456, 457, 460*, 462*, 463, 464*, 465*, 466, 467, 469*	
2025		500, 505, 507		430*, 426*, 428*		
2026		508, 512, 511				225, 226, 227
2027	1300, 1301, 1302, 8226, 8228, 8229	509, 510, 513		424, 435, 436, 440, 441, 442, 443, 444, 445, 447	448, 450, 458, 470, 471, 472, 474	219, 220, 221, 223
2028				475, 479		
2029	2000, 2001, 2022	3 NEW vehicles		481	482, 483, 484, 485	224

	Fixed Route Gillig	Fixed Route Cutaway	Trolleys	DART Cutaway: CDL	DART Cutaway: non-CDL	Caravans
2030	1900, 1901, 1902	514, 515, 516, 517		478, 477, 476	459, 461, 468, 486, 487, 488	
2031	1800, 1801, 1802	518, 519, 520, 521				
2032			T1803, T1804, T1805, T1806, T1807			
2033	1903, 1904, 1905, 1 NEW vehicle					
2034	2200, 2201, 2202, 2203, 2204, 2205					
2035						

*Vehicles to be replaced by another round of gasoline vehicles.

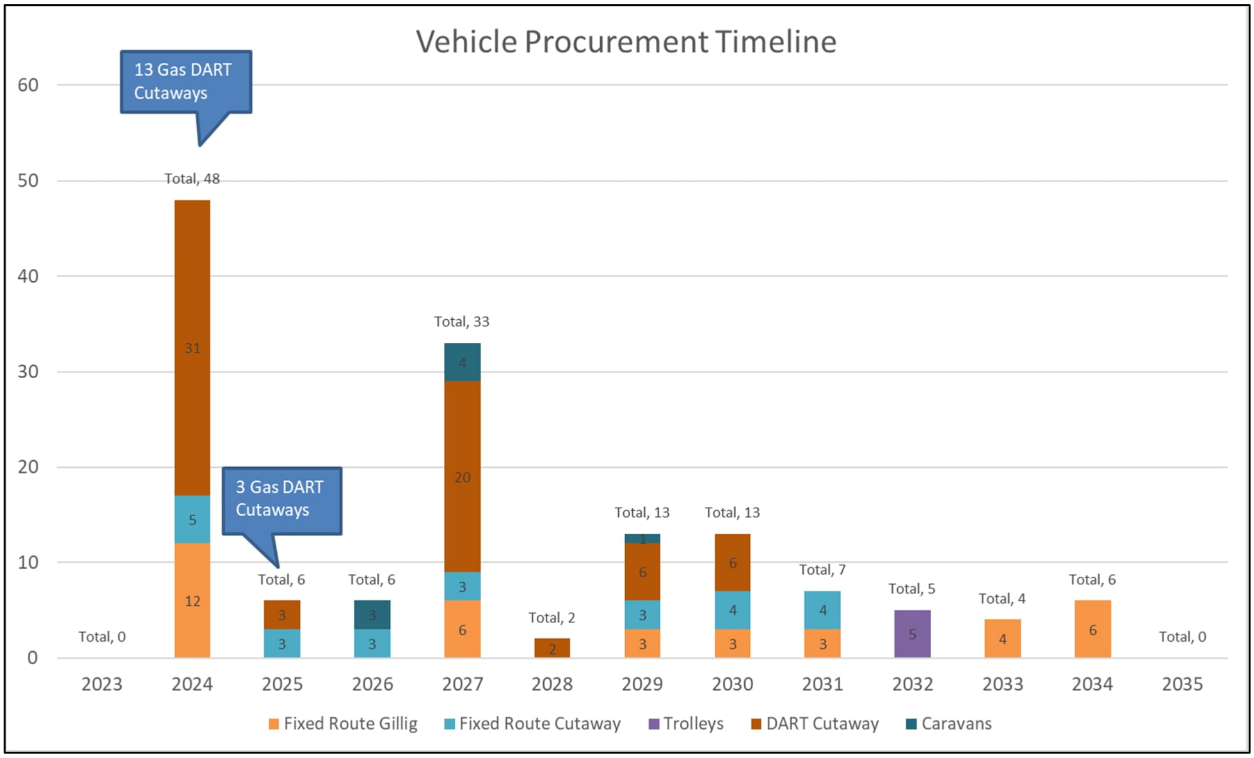


Figure 7 Vehicle Procurement Timeline

A major consideration for CCRTA's fleet electrification timeline is the availability of supporting charging infrastructure. It is anticipated that the 48 electrical vehicles procured in 2024 will charge overnight at the Depot (first of the locations to receive charging equipment) with installation of 36 Level 2 chargers, and four centralized DCFC chargers with three dispensers each, resulting in 48 available charging plugs that same year. In the following two years, 12 more vehicles will be purchased with 12 additional Level 2 chargers installed to support overnight charging for these vehicles.

However, because the Depot and HTC (terminal location) are far from one another when accounting for peak summer-time traffic, the addition of on-route charging infrastructure at HTC provides an opportunity for both fixed route and DART vehicles to remain in service without returning to the Depot early should problems arise with vehicle range and operations. Since DCFC infrastructure is planned for installation at HTC in 2024 as well, this will provide the on-route boost needed to support the operation of EVs that may otherwise be unable to complete their runs. As shown in Table 9, to align with the kickstart of EV procurement in 2024, the largest number of chargers will be installed at the Depot and HTC that same year to support the first batch of vehicles.

The next largest round of charging infrastructure build up will be in 2027. This is because the vehicles purchased prior to 2027 can be supported by the charging stations located at the Depot and HTC. This also allows CCRTA several years to evaluate locations for on-route charging and forge partnerships for eventual negotiations with local landowners. Purchases in 2027 include additional chargers at the Depot for overnight charging but will also include the procurement of equipment for on-route charging in Mashpee, and in Provincetown. As discussed in Section 6.2.1, Mashpee is the largest hub for demand-response operation and the terminal of the Bourne fixed route. Provincetown is an important area for installation of a charging station for both midday and overnight use as it is the terminal for the Flex and Shuttle routes and sees vehicles "parked out" overnight during the summer season.

For remaining transition years, depot chargers will be procured as the electrical vehicles are purchased.

Table 9 - Detailed Charger Procurement Schedule

	19.2 kW Level 2	150 kW DCFC (3 Dispensers)	100 kW DCFC (Single Dispenser)	300 kW DCFC (Single Dispenser)
2024	36 (Depot)	4 (Depot)	3 (HTC)	2 (HTC)
2025	6 (Depot)			
2026	6 (Depot)			
2027	27 (Depot)	2 (Depot) 2 (Provincetown)	5 (Mashpee)	1 (Provincetown)
2028	2 (Depot)			
2029	10 (Depot)	1 (Depot)		
2030	10 (Depot)	1 (Depot)		
2031	4 (Depot)	1 (Depot)		
2032		2 (Depot)		
2033		2 (Depot)		
2034		2 (Depot)		

9. Building Spatial Capacity

The Depot is located at 40 American Way in Dennis, Massachusetts. The existing building is mixed purpose with administrative offices, and a garage for vehicle maintenance and vehicle wash. All of CCRTA's fleet is stored outside, overnight. The Depot has limited parking for revenue vehicles, non-revenue vehicles, and employee parking and there is need for four additional maintenance bays to service future battery electric and diesel buses while the existing wash bay requires upgrades for wastewater recycling.

To address identified upgrades and space constraints at the Depot as well as prepare for fleet electrification, the Authority is exploring options like designing and building a new facility to support an electric fleet or buying another land parcel and operating out of two locations. However, CCRTA does not want to hamper current electrification efforts and the momentum that has been built through the course of Hatch's study, so the Authority is preparing to complete site upgrades required to support the beginning phases of fleet transition.

Hatch, along with CCRTA and Maverick, conducted a site assessment and performed a space-proofing exercise to develop a conceptual design for charging infrastructure for the Depot. During site layout development, measurements for revenue service vehicle parking, electrical charging infrastructure, and maintenance bay expansion were calculated. Hatch determined that the Depot has space to store revenue service vehicles with adequate room for some fleet expansion and the necessary service bay upgrades. The Depot has existing streetlights in the area where larger fixed-route vehicles are parked overnight that occupy space and limit parking flexibility. Hatch developed two conceptual plans; one layout with the existing streetlights, and one optimized layout with the streetlights removed. In the optimized layout, CCRTA could store a larger number of vehicles in this area. Ultimately CCRTA decided that the optimized layout would work better for the Authority's operational needs. The layouts shown in Figure 8 and Figure 9 provides storage and charging for 14 - fixed-route cutaways, 29 - 29' buses, eight - 35' buses and five - 32' trolleys. A total of 146 charging locations – 45 - DCFC charging locations, and 101 - Level 2 charging locations are depicted. The exercise revealed that the Depot has the capacity for 15 additional charging locations for future expansion: six Level 2 charging locations, and nine DCFC charging locations. This aligns with Hatch's operational simulations and analysis which indicated that CCRTA will require only minimal fleet expansion (four additional vehicles) for successful fleet electrification. Refer to Appendix C for the Depot's conceptual design drawings.

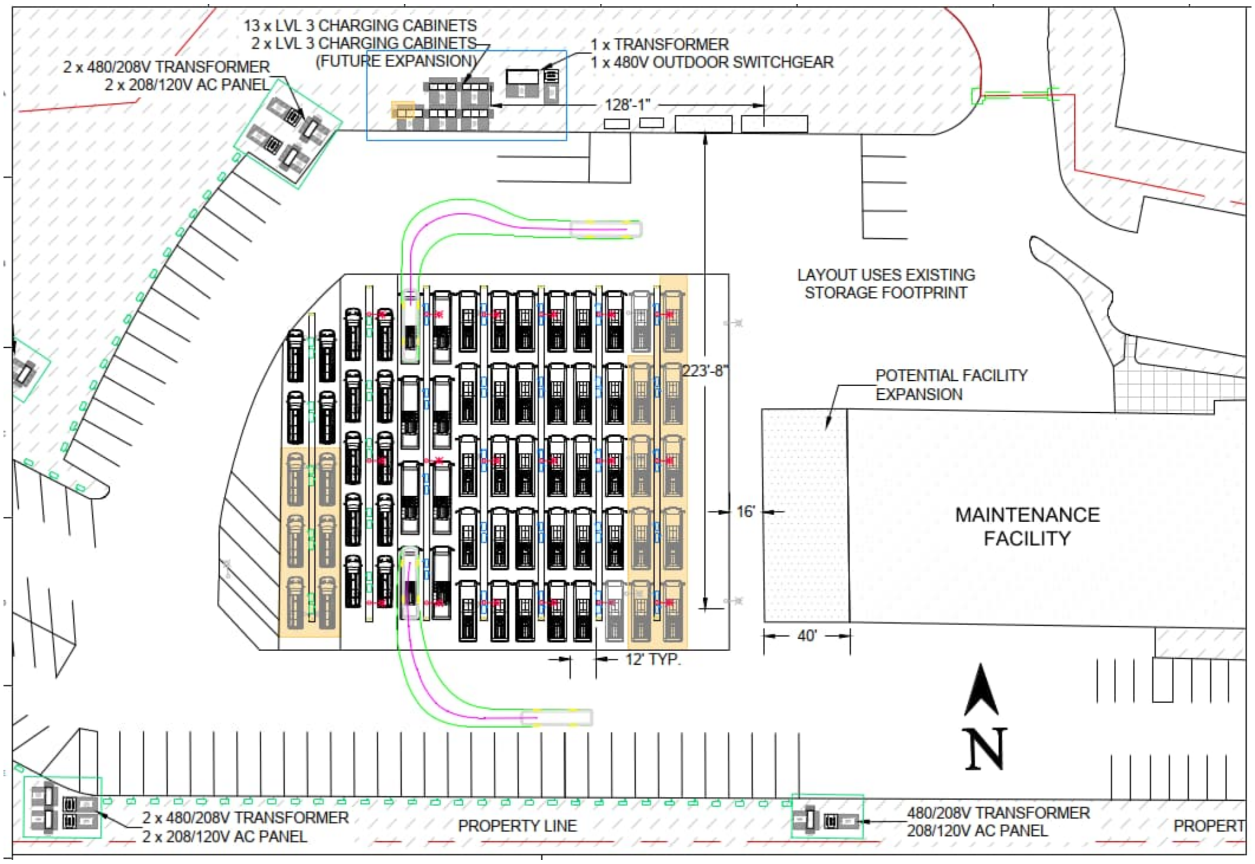


Figure 8 – the Depot Conceptual Equipment Layout for Charging Infrastructure (Central Lot)

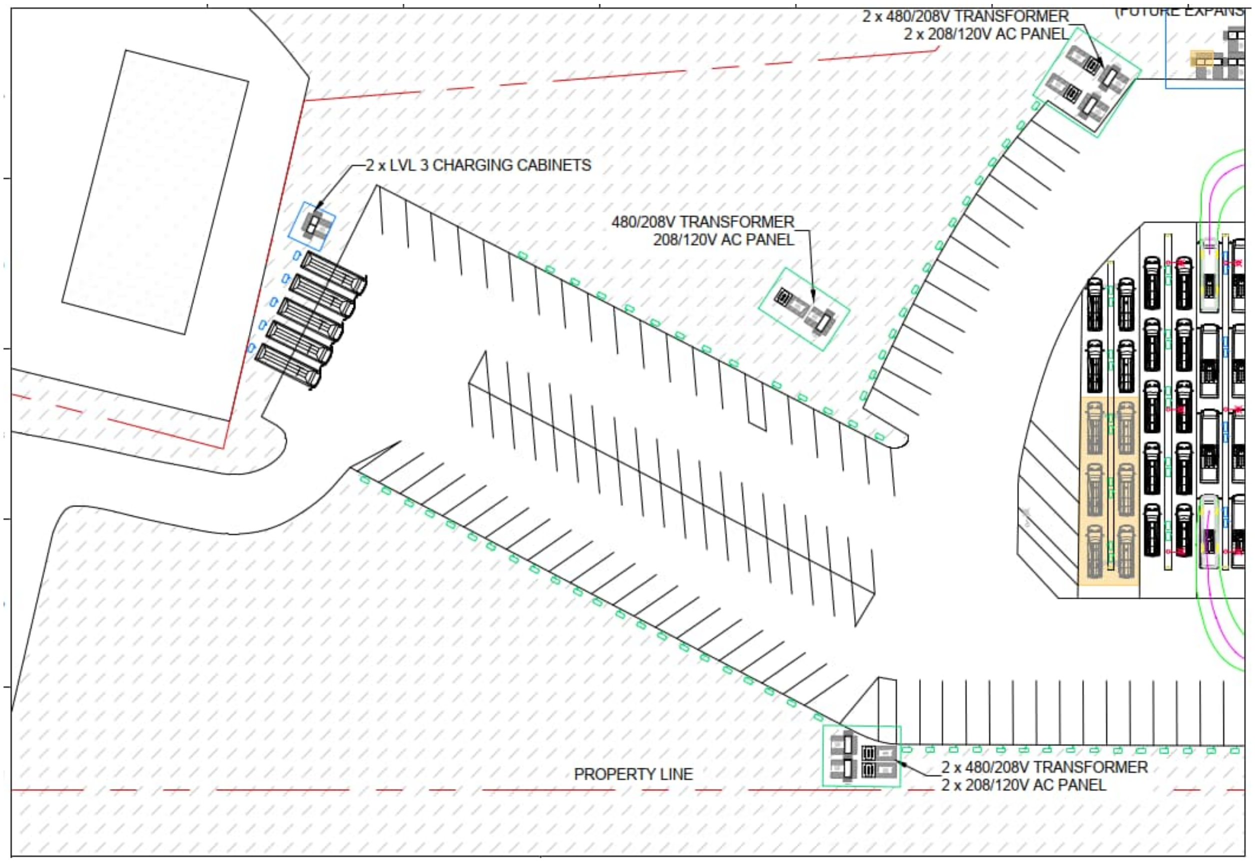


Figure 9 – the Depot Conceptual Equipment Layout for Charging Infrastructure (West Lot)

As outlined previously, Hatch recommends that on-route charging be installed at HTC early in the transition. HTC is CCRTA's main bus terminal for many fixed-route services and site to CCRTA administrative and executive offices. Located at 215 Iyannough Road in Hyannis, there are ten existing dual-plug Level 2 chargers for Authority and public use, with ample paved parking space for fleet vehicles and associated charging infrastructure.

Again, Hatch, along with CCRTA and Maverick, conducted a site assessment and performed a space-proofing exercise to develop a conceptual design for charging infrastructure and equipment layout, shown in Figure 10. During the site assessment, the team identified available, covered bus lanes where DCFC chargers could be installed for on-route charging stations. This layout depicts a total of five DCFC chargers with utility capacity for future expansion, if needed. Refer to Appendix D for HTC's conceptual design package.

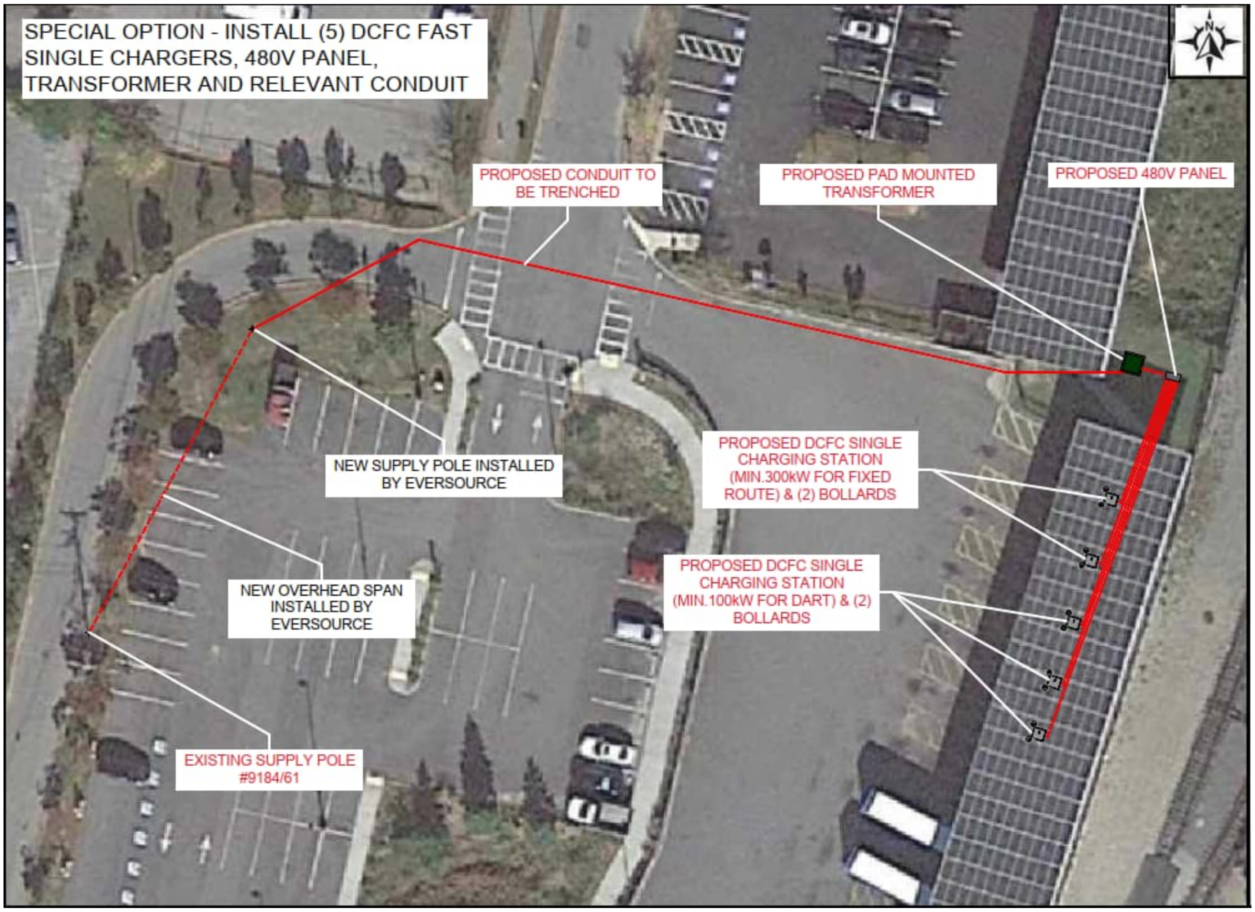


Figure 10- HTC Conceptual Equipment Layout for Charging Infrastructure

Layouts were not completed for the potential on-route charging locations like Mashpee, Provincetown, and Falmouth. Hatch recommends CCRTA begin conversations with local landowners and Eversource as early as possible so that the Authority will be well-positioned to develop conceptual design layouts later in the transition period. The upgrades discussed for the Depot and HTC, along with strategic planning regarding on-route charging locations as discussed in Section 6.2.1, will allow the Authority to build adequate space to support the future fleet, and supporting infrastructure.

10. Electrical, Infrastructure, Utility Capacity, and Utility Partnership

As discussed, Eversource is CCRTA's utility provider at the Depot and at HTC. Eversource also owns the distribution for most of the potential, future on-route charging locations identified for CCRTA's EV operation. Throughout this project CCRTA has been in frequent contact with Eversource and has developed a partnership to support their electrification initiatives. Through Eversource's Make Ready Incentive Program CCRTA becomes eligible for 100% reimbursement for infrastructure costs. CCRTA filed an application for each of the two primary locations where charging infrastructure will be required in the near term:

- The Depot – 40 American Way
- HTC - 215 Iyannough Rd

Upon application approval, CCRTA coordinated with Maverick to communicate projected future charger needs and utility upgrade requirements at these locations. Also, as part of this project, Maverick and CCRTA conducted field surveys at both locations as mentioned previously.

The Depot has a 480V 3-phase service that is stepped down to 208/120V through a step-down transformer installed outside of the building, by the visitor parking lot. This utility feed and transformer is not sufficient for the previously described charging needs at the Depot, which is estimated to be approximately 1,600kW during the overnight charging period when all vehicles are charging simultaneously. Moreover, the Eversource's Make Ready Program requires the charging infrastructure to be metered separately. As a result, a new dedicated 1,600kVA 480V 3-phase service with a separate meter will be required at the Depot to support charging infrastructure. This new dedicated service and all the downstream electric distribution equipment will be installed by Maverick at no cost to CCRTA. To date, Eversource has not raised any major concerns with regards to power availability at this site.

A review of the utility capacity at HTC was conducted as well. According to the charging schedule, an additional 500kW of electrical capacity will be required to accommodate the chargers at HTC. Like the Depot, a new dedicated service with separate metering will need to be installed at this location for charging infrastructure under the Make Ready Program. During the site visit, Maverick identified a utility line across Transportation Avenue from where a new service can be drawn. To date, Eversource has not raised any major concerns with regards to power availability at this site.

The three additional locations identified as potential, longer-term layover/on-route charging locations will need to be assessed in the future. Because the exact site locations are unknown, detailed utility analysis could not be conducted at this stage. Hatch recommends that CCRTA maintain continued coordination with Maverick and Eversource with regards to power availability at the sites, once selected. It is also recommended that CCRTA seek inputs from Eversource on the available power at the sites that are under consideration to inform the final selection decision.

11. Resiliency

Electricity supply and energy resilience are important considerations for CCRTA when transitioning from diesel to electric bus fleets. As the revenue fleet is electrified, the ability to provide service is dependent on access to reliable power. In the event of a power outage, there are two main options to consider for local backup power:

- Conventional Generation (diesel or CNG generators)
- Microgrid

On-site generation is a trusted option for prolonged outages as it can provide backup power for virtually unlimited duration. Compressed natural gas (CNG) and Diesel generators are most common for this kind of application. They are widely used for reliable backup power at industrial sites, factories, hospitals, hotels, airports, and many other sites where lifesaving and mission-critical operations take place.

A microgrid – the integration of onsite renewable energy production and an energy storage system – can be an effective resiliency alternative to fossil fuel-based generation. The largest advantage of renewable power generation is its zero emissions, thus clean energy. Solar generation is the most prevalent option for clean energy generation currently. This is because the application of other forms of clean power generation, like hydrogen fuel cell, is relatively new and costly for backup power application. As such the upfront costs for implementation, maintenance, and operations for these options are high.

Both options have advantages and disadvantages, however, either one can be an ideal solution for specific application. Hatch recommends that a system requirement analysis specific to CCRTA's operation be conducted to determine the best solution for CCRTA.

A secondary option for energy resiliency is redundant utility feeds on-site. A redundant feed can be requested from Eversource to serve as backup when there is an outage on the primary feed.

Lastly, CCRTA may consider operational resiliency rather than backup power as a feasible option for the Authority. In this case, spare vehicles with conventional propulsion technologies are retained from the retired fleet and kept on standby. Diesel vehicles that do not rely on electricity can substitute the electric fleet during an outage.

Table 10 summarizes the advantages and disadvantages of on-site generation and on-site storage systems. There are multiple factors to consider when choosing from these options. To make it manageable, the decision-making process can be broken down into steps. First, CCRTA will need to define its operational goals during power outages (core service); determining the extent to which service needs to operate. Second, the duration for which the core service needs to be maintained must be determined by analyzing the power outage data for each sites' utility feed. Additionally, decisions should be made on whether "value stacking" in the form of utility cost offset, GHG off-set from local solar production and peak shaving using energy storage system is desired.

Once the operational goals are determined, a technical and financial feasibility study should be conducted. This step would include a cost benefit analysis for each system to determine the ideal solution for CCRTA's unique needs.

Table 10 – Comparison of Power Resiliency Options

	Pros	Cons
Conventional Generation	• Ability to provide power for prolonged periods • Lower upfront cost	• GHG emitter • Maintenance and upkeep are required and can be costly
Solar	• Reduced utility costs • Offsets carbon emissions associated with electrical grid	• Inability to provide instantaneous power sufficient to support all operations • Constraints related to real-estate space and support structures • Requires battery storage for resiliency usage.
Energy Storage	• Serves as intermittent buffer for renewables • Reduces utility costs through peak-shaving	• Short power supply in case of outages • Batteries degrades over time resulting in less available storage as the system ages • Increased costs for high storage capacity
Back-up Fleet	• Reliable proven technology	• Requires upkeep and maintenance of the standby conventional fuel fleet • Requires additional vehicle storage space

Finally, a conceptual level system design can be developed along with a planning level cost estimate study that would serve as basis for an in-depth engineering design. Additional considerations like fuel supply options; potential solar partnerships with the adjacent airport; equipment size and specifications; and existing equipment assessment would be conducted at this stage.

11.1 Existing Conditions

As the Depot does not yet have the utility capacity for BEV operations, it also does not have resilient systems in place that would be able to support BEV operations should there be an electrical service interruption. At the beginning of the study, Hatch requested historical outage data for both the Depot and HTC from Eversource. Eversource's system was only able to retrieve outage data for twelve months and no outages for that time period were recorded at either site. Resiliency planning will need to be addressed with Eversource and Maverick and decisions will need to be made over the course of CCRTA's electrification transition - the Authority will have to choose an appropriate level of resiliency investment based on their anticipated emergency operational needs.

HTC is similar – although there is a generator present, it appears sized to support low-power building loads (e.g., lighting) during an outage rather than high-power bus charging. This would mean that a prolonged power outage would deprive CCRTA of the ability to operate service as it continues transitioning to electric bus operations.

11.2 Fire Mitigation

An electric bus's battery is a dense assembly of chemical energy. If this large supply of energy begins reacting outside of its intended circuitry, for example due to faulty wiring or defective or damaged components, the battery can start rapidly expelling heat and flammable gas, cause a "thermal runaway" fire. Given their abundant fuel supply, battery fires are notoriously difficult to put out and can even reignite after they are extinguished. Furthermore, without prompt fire mitigation the dispersed heat and gas will likely spread to whatever is located near the bus. If this is another electric bus then a chain reaction can occur, with the heat emanating from one bus overheating (and likely igniting) the batteries of another bus. This can endanger all the buses in the Depot.

For the aforementioned risks that BEVs operations introduce, mitigations are recommended. On the vehicles themselves, increasingly sophisticated battery management systems are being developed, ensuring that warning signs of battery fires – such as high temperature, swelling, and impact and vibration damage – are quickly caught and addressed. Though research is ongoing, most battery producers believe that with proper manufacturing quality assurance and operational monitoring the risk of a battery fire can be minimized.

The infrastructure best practices for preventing fire spread with EVs are still being developed. There are no current standards for fire suppression and mitigation of facilities housing BEVs. There are, however, relevant standards for the storage of high-capacity batteries indoors for backup power systems, such as UL9540, NFPA 70, and NFPA 230. Despite there not being any standards developed specifically for electric vehicle operations, the primary components of any depot fire mitigation strategy are well understood: detectors for immediate discovery of a fire, sprinklers to extinguish it as much as possible, and barriers to prevent it from spreading to other buses or the building structure. Each of these requires specific consideration with respect to CCRTA's facilities and operations. To consider these factors, Hatch recommends that CCRTA commission a fire safety study as part of detailed design work for the Depot upgrades or any future construction as well as at HTC.

12. Community Considerations

Hatch considered Environmental Justice (EJ) communities to inform development of an equitable transition strategy for CCRTA. First, to ensure Hatch's operations analysis considered Cape Cod EJ communities, CCRTA's service area was defined to determine which geographic areas on Cape Cod would be affected by a ZEV transition. From there, Hatch identified three different EJ programs to utilize; the Federal Justice40 Initiative, the US Department of Transportation's (DOT) Equitable Transportation Community Explorer (ETCE), and the MA EEA Environmental Justice Populations. Once the EJ programs were decided upon, Hatch then evaluated the EJ programs' indicators and screening methodology to identify the EJ communities in CCRTA's service area based on each program's thresholds.

Notably, three Justice 40-designated disadvantaged communities (by Census Tracts) were identified in CCRTA's service area; two in Barnstable and one in Falmouth. The identified communities have high rates of asthma, ranking around 90th percentile for asthma compared to Census Tracts nationwide.

Findings from the US DOT ETCE program identified communities in Bourne and Falmouth as well as in Barnstable and Truro with higher transportation cost burden scores, meaning that these communities devote a larger portion of their income to transportation. In addition, the areas with higher transportation cost burden were also identified as areas with higher concentrations of low-income and lower education-attainment households.

The MA EEA program identified EJ Populations clustered within CCRTA's service area, in particular areas in southern Falmouth, at the intersection of the towns of Bourne and Sandwich, Barnstable, specifically near the Cape Cod Airport, and in Eastham. The EJ Populations as defined by MA EEA, include some communities making less than 65% of MA annual median income, and areas where minorities comprise 40 percent or more of the population. Beyond areas with low-income households, some of the EJ Populations within the CCRTA service area experience additional burdens associated with English language isolation or where 25 percent or more of the households lack English language proficiency.

The preliminary strategy for electrification calls for the first batch of electric vehicles to be deployed and operated in Barnstable as charging infrastructure is planned for Hyannis Transportation Center (HTC) as early as 2024. Electric vehicles operating to/from HTC are anticipated to contribute less to air pollution; thereby offering the potential to reduce air quality concerns and contributions to greenhouse gas emissions in these communities. The location of HTC will also enable both fixed-route and demand-response vehicles to charge should electric range issues arise and will provide operational resiliency during the early transition period. This should reduce the potential for CCRTA ridership, inclusive of riders from the EJ communities identified above, to experience any changes to their existing service. Future transition planning strategy include on-route charging locations in other identified EJ communities, like Falmouth, further reducing the likelihood of service disruption or changes to existing service. For identified EJ communities like Bourne and Truro, the CCRTA transition plan recommends phased, operational strategies including: deferring procurement of electric vehicles servicing those routes until improvement in battery technology; adding charging infrastructure in areas where there is significant overlap between the terminals for fixed-route operation and the areas of highest demand-response ridership (such as Mashpee, the terminal of the Bourne fixed route, and Provincetown); and adding fleet vehicles to routes shown to have the largest energy deficits.

To ensure that community considerations are accounted for throughout the transition period and beyond, it is recommended that CCRTA continuously monitor and evaluate the transition plan's potential benefits and adverse impacts to the environment and public health including impacts of recommended infrastructure investments, asset procurement, and changes to services or programs, particularly to EJ communities. In addition, CCRTA should ensure level of service is adequate in EJ communities within the CCRTA service area through each step of the ZEV Transition Planning phase. Similarly, CCRTA should ensure that public participation is encouraged, and that the Authority is engaging and consulting with EJ communities, where appropriate, during the planning stages of electrification so that people are aware of the decisions affecting their environment.For more information on CCRTA's community considerations and EJ, refer to Appendix E for Hatch's complete report.

13. Policy Considerations and Resource Analysis

CCRTA is not alone in recognizing the immediate need to reduce carbon emissions and pollution to ensure a healthier climate. Leaders at both the state and federal levels recognize the benefits of ZEVs and have implemented strong plans to increase adoption of them. These plans include both timelines to achieve carbon emissions reductions and grant programs to provide the funding necessary for these reductions. CCRTA's decision to convert its fleet to ZEVs aligns well with these policies and incentives.

The federal government provides several types of incentives for transit authorities to convert their fleets to zero-emissions vehicles, the most well-known of which is the Low or No Emission Grant Program (49 U.S.C. 5339 (c)), or the "Low-No" program. Through this program, which can allocate up to $1.6 billion annually for five years, the FTA provides matching funds for procurements of zero-emissions vehicles as well as for bus facility upgrades to support these vehicles. The Buses and Bus Facilities Competitive Program (49 U.S.C. 5339 (b)), though not limited to zero-emissions vehicles, can also provide federal funding for vehicle and infrastructure procurements. Other, more general funding options are also available. For example, US DOT's Public Transportation Innovation Program provides funding for research projects analyzing a wide range of new ideas, including zero-emissions vehicle technologies. The FHWA's Congestion Mitigation and Air Quality Improvement Program (CMAQ) provides over $2.5 billion a year for measures, including the adoption of zero-emissions vehicles, that will improve air quality and reduce pollution. Notably, each of these programs are competitive, so CCRTA is not guaranteed to receive funding. As the zero-emissions vehicle landscape expands and a greater number of authorities begin converting their fleets, availability of this funding is expected to become scarcer. Though less common, some formula (i.e., non-competitive) funding is also available, for example through the Formula Grants for Rural Areas (49 U.S.C. 5311). This is generally more appropriate to fund operations rather than capital purchases.

The state of Massachusetts has also made clear the importance of zero-emission vehicle adoption. Table 11 provides a summary of current policies, resources and legislation that are relevant to CCRTA's ZEV fleet transition.

Table 11 - Available Policy and Resources

Policy	Details	Relevance to Agency Transition
The U.S. Department of Transportation's Public Transportation Innovation Program	Financial assistance is available to local, state, and federal government entities; public transportation providers; private and non-profit organizations; and higher education institutions for research, demonstration, and deployment projects involving low or zero emission public transportation vehicles. Eligible vehicles must be designated for public transportation use and significantly reduce energy consumption or harmful emissions compared to a comparable standard or low emission vehicle.	Can be used to fund electric vehicle deployments and research projects. (*Competitive funding)

Policy	Details	Relevance to Agency Transition
The U.S. Department of Transportation's Low or No Emission Grant Program	Financial assistance is available to local and state government entities for the purchase or lease of low-emission or zero-emission transit buses, in addition to the acquisition, construction, or lease of supporting facilities. Eligible vehicles must be designated for public transportation use and significantly reduce energy consumption or harmful emissions compared to a comparable standard or low emission vehicle.	Can be used for the procurement of electric vehicles and infrastructure (*Competitive funding)
The U.S. Department of Transportation's Urbanized Area Formula Grants - 5307	The Urbanized Area Formula Funding program (49 U.S.C. 5307) makes federal resources available to urbanized areas and to governors for transit capital and operating assistance in urbanized areas and for transportation-related planning. An urbanized area is an incorporated area with a population of 50,000 or more that is designated as such by the U.S. Department of Commerce, Bureau of the Census.	This is one of the primary grant sources currently used by transit agencies to procure vehicles and to build/renovate facilities. (*Competitive funding)
The U.S. Department of Transportation's Grants for Buses and Bus Facilities Competitive Program (49 U.S.C. 5339(b))	This grant makes federal resources available to states and direct recipients to replace, rehabilitate and purchase buses and related equipment and to construct bus-related facilities, including technological changes or innovations to modify low or no emission vehicles or facilities. Funding is provided through formula allocations and competitive grants.	This is one of the primary grant sources currently used by transit agencies to procure vehicles and to build/renovate facilities. (*Competitive funding)
The U.S. Department of Energy (DOE) Title Battery Recycling and Second-Life Applications Grant Program	DOE will issue grants for research, development, and demonstration of electric vehicle (EV) battery recycling and second use application projects in the United States. Eligible activities will include second-life applications for EV batteries, and technologies and processes for final recycling and disposal of EV batteries.	Could be used to fund the conversion of electric vehicle batteries at end of life as on-site energy storage.
Energy Storage System Research, Development, and Deployment Program	The U.S. Department of Energy (DOE) must establish an Energy Storage System Research, Development, and Deployment Program. The initial program focus is to further the research, development, and deployment of short- and long-duration large-scale energy storage systems, including, but not limited to,	Can be used to fund energy storage systems for the agency.

Policy	Details	Relevance to Agency Transition
	distributed energy storage technologies and transportation energy storage technologies.	
The U.S. Economic Development Administration's Innovative Workforce Development Grant	The U.S. Economic Development Administration's (EDA) STEM Talent Challenge aims to build science, technology, engineering, and mathematics (STEM) talent training systems to strengthen regional innovation economies through projects that use work-based learning models to expand regional STEM-capable workforce capacity and build the workforce of tomorrow. This program offers competitive grants to organizations that create and implement STEM talent development strategies to support opportunities in high-growth potential sectors in the United States.	Can be used to fund EV training programs.
Congestion Mitigation and Air Quality Improvement (CMAQ) Program	The U.S. Department of Transportation Federal Highway Administration's CMAQ Program provides funding to state departments of transportation, local governments, and transit agencies for projects and programs that help meet the requirements of the Clean Air Act by reducing mobile source emissions and regional congestion on transportation networks. Eligible activities for alternative fuel infrastructure and research include battery technologies for vehicles.	Can be used to fund capital requirements for the transition.
Hazardous Materials Regulations	The U.S. Department of Transportation (DOT) regulates safe handling, transportation, and packaging of hazardous materials, including lithium batteries and cells. DOT may impose fines for violations, including air or ground transportation of lithium batteries that have not been tested or protected against short circuit; offering lithium or lead-acid batteries in unauthorized or misclassified packages; or failing to prepare batteries to prevent damage in transit. Lithium-metal cells and batteries are forbidden for transport aboard passenger-carrying aircraft.	Should be cited as a requirement in procurement specifications.
Volkswagen Environmental Mitigation Trust	Under terms of court-approved partial settlements, Massachusetts is expected to receive more than $75 million to spend on environmental mitigation projects.	Can be used to fund electric buses and charging infrastructure.

Policy	Details	Relevance to Agency Transition
(Massachusetts Portion)	Specifically, the second draft amendment proposes committing additional funding to regional transit authority electric buses and chargers.	
Public Access Electric Vehicle Charging Station Grants	The Public Access Charging Program provides grants to non-residential entities for 80% of the cost of Level 2 EV charging stations and installation, and a maximum of $50,000 per street address for hardware and installation costs. Installations at government property qualify for 100% of the cost, up to $50,000. Qualified EV charging stations must be available to the public at least 12 hours per day. This program is part of Massachusetts Electric Vehicle Incentive Program (MassEVIP) and is funded by Massachusetts' portion of the Volkswagen Environmental Mitigation Trust.	Can be used to offset hardware and installation costs for EV Level 1 and 2 charging stations.
Workplace and Fleet Electric Vehicle (EV) Charging Station Grants	The Massachusetts Electric Vehicle Incentive Program (MassEVIP) provides grants for 60% of the cost of Level 1 or Level 2 EV charging stations, up to $50,000 per street address. Eligible entities include private, public, or non-profit workplaces and fleets with 15 or more employees on site. The program is funded by Massachusetts' portion of the Volkswagen Environmental Mitigation Trust. Applications are accepted on a first-come, first-served basis until funds are exhausted.	Can be used to offset hardware and installation costs for EV Level 1 and 2 charging stations.
Electric Vehicle (EV) Charging Station Installation Incentive - Eversource	Eversource's Electric Vehicle Charging Station program provides make-ready installation costs for non-residential customers to install approved Level 2 or direct current fast charging (DCFC) stations at businesses, multi-unit dwellings, workplaces, and fleet facilities. To qualify, customers must own, lease, or operate a site where vehicles are typically parked for at least two hours. Eligible installation expenses include trenching, dedicated service meter, conduit, and wiring costs.	Can be used to fund Level 2 or DCFC EV charging stations.
Diesel Emissions Reduction Act (DERA) Grant	The Massachusetts Department of Environmental Protection (MassDEP) provides U.S. Environmental Protection Agency Diesel Emissions Reduction Act (DERA)	Funding to offset costs associated with diesel emission reduction projects.

Policy	Details	Relevance to Agency Transition
	funding for projects that reduce diesel emissions in Massachusetts. Funding for eligible project costs is available for local or state agencies and public colleges and universities that reduce diesel emissions by converting engines to alternative fuels, retrofitting exhaust controls, purchasing new vehicles, or adding idle reduction equipment. MassDEP prioritizes projects that benefit environmental justice communities.	
EV Infrastructure Support	Massachusetts utilities joined the National Electric Highway Coalition (NEHC), committing to create a network of direct current fast charging (DCFC) stations connecting major highway systems from the Atlantic Coast to the Pacific of the United States. NEHC utility members agree to ensure efficient and effective fast charging deployment plans that enable long distance EV travel, avoiding duplication among coalition utilities, and complement existing corridor DCFC sites.	Eversource is a participating utility in NEHC. Support could be provided to Cape Cod region for DCFC deployment plans, with potential use by CCRTA fleet vehicles.
Public EV Charging Station Requirements	Owners and operators of public EV charging stations that require payment must provide payment options that allow access by the public. In addition, payment should not require users to pay a subscription fee or obtain a membership of any kind; however, required fees may be conditional on such memberships. Owners and operators can impose reasonable restrictions on EV charging station use, such as limiting access to visitors of the business. In addition, owners and operators of public EV charging stations must provide the location, hours of operation, payment, and characteristics of each EV charging station to the U.S. Department of Energy's Alternative Fuels Data Center.	For future on-route charging station planning and implementation, CCRTA must consider requirements for public EV charging stations prior to deciding whether or not public or private stations should be installed.

14. Cost Considerations

To understand the financial impact of transitioning to a new technology, it is important to consider the costs involved with acquiring and operating the new technology and compare it to the cost of acquiring and operating the current system in kind. To do this, a life cycle cost (LCC) model was constructed. The LCC includes initial capital as well as operations and maintenance costs of the battery-electric and fossil fuel vehicles and supporting infrastructure that would make up the future fleet. These costs can then be compared to the costs of replacing the existing fossil fuel-based operation with another round of fossil fueled vehicles. The operations and maintenance costs are based on the peak service levels analyzed above and scaled to account for off-peak.

Table 12 outlines the LCC model components, organized by basic cost elements, for fossil fuel and BEV technologies.

Table 12 - Primary Cost Categories by Vehicle Type

Category	Fossil fuel	Future Fleet
Capital	Vehicle purchase	Vehicle purchase
	Mid-life overhaul	Mid-life overhaul
		Battery replacement/warranty
		Charging infrastructure
		Electrical infrastructure upgrades
		Utility feed upgrades
Operations	Fossil fuel	Electricity
	Operator's cost	Operator's cost
		Demand charges for electricity
		Diesel fuel for auxiliary heaters
Maintenance	Vehicle maintenance	Vehicle maintenance
		Charger maintenance

For the above cost categories, certain base assumptions were developed to ensure that the cost model reflected real-world practices. These assumptions were derived from various sources including industry practices, CCRTA stakeholder inputs, and CCRTA's strategic plan.

Capital Investment

- The lifespan of a bus is 12 years.
- The lifespan of other vehicles including cutaways, trolleys, and vans is seven years.
- The electric service infrastructure installation cost, including conduits and wires from control box panel to charging stations section, was assumed to be covered by the Eversource Make Ready Incentive Program.
- Installation costs for the chargers is excluded from this estimate.
- 12-year battery warranties are purchased with the bus, so battery replacement at vehicle midlife is unnecessary.
- Standard warranties for other vehicles including cutaways, trolleys, and vans are between 5-8 years, dependent on the manufacturer, and is sufficient to mostly cover the useful life of the vehicle.

Costs

- 3% year-over-year inflation
- The utility rates structure is assumed to be the large General Service rate (G-3 – M.D.P.U. No.31) from Eversource

The upfront purchase cost of BEV is much higher than for fossil fuel ones. This is largely due to the high cost of the propulsion batteries. Although battery cost is declining each year it is still very high, particularly for heavy-duty transit vehicles. Because transit agencies prefer high-capacity batteries to extend vehicle range, the additional price of the batteries overshadows the cost savings from eliminating the engine and associated components on a diesel or gasoline vehicle.

Electrifying a transit fleet often requires major infrastructure investment as well. This investment ensures that the chargers, the facility, and the utility connection are all suited for EV operations. Chargers are a prerequisite to EV operation; they must be purchased, installed, and commissioned. Particularly for heavy-duty applications like transit service, the required chargers are often high-powered and expensive. The facility must also be adapted for EV charging. In the case of modern facilities designed with spare electrical capacity, this will only require installation of additional conduit to connect to the electrical panel. For other, older facilities with outdated electrical and fire detection this could involve a multimillion-dollar upgrade before the first charger can be installed. Finally, the facility's utility connection often requires upgrades as well, as detailed in Section 10. Although bus depots are industrial facilities, their existing electrical systems are usually unsuited for the heavy power demands of EV charging. Although the cost of utility and facility upgrades varies on a case-by-case basis, the price of chargers themselves is relatively consistent and is presented below.

These upfront capital costs are expected to be balanced out by recurring savings on operations and maintenance cost. For operations, EVs are cheaper to recharge than fossil fuel vehicles are to refuel. This is especially true if a charge management system is used to avoid electricity demand charges. In addition to operations spending, maintenance costs are expected to decline as well. EVs have fewer drivetrain parts, especially moving parts, than fossil fuel vehicles. Therefore, components will wear out less often, meaning that less time must be spent maintaining them and spare parts can be bought less frequently.

Table 13 lists the operating and capital costs that Hatch assumed for this study. These are based on CCRTA figures and general industry trends and have been escalated to 2023 dollars where necessary.

Table 13 Cost Assumptions

Asset	Estimated Cost Per Unit	
	Fossil	Battery-Electric
29' Transit Bus	$531,000	$960,000
35' Transit Bus	$546,000	$960,000
21' Cutaway	$70,000	$125,000
23' Cutaway	$70,000	$170,000
26' Cutaway	$80,000	$295,000
28' Cutaway	$80,000	$295,000
32' Trolley	$325,000	$960,000
Van	$40,000	$70,000
Bus Maintenance, per mile	$1.30	$0.96
Other Vehicle Maintenance, per mile	$1.25	$0.92
Bus Battery Warranty	$75,000	

Asset	Estimated Cost Per Unit	
	Fossil	Battery-Electric
19.2 kW Level 2	$7,500	
150 kW DCFC (3 Dispensers)	$150,000	
100 kW DCFC (Single Dispenser)	$110,000	
300 kW DCFC (Single Dispenser)	$200,000	
Operator Wages, Benefits, and Overhead, per hour	$43.00	
Diesel Fuel, per gallon	$4.50	
Gasoline Fuel, per gallon	$3.50	
Energy Cost (per kWh)	$0.1235	

Because the transition to ZEVs will be gradual, LCC calculations necessarily overlap multiple bus procurement periods. This was addressed by setting the start of the analysis period to the year after the transition to future fleet composition is complete (2034), with the analysis period stretching for a full bus lifespan (12 years). Gasoline vehicles have a useful life of six to seven years. To compare the current baseline fleet with the future fleet over a lifecycle of 14 years, two procurement cycles were considered for gasoline vehicles.

For vehicles that are already part of the fleet at the beginning of the analysis period, or for buses with remaining life at the end, a residual value was calculated and added or subtracted as appropriate.
The LCC analysis determines the relative cost difference between the baseline (fossil fuel) case and the proposed case (electric). Therefore, it only includes costs which are expected to be different between the options. Costs common to both alternatives, such as bus stop maintenance, are not included as they do not have a net effect on the LCC comparison. Thus, the model indicates the most economical option but does not represent the full or true cost of owning either of the options. Table 14 and Figure 11 compares the LCC of the future fleet with the current fossil fuel baseline.

Table 14 - Lifecycle Cost Estimates

	Fixed Route		DART	
	Fossil Baseline	Future Fleet	Fossil Baseline	Future Fleet
Vehicle Capital Cost	$31,527,867	$67,596,985	$13,086,779	$35,323,723
Infrastructure Capital Cost	$0	$3,455,882	$0	$1,623,177
Vehicle Maintenance Cost	$42,054,180	$31,803,379	$33,323,374	$24,763,479
Infrastructure Maintenance Cost	$0	$976,663	$0	$642,428
Operations Cost	$105,903,325	$77,441,779	$104,207,956	$99,921,500
Total	$179,485,372	$181,274,688	$150,618,109	$162,274,307

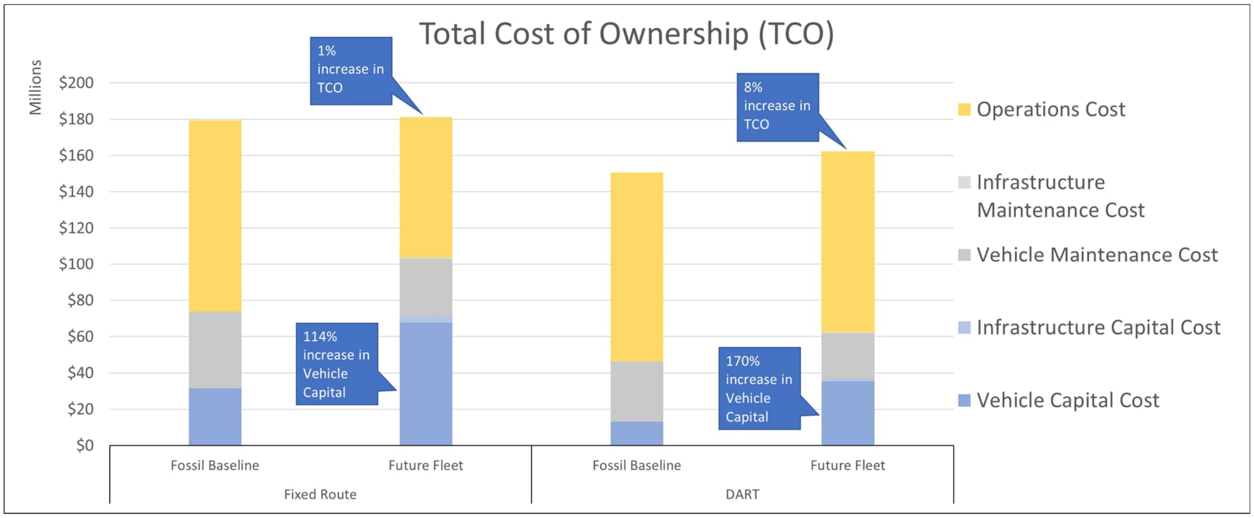


Figure 11 - Lifecycle Cost Estimates

As shown in Figure 11, there is a significant increase in the upfront capital requirement for vehicle procurement. CCRTA will need an additional capital investment of 114% and 170% to procure future fixed route vehicles and demand response vehicles, respectively. In addition, CCRTA will need additional capital investment in charging infrastructure at the four locations discussed previously in this report.

However, BEVs are expected to reduce recurring costs for both maintenance and daily operations. Maintenance costs will likely decline because of the simplified nature of EV drivetrains, which reduces brake wear, eliminates several maintenance-intensive components, and enables more advanced vehicle diagnostics. Accordingly, vehicle maintenance costs for the future fleet, comprised primarily of EVs, are estimated to decline by 25% when compared to the current fleet.

Moreover, the operating costs for the future fleet are also expected to decrease by 16% (assuming a well-designed charging schedule) as electricity costs are generally lower than diesel and gasoline costs. As a result, the overall cost impact of transiting CCRTA's fleet from fossil fuel-based vehicles to predominantly EVs is estimated to be only 4%. This cost benefit projection will likely improve in the future, as Eversource is developing an EV specific rate structure (EV-2) which should further reduce the operations cost of electric vehicles. It is recommended that the lifecycle cost model is updated with the new rate inputs when Eversource makes the EV specific rate structure available.

As mentioned above, the LCC allows for a cost of ownership comparison for the two types of fleets. However, it lacks the details required to develop a capital spending plan to help guide CCRTA with financial planning for the increase capital investment requirements and funding applications. Therefore, in addition to the LLC, the following capital investment plan was developed based on the vehicles and charging procurement timeline. Figure 12 shows the amount of investments that CCRTA will need to plan for in order to achieve its zero emission transition goals in accordance with the timeline developed in this study.

As expected, there is a big spike in capital spending requirements for the year 2024 which aligns with the first round of vehicle procurement and associated charging infrastructure development at the depot and HTC. The next two years, 2025 and 2026 will see lower investment requirements. Since additional vehicle purchases will require on-route charging infrastructure at Provincetown and Mashpee Commons scheduled for installation in 2027, CCRTA will witness increased capital spending requirements in 2027. During years 2029 through 2033 this investment will even out year over year.

Overall, CCRTA will need to plan for a total of $79 million over the course of the 12-year transition period. Note that this number includes the cost of procuring gasoline cutaways for DART services. Should CCRTA's strategy change, for example if decisions are made to bring on-route charging to additional locations or if technology advances allow for added vehicle range such that gasoline vehicles are not necessary, then the capital plan will need to change accordingly.

Hatch estimated the year-over-year capital requirements for this transition based on the cost assumptions in Table 13. This estimate is summarized in Figure 12 below.

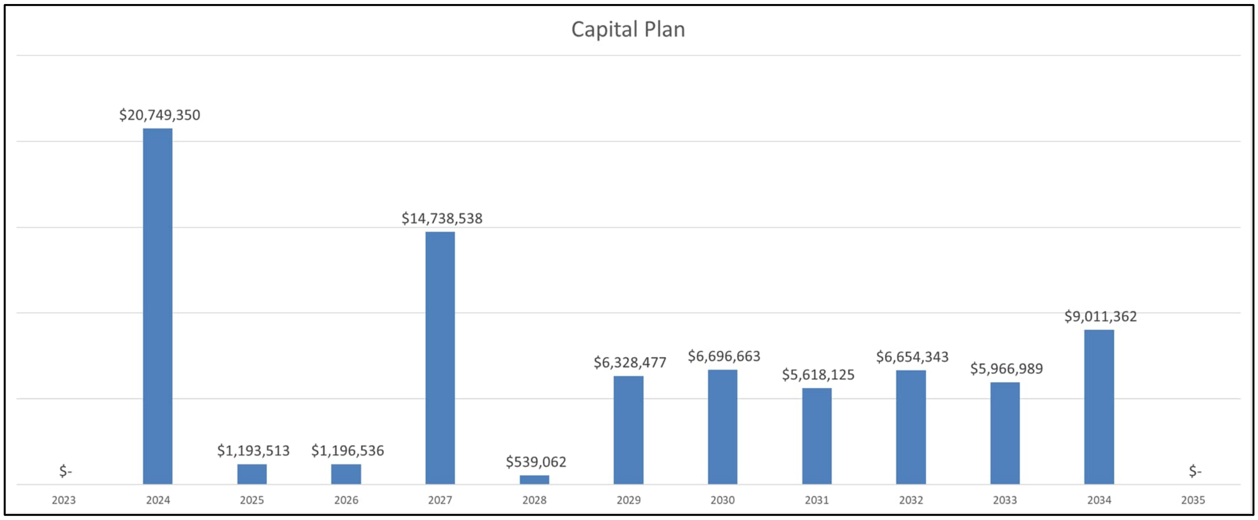


Figure 12 Year-over-Year Capital Requirement

The BEV market is a new and developing space, with rapid advancements in technology. Although Hatch has used the best information available to date to analyze the alternatives and recommend a path forward, it will be important in the coming years for CCRTA to review the assumptions underlying this report to ensure that they have not changed significantly. Major changes in capital costs, fuel costs, labor costs, routes, schedules, or other operating practices may make it prudent for CCRTA to change the speed of its electrification transition or change the desired end-state altogether.

The proposed fleet transition strategy requires initial capital spending to reduce recurring cost and achieve other strategic goals. This need is common to many transit projects and is representative of the transit industry, with nearly all bus and rail systems requiring capital investments up front to save money in other areas (traffic congestion, air pollution, etc.) and achieve broader societal benefits over the long term. By extension, just as with the transit industry at large, policy and financial commitment will be required from government leaders to achieve the desired benefits. The federal government's contribution to these goals via FTA and Low-No grants is already accounted for, leaving state and local leaders to cover the remaining increase in upfront capital cost.

15. Emissions Impact

A primary goal for CCRTA's transition to zero-emission vehicles is to decrease the Authority's carbon footprint by reducing GHG emissions. The anticipated emissions from CCRTA's future fleet and emissions from the current fleet were calculated and compared to quantify the Authority's overall emissions reduction per the transition to BEVs.

To provide a complete view of the reduction in emissions offered by the proposed transition strategy, the effects were analyzed based on three criteria:

- Well-to-tank
- Tank-to-wheel
- Grid

Well-to-tank emissions are those associated with energy production. For fossil fuel vehicles well-to-tank emissions are due to gasoline or diesel production, processing, and delivery. This emissions estimate used industry averages for the well-to-wheel emissions associated with the delivery of gasoline fuel to the gas stations CCRTA uses.

The tank-to-wheel emissions impact considers the emissions reduction in the communities where the vehicles are operated. As a tank-to-wheel baseline, the ‘tailpipe’ emissions associated with CCRTA’s existing diesel and gasoline vehicles were calculated. These calculations used industry emissions averages for gasoline vehicles and CCRTA’s fuel economy data.

BEVs have a third emissions source: grid electricity generation. To calculate the emissions associated with the grid, Hatch assumed an EPA and EIA average grid mix for Massachusetts.

Figure 13 summarizes the results of the emissions calculations; reflecting the total emissions that would result from operation of BEVs if the grid did not change from its current state. These results demonstrate that per the transition plan, the Authority will achieve 66% emissions reduction assuming the current grid mix. Further reduction can be expected because Eversource (CCRTA’s utility provider) and Nextra Energy (CCRTA’s current energy provider) have goals for decarbonizing the grid. In its 2021 Sustainability Report, Eversource aims to have a carbon neutral grid by 2030 and Nextra Energy has published its goal for 100% renewable energy by 2045. In March of this year, CCRTA signed a new Contract with Power Options to renegotiate electricity rates. The new provider is Constellation Energy Resources. In its 2022 sustainability report, Constellation Energy specified a goal to generate 95 percent clean energy by 2030 and 100 percent by 2040.

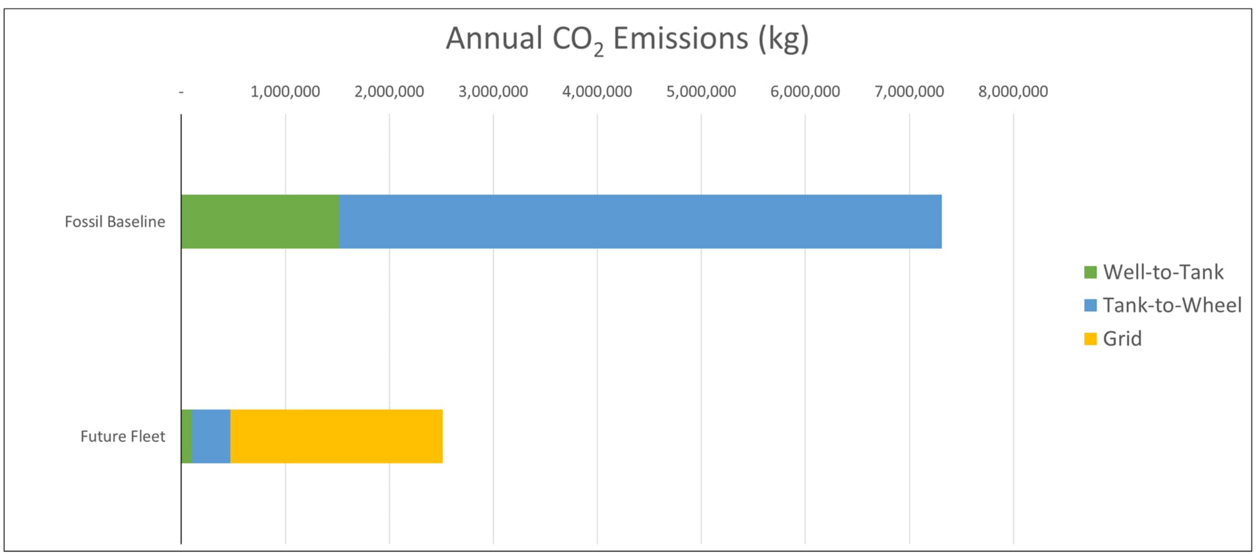


Figure 13 - Annual CO2 Emissions (kg)

16. Workforce Assessment

CCRTA staff currently operate a revenue fleet composed entirely of fossil fuel vehicles. As a result, the staff have skill gaps related to EV and charging infrastructure technologies that will be operated in the future. To ensure that both existing and future staff members can operate CCRTA's future system, a workforce assessment was conducted. Table 15 details skills gaps for the workforce groups within the authority and outlines training requirements to properly prepare the staff for future operations.

Table 15 - Workforce Skill Gaps and Required Training

Workforce Group	Skill Gaps and Required Training
Maintenance Staff	High voltage systems, vehicle diagnostics, electric propulsion, charging systems, and battery systems
Electricians	Charging system functionality and maintenance
Agency Safety/Training Officer/First Responders	High Voltage operations and safety, fire safety
Operators	EV operating procedures, charging system usage
General Agency Staff and Management	Understanding of vehicle and charging system technology, EV operating practices

To address these training requirements Hatch recommends that CCRTA consider the following training strategies, while recognizing that CCRTA has already implemented some of the listed strategies:

- Add requirements to vehicle and infrastructure specifications to require contractors to deliver training programs to meet identified skill gaps as part of capital projects.
- Coordinate with other peer transit authorities to transfer 'lessons learned.' Send staff to transit authority properties that have already deployed BEVs to learn about the technology.
- Coordinate with local vocational and community colleges to learn about education programs applicable to battery electric technologies. Also, consider partnering with a school to develop a curriculum if none exists.

This fall, CCRTA began conversations with two Cape Cod technical schools and a local community college regarding potential collaboration opportunities for curriculum, training, and hands-on learning. In addition, the Authority has been working to secure training for both Operators and technicians in advance of the delivery of the 20 MAP vehicles. CCRTA is well positioned for continued development of staff skills necessary to maintain and operate BEVs over the transition period and Hatch recommends that CCRTA continue these efforts ahead of the delivery of the first vehicles and charging systems.

17. Recommendations and Next Steps

The public transit industry is currently at the beginning stages of a wholesale transition to zero emissions technologies. As battery electric technology matures, climate concerns become more pressing, and fossil fuels increase in cost, many transit agencies will transition their fleets away from gasoline and diesel-powered vehicles in favor of battery electric. By facilitating this study, CCRTA took the first step toward fleet electrification, and the Authority stands well-positioned to continue this process in the coming years. In partnership with MassDOT, other transit authorities in Massachusetts, as well as with other key stakeholders, CCRTA will be able to reduce emissions, noise, operating cost, and other negative factors associated with fossil fuel operations, while operating sustainably for years to come.

For CCRTA to achieve sustainable and economical fleet electrification, Hatch recommends the following steps:

+ Proceed with transitioning the Authority's vehicles and infrastructure in the manner described in this report.
+ For the vehicles:
    + Consider ordering vehicles as part of larger orders or partnering with other regional transit authorities (RTAs), fleet operators (Steamship Authority) or MassDOT to form large joint procurements.
    + Where feasible, consider flexibility in vehicle types to increase competition on future vehicle procurements.
    + With future BEV orders, require the bus vendor to have a technician on site or nearby in case of problems. This is most economical when the technician is shared with nearby authorities.
+ For the infrastructure:
    + Upgrade the Depot and HTC's electrical utilities according to the Make Ready Incentive Program to support charging infrastructure. Use the conceptual designs provided by Hatch and Maverick as the basis for planning and upgrades.
    + Evaluate and strategize regarding locations for on-route charging and forge partnerships for eventual negotiations with local landowners in areas identified for this infrastructure.
    + Continue coordination with Eversource and Maverick with regards to power availability at the sites, once selected. It is also recommended that CCRTA seek inputs from Eversource on the available power at the sites that are under consideration to inform the final selection decision.
    + Conduct a fire safety analysis at the Depot and HTC in accordance with Section 11.2 and standards UL9540, NFPA 70 and 230, including staff training for fire response.
    + Choose an appropriate level of resiliency investment based on anticipated emergency operational needs – whether microgrid or on-site generation.
+ For other components of the transition:
    + Add requirements to future procurements for staff training.
    + Participate in industry conferences and coordination with other Massachusetts RTAs to share best practices for staff training programs, as described in Section 16.
    + Continue coordination with local education institutions for training program development.
    + Coordinate transition efforts with peer transit agencies.
    + Continually monitor utility structures and peak charge rates and adjust charging schedules accordingly.
    + Review the cost assumptions underlying this report to ensure that they have not changed significantly. Major changes in capital costs, fuel costs, labor costs, routes, schedules, or other operating practices may require CCRTA to modify the transition strategy.
    + Continuously monitor and evaluate the transition plan's potential benefits and adverse impacts to the environment and public health, particularly to EJ communities.
    + Ensure level of service is adequate in EJ communities within the CCRTA service area through each step of transition.
    + Ensure that public participation is encouraged, and that the Authority is engaging and consulting with EJ communities, where appropriate.
    + Review this transition plan annually to update based on current assumptions, plans, and conditions.

Appendix A: CCRTA Vehicle Conversion Equivalents List

Service Type	Vehicle # / Vehicle make	Vehicle Year	Total Vehicles	Vehicle Description	Max Seating	Retirement year	Cost of Electric Vehicle replacement	Electric Vehicle/ Seating capacity	Electric Vehicle Model
Fixed Route Cutaway	Ford E-450 E4FF	2019	8	Cutaway White Van 26 ft	15	2026	$170,000	Mid-Sized Cutaway/ 12	Ford E-Transit Cutaway
Fixed Route Cutaway	Chevrolet Express	2020	6	Arboc White Van 28 ft	17	2027	$295,000	Large sized Cutaway / 14	Lightning ZEV 3 VAN /Ford Transit 350HD Passenger Van
Fixed Route Cutaway	Chevrolet Express	2021	8	Arboc White Van 28ft	20	2028	$295,000	Large Sized Cutaway/ 14	Lightning ZEV 3 VAN /Ford Transit 350HD Passenger Van
Fixed Route Bus	Gillig	2010	3	Rear engine/ 29ft	30	2022	$960,000	Bus 29 ft/ 30	Gillig/ New Flyer,30 ft
Fixed Route Bus	Gillig	2013	3	Rear engine 29 ft	30	2025	$960,000	Bus 30 ft/30	Gillig/ New Flyer,30ft
Fixed Route Bus	Gillig	2018	3	Rear engine 29 ft	28	2030	$960,000	Bus 29 ft /28	Gillig/ New Flyer,30ft
Fixed Route Bus	Gillig	2019	6	Rear engine (2) 29 ft & (4) 35 ft	33	2031	$960,000	Bus 29 & 35 ft /30 & 35	Gillig/ New Flyer,35ft
Fixed Route Bus	Gillig	2021	3	Rear engine 35ft	33	2033	$960,000	Bus 35 ft /33	Gillig/ New Flyer,35 ft
Fixed Route Bus	Gillig	2022	6	Rear engine (3) 29 ft & (3) 35ft	33 & 28	2034	$960,000	Bus 29 & 35 ft / 30 &35	Gillig/ New Flyer,35ft
Fixed Route Bus	Gillig	2006	6	Rear engine 29ft	25	2024	$960,000	Bus 29 ft /25	Gillig/ New Flyer,30ft
Fixed Route Bus	Gillig	2008	6	Rear engine 29 & 35 ft	30 &35	2026	$960,000	Bus 29 & 35 ft /30 & 35	Gillig/ New Flyer,35ft
Trolleys	Ford F-53 Villager	2018	5	Villager, front engine 32ft	28	(2) 2025, (3) 2026	$960,000	Replace with Gillig bus 29 ft	Gillig/ New Flyer,35ft/ Green Power Heavy Duty Class 4 Electric Capacity 25

Service Type	Vehicle # / Vehicle make	Vehicle Year	Total Vehicles	Vehicle Description	Max Seating	Retirement year	Cost of Electric Vehicle replacement	Electric Vehicle/ Seating capacity	Electric Vehicle Model
DART Non CDL Cutaway	Ford E-450 Phoenix	2017	1	Cutaway white Van 25.75 ft	15	2024	$170,000	Mid-sized Cutaway/ 12	Ford E-Transit Cutaway
DART Non CDL Cutaway	Ford E-350 Phoenix	2017	18	Cutaway Van White 21.5 ft	12	2023	$125,000	Small Sized Cutaway/ 8	Ford E-Transit Cutaway
DART Non CDL Cutaway	Ford E-350 Phoenix	2018	3	Cutaway White 21.5 ft	8	2024	$125,000	Small Sized Cutaway/ 8	Ford E-Transit Cutaway
DART Non CDL Cutaway	Ford E-350 E3FX	2019	2	Cutaway White Van 21.5 ft	8	2025	$125,000	Small Sized Cutaway/ 8	Ford E-Transit Cutaway
DART Non CDL Cutaway	Ford E-350 E3FX	2021	1	Cutaway White Van 21ft	8	2026	$125,000	Small Sized Cutaway/ 8	Ford E-Transit Cutaway
DART Non CDL Cutaway	Ford E-350 Phoenix	2023	7	Cutaway White Van 21 ft	12	2029	$125,000	Small Sized Cutaway/ 8	Ford E-Transit Cutaway
DART CDL Cutaways	Ford F-450 Elkhart	2016	28	Cutaway White Van 26 ft	17	2023	$295,000	Large sized Cutaway/14	Lightning ZEV 3 VAN /Ford Transit 350HD Passenger Van
DART CDL Cutaways	Ford E-450 Econoline	2019	1	Cutaway White Van 26ft	16	2026	$295,000	Large Sized Cutaway/14	Lightning ZEV 3 VAN /Ford Transit 350HD Passenger Van
DART CDL Cutaways	Ford E-450 Econoline	2021	2	Cutaway White Van 26 ft	16	2028	$295,000	Large sized Cutaway/14	Lightning ZEV 3 VAN /Ford Transit 350HD Passenger Van

Service Type	Vehicle # / Vehicle make	Vehicle Year	Total Vehicles	Vehicle Description	Max Seating	Retirement year	Cost of Electric Vehicle replacement	Electric Vehicle/ Seating capacity	Electric Vehicle Model
DART CDL Cutaways	RAM 3500 Promaster	2020	3	Cutaway White Van 23 ft	14	2027	$170,000	Mid-Sized Cutaway/ 12	Ford E-Transit Cutaway
DART CDL Cutaways	Ford E-450 Econoline	2022	2	Cutaway White Van 26ft	16	2029	$295,000	Large Sized Cutaway/14	Lightning ZEV 3 VAN /Ford Transit 350HD Passenger Van
Caravans	Dodge Caravan	2018	1	Van 16.9 ft	3	2024	$70,000	SUV/3	Chevy Electric EQUINOX EV/Rivian R1S
Caravans	Dodge Caravan	2017	2	Van 16.9 ft	3	2023	$70,000	SUV/3	Chevy Electric EQUINOX EV/Rivian R1S
Caravans	Dodge Caravan	2019	2	Van 16.9 ft	3	2025	$70,000	SUV/3	Chevy Electric EQUINOX EV/Rivian R1S
Smart Dart Caravans	Dodge Caravan	2019	3	Van 16.9 ft	5	2025	$70,000	SUV/3	Chevy Electric EQUINOX EV/Rivian R1S

Appendix B: Eversource Qualified Products List

Commercial Project Electric Vehicle Charger Qualified Product List

This qualified product list (QPL) includes all electric vehicle charging network software and hardware providers that have been qualified to be eligible for rebates under the program, as of the effective date shown at the bottom of the document. Customers may select from any approved network software provide and any approved hardware provider. Customers should note that not all network software and hardware is compatible. Please confirm software and hardware compatibility with the vendor.

Qualified Charging Network Software Providers

Provider	Level 2 or DCFC Support
AmpedUp!	Both
AmpUp	Both
Blink	Both
ChargeLab	Both
ChargePoint	Both
ChargeUP	Level 2
Driivz	DCFC
Enel X	Both
Energy5 Network	Level 2
EV Connect	Both
EV Gateway	Both
EverCharge	Level 2
EVgo	DCFC
Evoke	Both
EVPassport	Both
FLO	Both
Ford Pro Depot Charging Software	Both
In-Control Network	Both
Leviton	Both
Livingston Energy Group	Both
Loop	Both
NovaCHARGE	Both
Nuvve	Both
PowerPump	Level 2
SemaConnect	Both
Shell Recharge Solutions	Both
SWTCH	Both
Xeal	Level 2
Zevtron	Both

Qualified Charging Hardware Providers

Level 2 Electric Vehicle Supply Equipment	
Hardware Manufacturer	**Hardware Model**
ABB	Terra AC Wallbox 40A, 80A
Aispex	PLTM-48, GOLD-48, SLVR-48
Atom Power	AP3P400
Atom Power	AS2P-60-EVSE, AS2P-100-EVSE
Blink (Lite-On)	HQ 200 Smart (HQW2-50C*)
Blink (Lite-On)	IQ200 Advanced (IQW2)
Blink (Lite-On)	MQ 200 (MQW2-50C*)
BreezeEV (Light Efficient Design)	EVC-L2-48A-L1-1*
BTCPower	EVP-2001-30*, EVP-2002-30*
BTCPower	L2W/P 30A, 40A, 70A
ChargePoint	CPF50
ChargePoint	CT4000
ChargePoint	CT6000 (fleet only)
Clipper Creek	HCS-40R
Enel X	JuiceBox Pro 32, 40, 48
Enel X	JuicePedestal 32, 40, 48
EverCharge	EV002
EvoCharge	iEVSE
EvoCharge	iEVSE Plus
EVPassport (Phihong)	Ezra (AW Series)
EVPassport (Phihong)	Rosa (AX Series)
EVSE LLC	3703
EVSE LLC	3704
EVSE LLC	3722
FLO (AddEnergies Technologies Inc.)	CoRe+
FLO (AddEnergies Technologies Inc.)	CoRE+ MAX
FLO (AddEnergies Technologies Inc.)	SmartTWO
Ford (Siemens)	Pro Charging 48A, 80A fleet (NL38-10C823-AA)
JuiceBar	JB3.0 32, 40, 48, 80
InCharge Energy (Lite-On)	ICE-40AC, ICE-80AC
Leviton (ChargePoint)	EVR Green 4000 (CT4000)
Lite-On	L2-LPWF
Livingston Energy Group	CP-203
Livingston Energy Group	CP-208
Livingston Energy Group (EVSE LLC)	3703-103+ IHD (3703)
Livingston Energy Group (EVSE LLC)	3704-10 IHD (3704)

Level 2 Electric Vehicle Supply Equipment	
Hardware Manufacturer	**Hardware Model**
Loop	EVS-32A-L2*
Loop	EVS-80A-L2*
NovaCHARGE	NC7000, NC8000
Nuvve	Power Port
Phihong	AW Series
Phihong	AX Series
PowerCharge	E20 XXE/XXP
PowerPump (CCM International)	AC5500-G
SemaConnect	Series 6
SemaConnect	Series 7
SemaConnect	Series 8
Siemens	Versicharge G3
Siemens	VersiCharge 40A, 48A
SWTCH (Lite-On)	EX-1762-1A30, EX-1193-1A13
Tellus Power Green	UP 160J
US Energy / Energy5 (Lite-On)	PowerPump C32-01 (EX-1762)
Wallbox	Pulsar Plus

DC Fast Chargers	
Hardware Manufacturer	**Hardware Model**
ABB	HVC 100, 150
ABB	T54 HV
ABB	Terra 184, 124, 94, 54
ABB	Terra HP 175, 350
ADS-TEC	ChargeBox 320 KW
BTCPower	HPC 100, 150, 200
BTCPower	HPCD1-350
BTCPower	L3R-100-480
BTCPower	L3R-50-208
BTCPower	L3S-50-208
BTCPower	L3S-50-480
BTCPower	100 kW AIO, 180 kW AIO, 180/240/360 kW Split System
ChargePoint	Express 250
ChargePoint	Express Plus[1]
Delta	100kW, 350kW
Enel X	JuicePump 50, 75
EVPassport (Phihong)	Larry (DSWU601*)
EVPassport (Phihong)	Ruth (DSWU122*)
EVPassport (Phihong)	Zeus (DSWU182*)
FLO (AddEnergie)	SmartDC 100kW
FLO (AddEnergie)	SmartDC 50kW
FreeWire	Boost Charger 150
Leviton (ChargePoint)	EVR Green DCFC (Express 250)
Nuvve (Rhombus)	RES-HD60-V2G, RES-HD125-V2G
Phihong	DSWU122*
Phihong	DSWU601*
Phihong	DSWU901*
Phihong	DS60, DS90, DS120, DS150, DS180, DO360
Rhombus	RES-DCVC- 60, 125
Rhombus	Res-HD125-V2G
Rhombus	Res-HD60-V2G
SemaConnect (Phihong)	SemaConnect 60, 90, 150, 180, 360 kW
Siemens	Ultra50
Signet	350kW
Tellus Power Green	TP-EVPD 60kW, 120kW, 160kW, 180kW, 200kW, 240kW, 300kW, 360kW
Tritium	PKM 100, 150

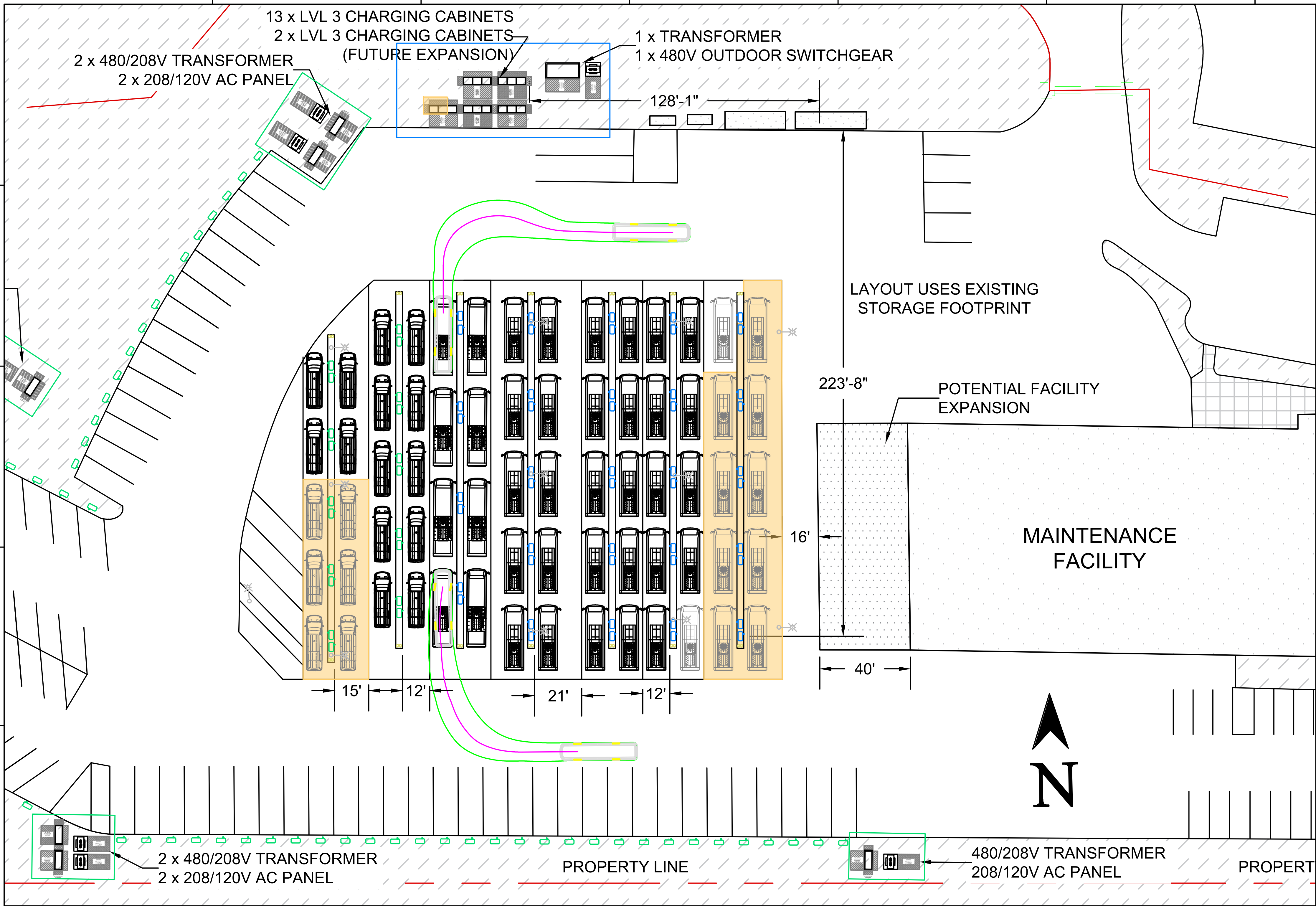
DC Fast Chargers	
Hardware Manufacturer	**Hardware Model**
Tritium	PKM 360-PU
Tritium	RT 175-S
Tritium	RT 50, 75, 150, 175
Tritium	RTM 50, 75

[1]ChargePoint's Express Plus must be installed with a minimum of two power modules per site

The equipment will differ on charger models, software, costs and manufacturer details. Eversource does not offer preferences or recommendations for any of the approved equipment. Program participants are responsible for determining the suitability of these products and services.

Appendix C: the Depot's Conceptual Design Drawings

Note: CCRTA-CS-100 to CCRTA-CS-102 shows layout utilizing existing street lighting while CCRTA-CS-103 to CCRTA-CS-105 shows optimized layout utilizing new street lighting



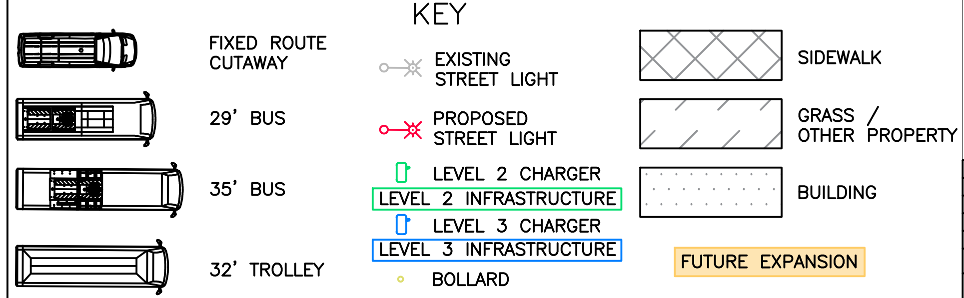
Notes/Assumptions:

- Chargers shall be placed in well-lit and visible locations to avoid vandalization.
- Chargers shall not be installed on sloped or pitched roadway.
- 350ft. maximum trenching from power cabinets to furthest charger
- This schematic assumes that new medium voltage service is required from the utility.
- All dimensions provided are generic and subject to change.
- Layout uses existing storage footprint and street light locations.
- 146 total charging locations
  - •• 45 Level 3 charging locations
  - •• 101 Level 2 charging locations

Central Storage Location

- Storage and charging for:
  - •• 14 fixed route cutaways
  - •• 29 29ft. buses
  - •• 8 35ft. buses
- Future expansion:
  - •• 9 Level 3 charging locations
  - •• 6 Level 2 charging locations

KEY



DO NOT SCALE

THIS DRAWING WAS PREPARED FOR THE EXCLUSIVE USE OF [NAME OF CLIENT] ("CLIENT") AND IS ISSUED PURSUANT TO [THE RELEVANT AGREEMENT] BETWEEN CLIENT AND [HATCH CORP] ("HATCH"). UNLESS OTHERWISE AGREED IN WRITING WITH CLIENT OR SPECIFIED ON THIS DRAWING, (A) HATCH DOES NOT ACCEPT AND DISCLAIMS ANY AND ALL LIABILITY OR RESPONSIBILITY ARISING FROM ANY USE OF OR RELIANCE ON THIS DRAWING BY ANY THIRD PARTY OR ANY MODIFICATION OR MISUSE OF THIS DRAWING BY CLIENT, AND (B) THIS DRAWING IS CONFIDENTIAL AND ALL INTELLECTUAL PROPERTY RIGHTS EMBODIED OR REFERENCED IN THIS DRAWING REMAIN THE PROPERTY OF HATCH.

HATCH LTK

No.	DESCRIPTION	BY	CHK'D	DATE
C	Edits to charger counts and formatting. Addition of Trolley bus charging			
B	Addition of Level 2 Chargers	E.L.	M.B.	8/3/23
A	Initial Release			

REVISIONS

ROLE	NAME	SIGNATURE	DATE
DESIGNER	Edward Lopez	E.L.	6/22/23
DSGN. APPROVER	Mihir Bodarya	M.H.	6/22/23
PROJ. MANAGER	Emily Marble	E.M.	6/22/23

DRAWING APPROVAL STATUS:

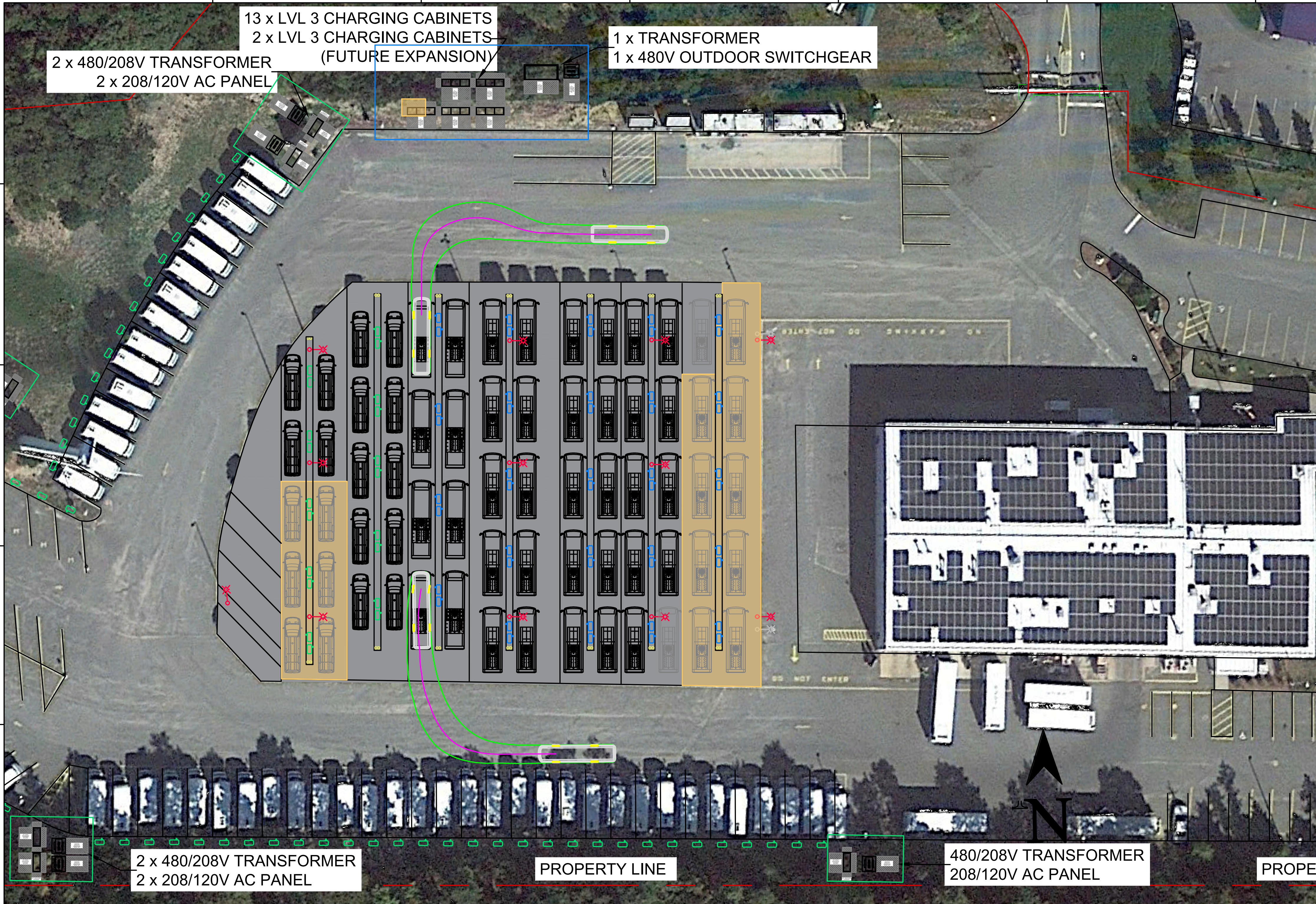
CONCEPTUAL SKETCH

CCRTA

DENNIS DEPOT
CHARGING LAYOUT AND ANALYSIS
WITH EXISTING STREET LIGHTING

SCALE 1:50 OR AS NOTED | DWG. No. CCRTA-CS-100 | REV C

SHEET SIZE: ANSI-D



Notes/Assumptions:

- Chargers shall be placed in well-lit and visible locations to avoid vandalization.
- Chargers shall not be installed on sloped or pitched roadway.
- 350ft. maximum trenching from power cabinets to furthest charger
- This schematic assumes that new medium voltage service is required from the utility.
- All dimensions provided are generic and subject to change.
- Layout uses existing storage footprint and street light locations.
- 146 total charging locations
  - •• 45 Level 3 charging locations
  - •• 101 Level 2 charging locations

Central Storage Location

- Storage and charging for:
  - •• 14 fixed route cutaways
  - •• 29 29ft. buses
  - •• 8 35ft. buses
- Future expansion:
  - •• 9 Level 3 charging locations
  - •• 6 Level 2 charging locations

KEY

FIXED ROUTE CUTAWAY	EXISTING STREET LIGHT
29' BUS	PROPOSED STREET LIGHT
35' BUS	LEVEL 2 CHARGER
	LEVEL 2 INFRASTRUCTURE
32' TROLLEY	LEVEL 3 CHARGER
	LEVEL 3 INFRASTRUCTURE
	BOLLARD
SIDEWALK	GRASS / OTHER PROPERTY
BUILDING	FUTURE EXPANSION

DO NOT SCALE

HATCH LTK

No.	DESCRIPTION	BY	CHK'D	DATE
C	Edits to charger counts and formatting. Addition of Trolley bus charging			
B	Addition of Level 2 Chargers	E.L.	M.B.	8/3/23
A	Initial Release			

REVISIONS

ROLE	NAME	SIGNATURE	DATE
DESIGNER	Edward Lopez	E.L.	6/22/23
DSGN. APPROVER	Mihir Bodarya	M.H.	6/22/23
PROJ. MANAGER	Emily Marble	E.M.	6/22/23

DRAWING APPROVAL STATUS:

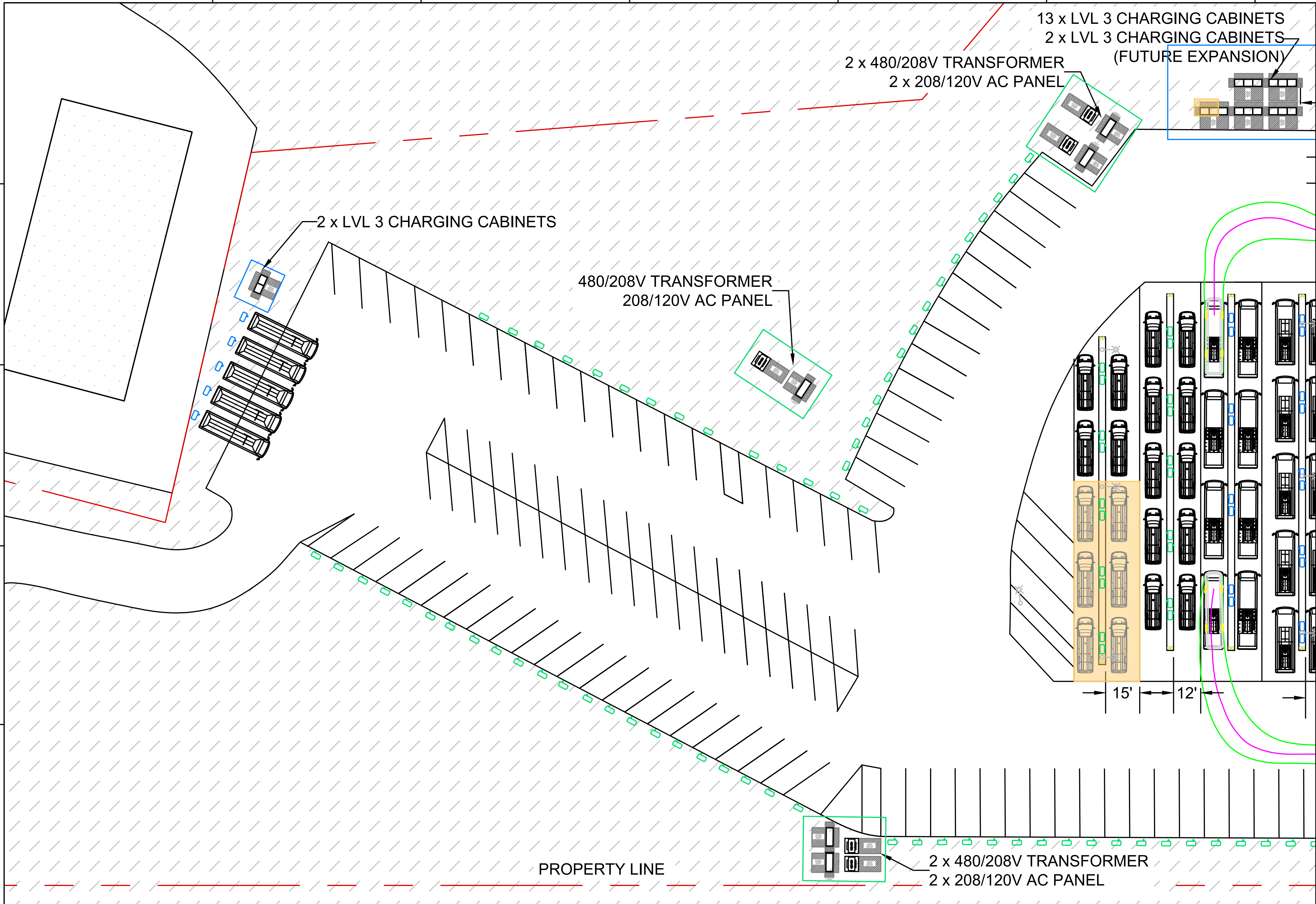
CONCEPTUAL SKETCH

CCRTA

DENNIS DEPOT
CHARGING LAYOUT AND ANALYSIS
WITH EXISTING STREET LIGHTING MAP UNDERLAY

SCALE 1:50 OR AS NOTED | DWG. No. CCRTA-CS-101 | REV C

SHEET SIZE: ANSI-D



Notes/Assumptions:

- Chargers shall be placed in well-lit and visible locations to avoid vandalization.
- Chargers shall not be installed on sloped or pitched roadway.
- 350ft. maximum trenching from power cabinets to furthest charger
- This schematic assumes that new medium voltage service is required from the utility.
- All dimensions provided are generic and subject to change.
- 146 total charging locations
  - 45 Level 3 charging locations
  - 101 Level 2 charging locations

Exterior Storage Locations

- Storage and charging for:
  - 87 various Ops vehicles
  - 5 32' Trolley buses

KEY

- FIXED ROUTE CUTAWAY
- 29' BUS
- 35' BUS
- 32' TROLLEY
- EXISTING STREET LIGHT
- PROPOSED STREET LIGHT
- LEVEL 2 CHARGER
- LEVEL 2 INFRASTRUCTURE
- LEVEL 3 CHARGER
- LEVEL 3 INFRASTRUCTURE
- BOLLARD
- SIDEWALK
- GRASS / OTHER PROPERTY
- BUILDING
- FUTURE EXPANSION

DO NOT SCALE

HATCH LTK

No.	DESCRIPTION	BY	CHK'D	DATE
B	Edits to charger counts and formatting. Addition of Trolley bus charging			
A	Initial Release			

REVISIONS

ROLE	NAME	SIGNATURE	DATE
DESIGNER	Edward Lopez	E.L.	6/22/23
DSGN. APPROVER	Mihir Bodarya	M.H.	6/22/23
PROJ. MANAGER	Emily Marble	E.M.	6/22/23

DRAWING APPROVAL STATUS:

CONCEPTUAL SKETCH

CCRTA

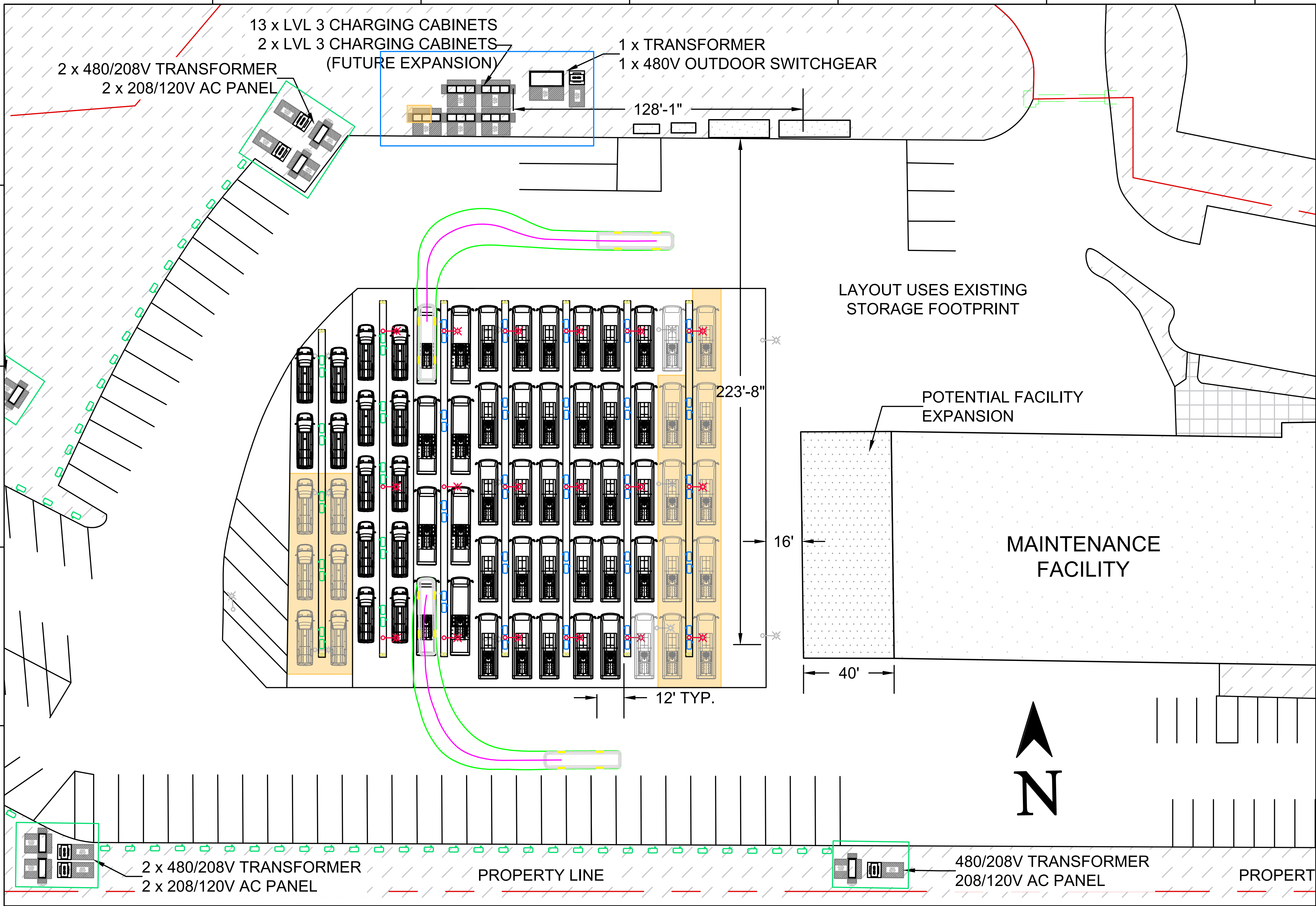
DENNIS DEPOT WEST LOT
CHARGING LAYOUT AND ANALYSIS
WITH EXISTING STREET LIGHTING

SCALE 1:50 OR AS NOTED

DWG. No. CCRTA-CS-102

REV B

SHEET SIZE: ANSI-D



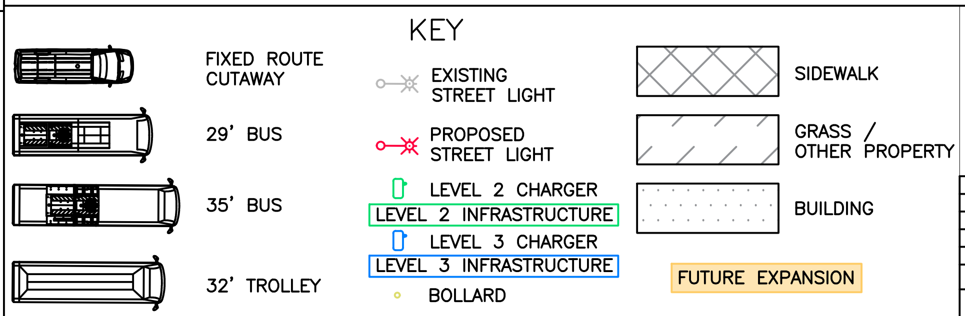
Notes/Assumptions:

- Chargers shall be placed in well-lit and visible locations to avoid vandalization.
- Chargers shall not be installed on sloped or pitched roadway.
- 350ft. maximum trenching from power cabinets to furthest charger
- This schematic assumes that new medium voltage service is required from the utility.
- All dimensions provided are generic and subject to change.
- Layout assumes the removal of existing street lights and installation of new street lights
- 146 total charging locations
  - 45 Level 3 charging locations
  - 101 Level 2 charging locations

Central Storage Location

- Storage and charging for:
  - 14 fixed route cutaways
  - 29 29ft. buses
  - 8 35ft. buses
- Future expansion:
  - 9 Level 3 charging locations
  - 6 Level 2 charging locations

KEY



DO NOT SCALE

HATCH LTK

No.	DESCRIPTION	BY	CHK'D	DATE
C	Edits to charger counts and formatting. Addition of Trolley bus charging			
B	Addition of Level 2 Chargers	E.L.	M.B.	8/3/23
A	Initial Release			

REVISIONS

ROLE	NAME	SIGNATURE	DATE
DESIGNER	Edward Lopez	E.L.	6/22/23
DSGN. APPROVER	Mihir Bodarya	M.H.	6/22/23
PROJ. MANAGER	Emily Marble	E.M.	6/22/23

DRAWING APPROVAL STATUS:

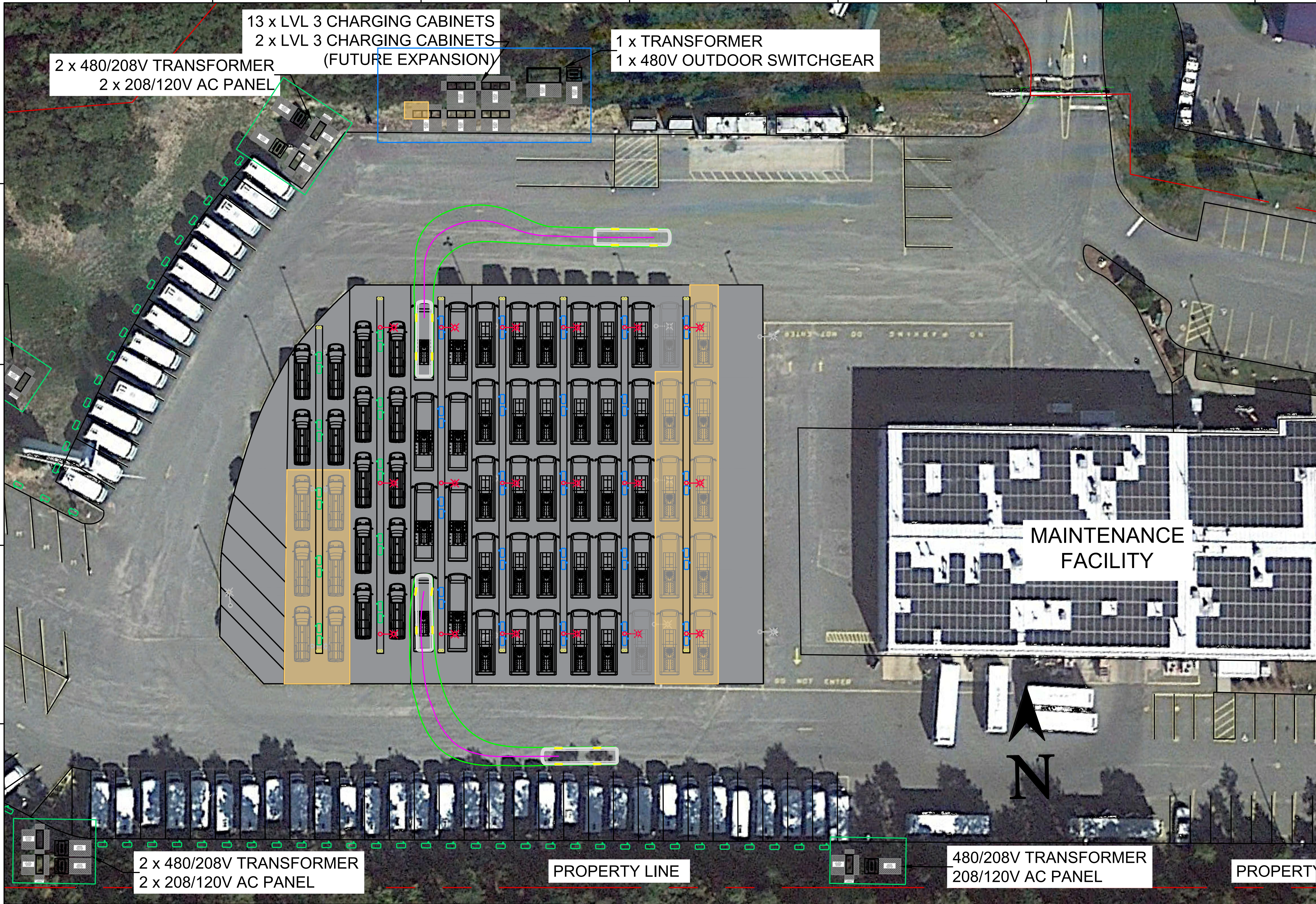
CONCEPTUAL SKETCH

CCRTA

DENNIS DEPOT
CHARGING LAYOUT AND ANALYSIS
OPTIMIZED LAYOUT

SCALE 1:50 OR AS NOTED | DWG. No. CCRTA-CS-103 | REV C

SHEET SIZE: ANSI-D



Notes/Assumptions:

- Chargers shall be placed in well-lit and visible locations to avoid vandalization.
- Chargers shall not be installed on sloped or pitched roadway.
- 350ft. maximum trenching from power cabinets to furthest charger
- This schematic assumes that new medium voltage service is required from the utility.
- All dimensions provided are generic and subject to change.
- Layout assumes the removal of existing street lights and installation of new street lights
- 146 total charging locations
  - •• 45 Level 3 charging locations
  - •• 101 Level 2 charging locations

Central Storage Location

- Storage and charging for:
  - •• 14 fixed route cutaways
  - •• 29 29ft. buses
  - •• 8 35ft. buses
- Future expansion:
  - •• 9 Level 3 charging locations
  - •• 6 Level 2 charging locations

KEY

- FIXED ROUTE CUTAWAY
- 29' BUS
- 35' BUS
- 32' TROLLEY
- EXISTING STREET LIGHT
- PROPOSED STREET LIGHT
- LEVEL 2 CHARGER
- LEVEL 2 INFRASTRUCTURE
- LEVEL 3 CHARGER
- LEVEL 3 INFRASTRUCTURE
- BOLLARD
- SIDEWALK
- GRASS / OTHER PROPERTY
- BUILDING
- FUTURE EXPANSION

DO NOT SCALE

HATCH LTK

No.	DESCRIPTION	BY	CHK'D	DATE
C	Edits to charger counts and formatting. Addition of Trolley bus charging			
B	Addition of Level 2 Chargers	E.L.	M.B.	8/3/23
A	Initial Release			

REVISIONS

ROLE	NAME	SIGNATURE	DATE
DESIGNER	Edward Lopez	E.L.	6/22/23
DSGN. APPROVER	Mihir Bodarya	M.H.	6/22/23
PROJ. MANAGER	Emily Marble	E.M.	6/22/23

DRAWING APPROVAL STATUS:

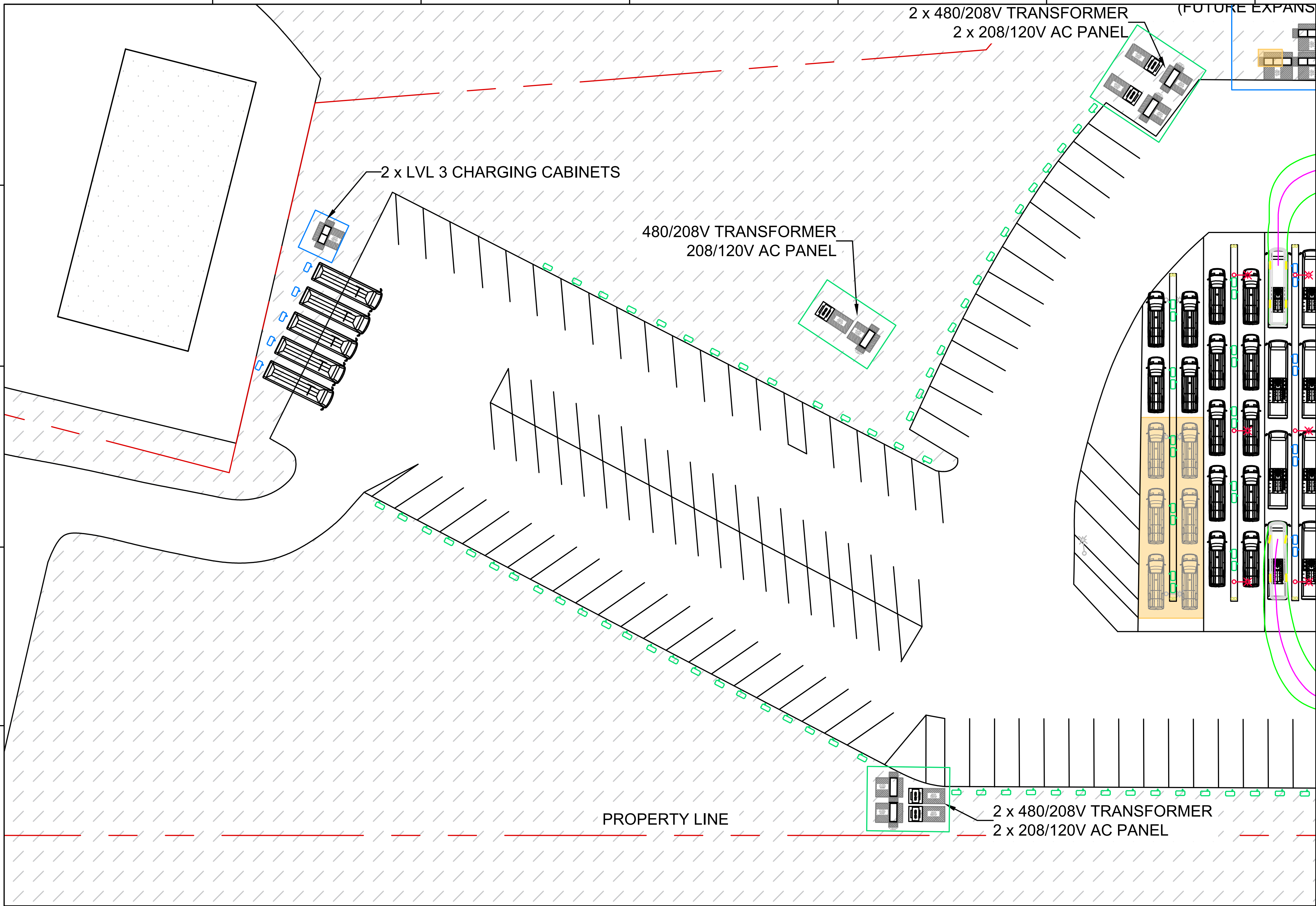
CONCEPTUAL SKETCH

CCRTA

DENNIS DEPOT
CHARGING LAYOUT AND ANALYSIS
OPTIMIZED LAYOUT MAP UNDERLAY

SCALE 1:50 OR AS NOTED | DWG. No. CCRTA-CS-104 | REV C

SHEET SIZE: ANSI-D



Notes/Assumptions:

- Chargers shall be placed in well-lit and visible locations to avoid vandalization.
- Chargers shall not be installed on sloped or pitched roadway.
- 350ft. maximum trenching from power cabinets to furthest charger
- This schematic assumes that new medium voltage service is required from the utility.
- All dimensions provided are generic and subject to change.
- 146 total charging locations
  - 45 Level 3 charging locations
  - 101 Level 2 charging locations

Exterior Storage Locations

- Storage and charging for:
  - 87 various Ops vehicles
  - 5 32' Trolley buses

KEY

FIXED ROUTE CUTAWAY	EXISTING STREET LIGHT
29' BUS	PROPOSED STREET LIGHT
35' BUS	LEVEL 2 CHARGER / LEVEL 2 INFRASTRUCTURE
32' TROLLEY	LEVEL 3 CHARGER / LEVEL 3 INFRASTRUCTURE
	BOLLARD

SIDEWALK

GRASS / OTHER PROPERTY

BUILDING

FUTURE EXPANSION

DO NOT SCALE

HATCH LTK

No.	DESCRIPTION	BY	CHK'D	DATE
B	Edits to charger counts and formatting. Addition of Trolley bus charging			
A	Initial Release			

REVISIONS

ROLE	NAME	SIGNATURE	DATE
DESIGNER	Edward Lopez	E.L.	6/22/23
DSGN. APPROVER	Mihir Bodarya	M.H.	6/22/23
PROJ. MANAGER	Emily Marble	E.M.	6/22/23

DRAWING APPROVAL STATUS:

CONCEPTUAL SKETCH

CCRTA

DENNIS DEPOT WEST LOT
CHARGING LAYOUT AND ANALYSIS
OPTIMIZED LAYOUT

SCALE 1:50 OR AS NOTED

DWG. No. CCRTA-CS-105

REV B

SHEET SIZE: ANSI-D

Appendix D: HTC's Conceptual Design Package

EVERSOURCE APPROVED
NAME:
SIGNED:
DATE:

CLIENT/OWNER APPROVED
NAME:
SIGNED:
DATE:

CLIENT POST CONSTRUCTION APPROVED
NAME:
SIGNED:
DATE:

EVERSOURCE ENERGY

ELECTRIC VEHICLE CHARGING STATIONS

SITE NAME: CCRTA_HYANNIS_215 LYANNOUGH RD, HYANNIS, MA 02601

SITE TYPE: EV INFRASTRUCTURE ELECTRICAL SPECIAL OPTION
JURISDICTION: BARNSTABLE COUNTY

DESIGN PROPOSAL

SITE INFORMATION

PROPOSED EV SITE ADDRESS:	215 LYANNOUGH RD, HYANNIS, MA 02601
PROPERTY OWNER:	CCRTA
EQUIPMENT SUPPLIER:	MERRIMAC INDUSTRIAL
POWER COMPANY:	EVERSOURCE ENERGY
JURISDICTION:	BARNSTABLE COUNTY
LATITUDE:	41°39'25.83"N
LONGITUDE:	70°16'45.06"W
CONTACT ENGINEER:	SEAN TULLY
EVERSOURCE SUPPLY TRANSFORMER:	#TBD
EVERSOURCE WO#:	#TBD

CALL BEFORE YOU DIG

UNDERGROUND SERVICE ALERT
UTILITY NOTIFICATION CENTER OF MASSACHUSETTS
811 OR +1 888-344-7233
3 WORKING DAYS UTILITY NOTIFICATION PRIOR TO CONSTRUCTION

DIGSAFE MARKED:

DIGSAFE CALLED IN:

DIGSAFE NUMBER:

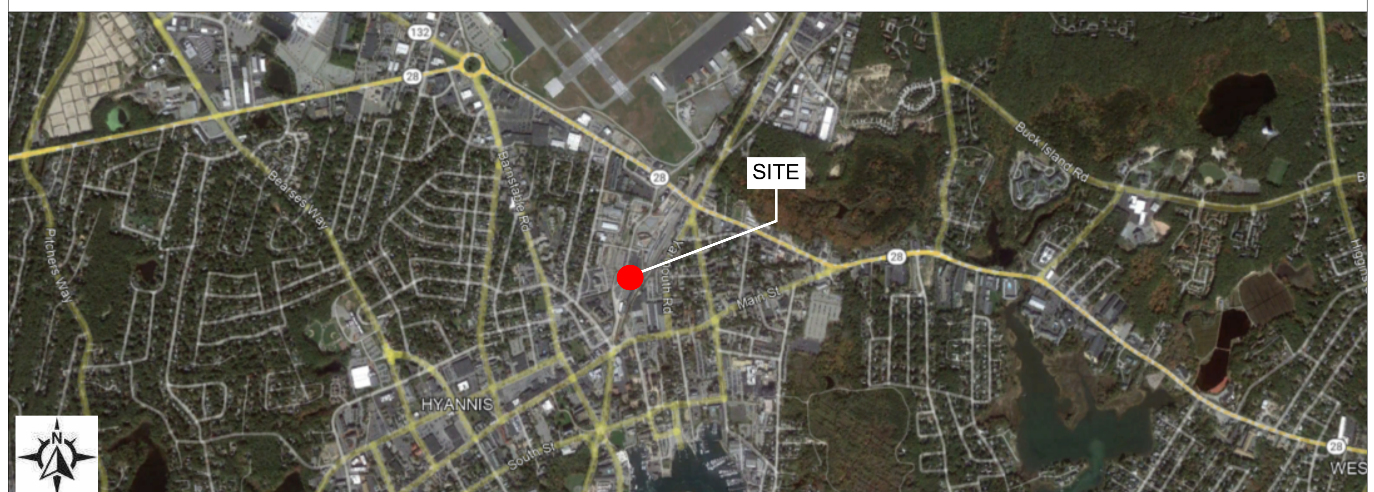
START DATE:

EXPIRY DATE:

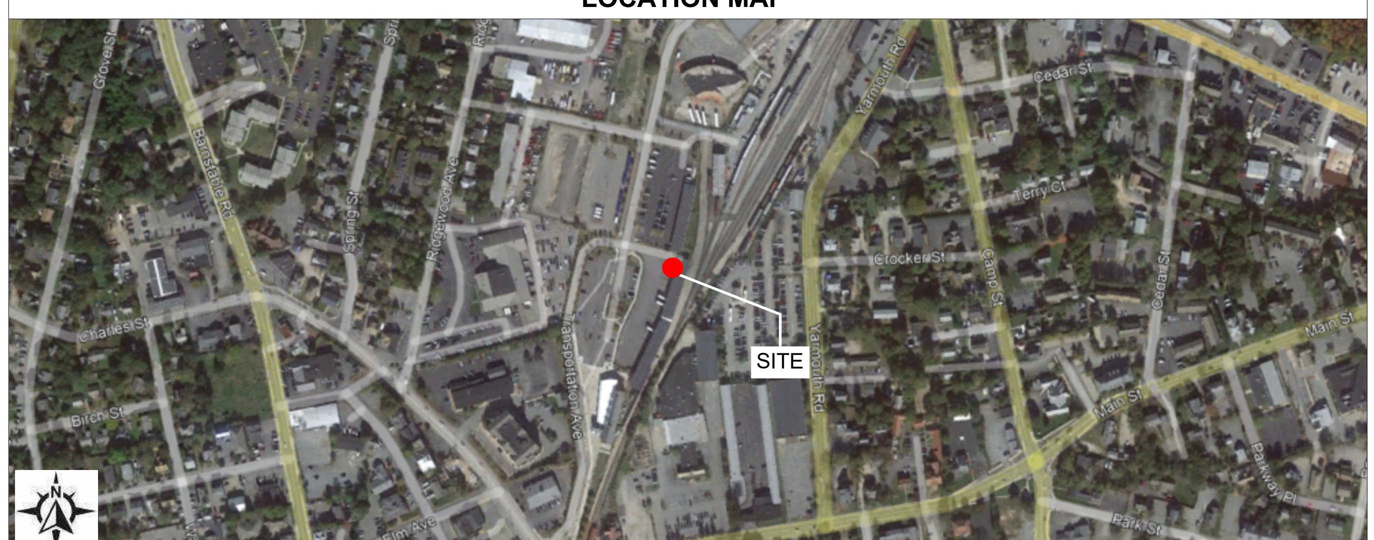
IMPORTANT NOTICE

THE EXISTING CONDITIONS REPRESENTED HEREIN ARE BASED ON VISUAL OBSERVATIONS AND INFORMATION PROVIDED BY OTHERS. THE CONTRACOR SHALL VISIT THE SITE AND VERIFY ALL EXISTING CONDITIONS PRIOR TO CONSTRUCTION. REPORT ALL CONFLICTS OR DISCREPENCIES PRIOR TO CONSTRUCTION.

AREA MAP



LOCATION MAP



IMPORTANT SITE NOTES

DO NOT SCALE DRAWINGS

CONTRACTOR SHALL VERIFY ALL PLANS, EXISTING DIMENSIONS & CONDITIONS ON THE JOB SITE & SHALL IMMEDIATELY NOTIFY THE ENGINEER IN WRITING OF ANY DISCREPENCIES BEFORE PROCEEDING WITH THE WORK

SCOPE OF WORK

MAKE READY INSTALLATION FOR ELECTRIC VEHICLE CHARGING STATIONS AND ASSOCIATED SUPPORT EQUIPMENT AT GROUND AND UNDERGROUND LEVEL

APPLICABLE CODES

ALL WORK SHALL COMPLY WITH THE FOLLOWING APPLICABLE CODES: MA STATE BUILDING CODE, 9TH EDITION
MA STATE PLUMBING CODE
MA STATE MECHANICAL CODE
MA ELECTRICAL CODE
MA FIRE PREVENTION REGULATIONS
IN THE EVENT OF CONFLICT, THE MOST RESTRICTIVE CODE SHALL PREVAIL

DRAWING INDEX

SHEET NO.	SHEET TITLE
T-1	TITLE SHEET & PROJECT DATA
C-1	PROPOSED SITE PLAN

ARCHITECT/ENGINEER

MAVERICK
One Westinghouse Plaza, Suite D6, Boston, Massachusetts, 02136

MAVERICK
1 Westinghouse Plaza, Suite D6, Boston, Massachusetts, 02136
+1 617-361-6700

EVERSOURCE ENERGY
800 Boylston St, Boston, Massachusetts, 02199
+1 800-592-2000

PROJECT NO:	10-19-0005.562
DRAWN BY:	D.D.
CHECKED BY:	D.C.

REV	DATE	DESCRIPTION
1	08/10/2023	ISSUED FOR REVIEW
0	04/21/2023	ISSUED FOR REVIEW

IT IS A VIOLATION OF THE LAW FOR ANY PERSON, UNLESS THEY ARE ACTING UNDER THE DIRECTION OF A LICENSED PROFESSIONAL ENGINEER, TO ALTER THIS DOCUMENT

CCRTA_HYANNIS_215 LYANNOUGH RD, HYANNIS, MA 02601

ELECTRIC VEHICLE CHARGING STATIONS

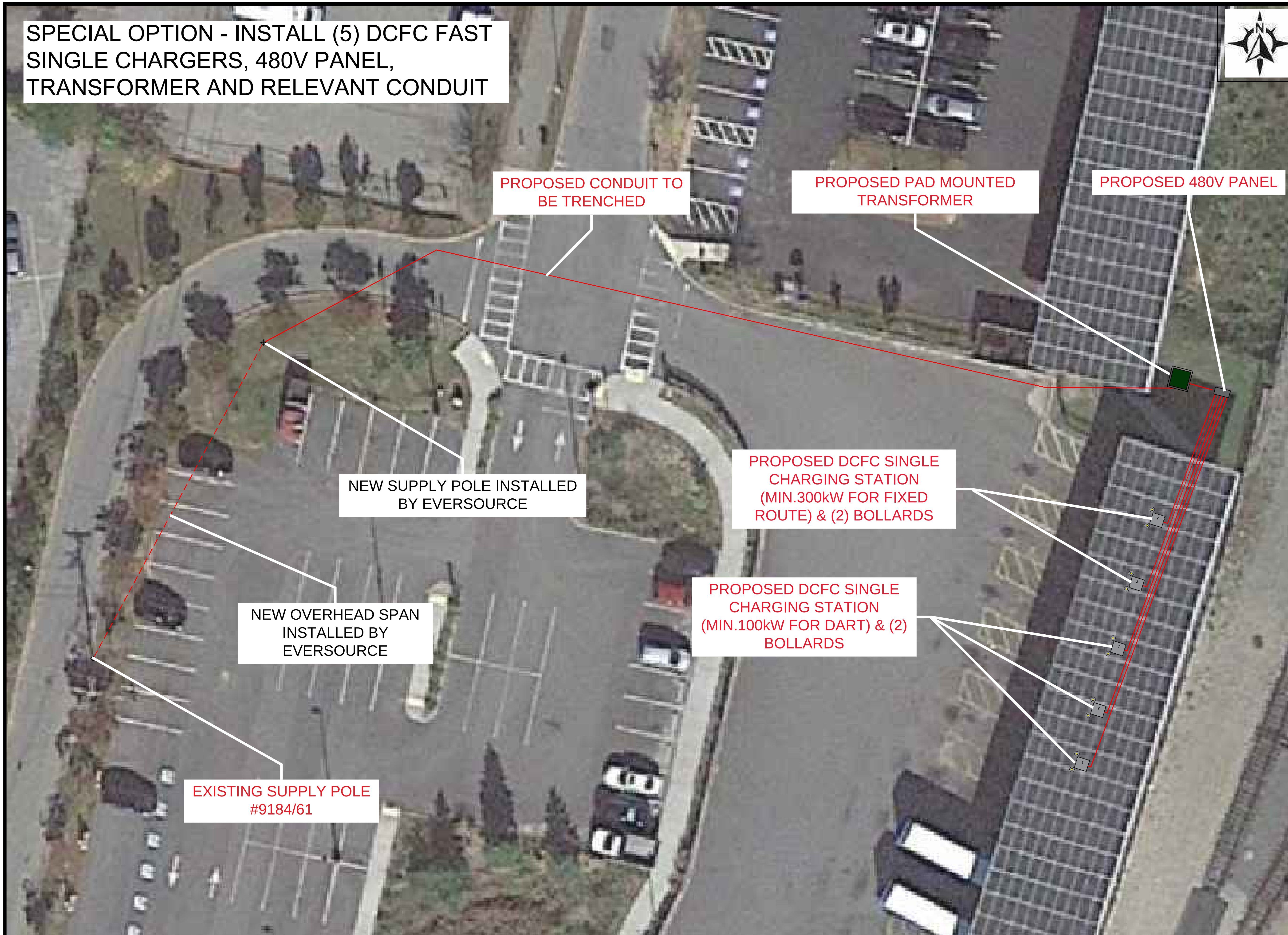
SHEET TITLE

TITLE SHEET & PROJECT DATA

SHEET NUMBER

T-1

SPECIAL OPTION - INSTALL (5) DCFC FAST SINGLE CHARGERS, 480V PANEL, TRANSFORMER AND RELEVANT CONDUIT



MAVERICK

1 Westinghouse Plaza,
Suite D6, Boston,
Massachusetts, 02136
+1 617-361-6700

EVERSOURCE ENERGY

800 Boylston St,
Boston,
Massachusetts, 02199
+1 800-592-2000

PROJECT NO:	10-19-0005.562
DRAWN BY:	D.D.
CHECKED BY:	D.C.

REV	DATE	DESCRIPTION
1	08/10/2023	ISSUED FOR REVIEW
0	04/21/2023	ISSUED FOR REVIEW

CCRTA_HYANNIS_215 LYANNOUGH RD, HYANNIS, MA 02601

ELECTRIC VEHICLE CHARGING STATIONS

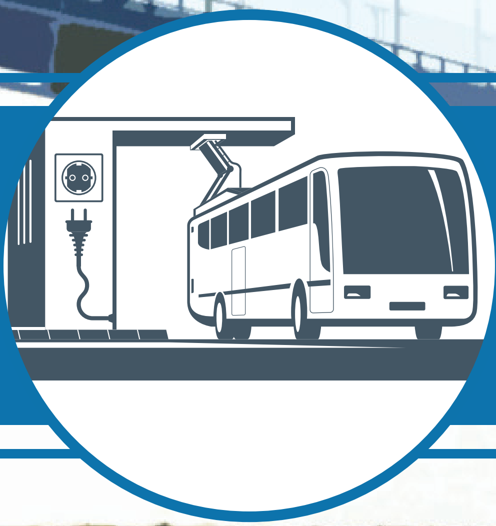
SHEET TITLE

PROPOSED SITE PLAN

SHEET NUMBER

C-1

Appendix E: EJ Community Considerations for ZEV Fleet Transitions



Cape Cod Regional Transit Authority

EJ Community Considerations for ZEV Fleet Transitions

Rev. 1 | October 10, 2023

1. Introduction

As part of the zero emission vehicle (ZEV) transition study, Hatch considered Environmental Justice (EJ) communities to inform development of an equitable transition strategy for Cape Cod Regional Transit Authority (CCRTA). EJ considerations are critical to transition planning, codified as commonwealth policy, and are also a requirement to receive federal funding. EJ is defined as the equal protection and meaningful involvement of all people and communities with respect to the development, implementation, and enforcement of energy, climate change, and environmental laws, regulations, and policies and the equitable distribution of energy and environmental benefits and burdens. EJ is based on the principle that all people have a right to be protected from environmental hazards and burdens, with all members of a community provided the opportunity to live in and enjoy a clean and healthful environment regardless of their background.[1]

EJ communities are members of the population that are vulnerable or at risk of being unaware of or unable to participate in environmental decision-making or to gain access to environmental resources due to socioeconomic disadvantages. The need for EJ is most widely recognized in communities of color and low-income communities. Communities who typically live in dense urban neighborhoods or proximate to industrial or contaminated sites are susceptible to EJ issues; these conditions make them more prone to environmental and health risks, affecting their quality of life.

ZEV transition planning has the potential to support EJ communities through the improvement of air quality with reduced particulate matter, encouragement of community participation, reduction of greenhouse gas (GHG) emissions, improvement of overall transit service, and by providing cleaner transit facilities and infrastructure.

2. Methodology

First, to ensure Hatch's operations analysis considered Cape Cod EJ communities, CCRTA's service area was defined to determine which geographic areas on Cape Cod would be affected by a ZEV transition. From there, Hatch identified three different EJ programs to utilize; the Federal Justice40 Initiative, the US Department of Transportation's (DOT) Equitable Transportation Community Explorer (ETCE), and the MA EEA Environmental Justice Populations. Once the EJ programs were decided upon, Hatch then evaluated the EJ programs' indicators and screening methodology to identify the EJ communities in CCRTA's service area based on each program's thresholds.

[1] Environmental Justice Policy of the Executive Office of Energy and Environmental Affairs, Commonwealth of Massachusetts, Updated June 24, 2021

3. Findings

Notably, three Justice 40-designated disadvantaged communities (by Census Tracts) were identified in CCRTA's service area; two in Barnstable and one in Falmouth. See Figure 1 for the areas of Justice40 disadvantaged tracts. The numbers on the map denote the census tracts. About five percent of the total population, or 10,000 residents, of the CCRTA service area is part of a disadvantaged community. These communities experience higher than average disadvantages when it comes to health (heart diseases); costs of living (increased spending on housing and energy); traffic proximity (live near major roads); income (low median income); and educational attainment. Notably, the Justice 40-designated communities within the CCRTA service area have high rates of asthma, ranking around 90th percentile for asthma compared to Census Tracts nationwide.

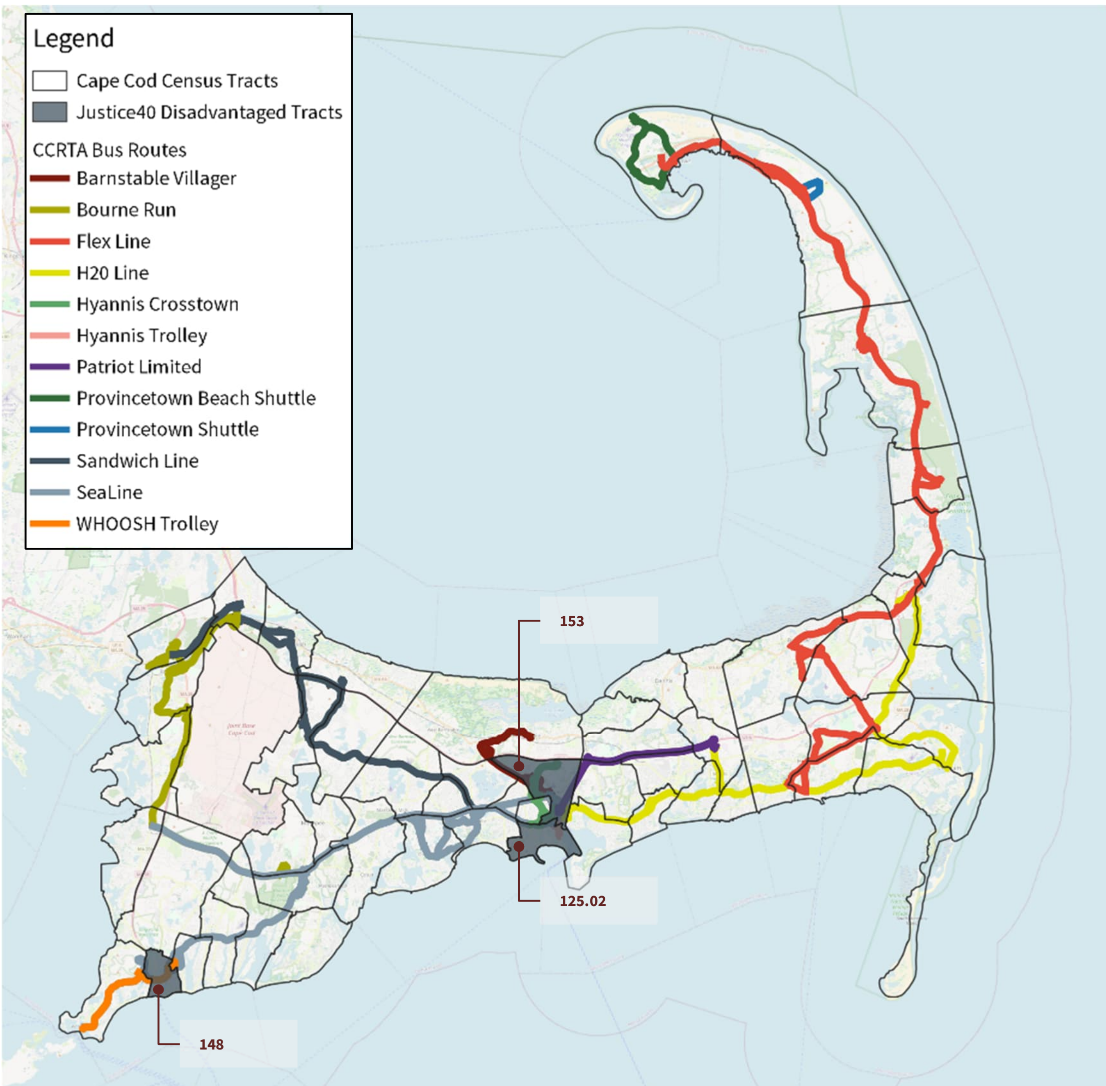


Figure 1 - CCRTA Bus Routes and White House Justice40-Designated Census Tracts

As shown in Figure 2, findings from the US DOT ETCE program identified communities in Bourne and Falmouth as well as in Barnstable and Truro with higher transportation cost burden scores, meaning that these communities devote a larger portion of their income to transportation. In addition, the areas with higher transportation cost burden were also identified as areas with higher concentrations of low-income and lower education-attainment households. Generally speaking, transportation cost burden limits a household's ability to spend on other essentials such as groceries and medical care, which may in turn lead to adverse health outcomes like chronic illnesses and higher obesity rates.

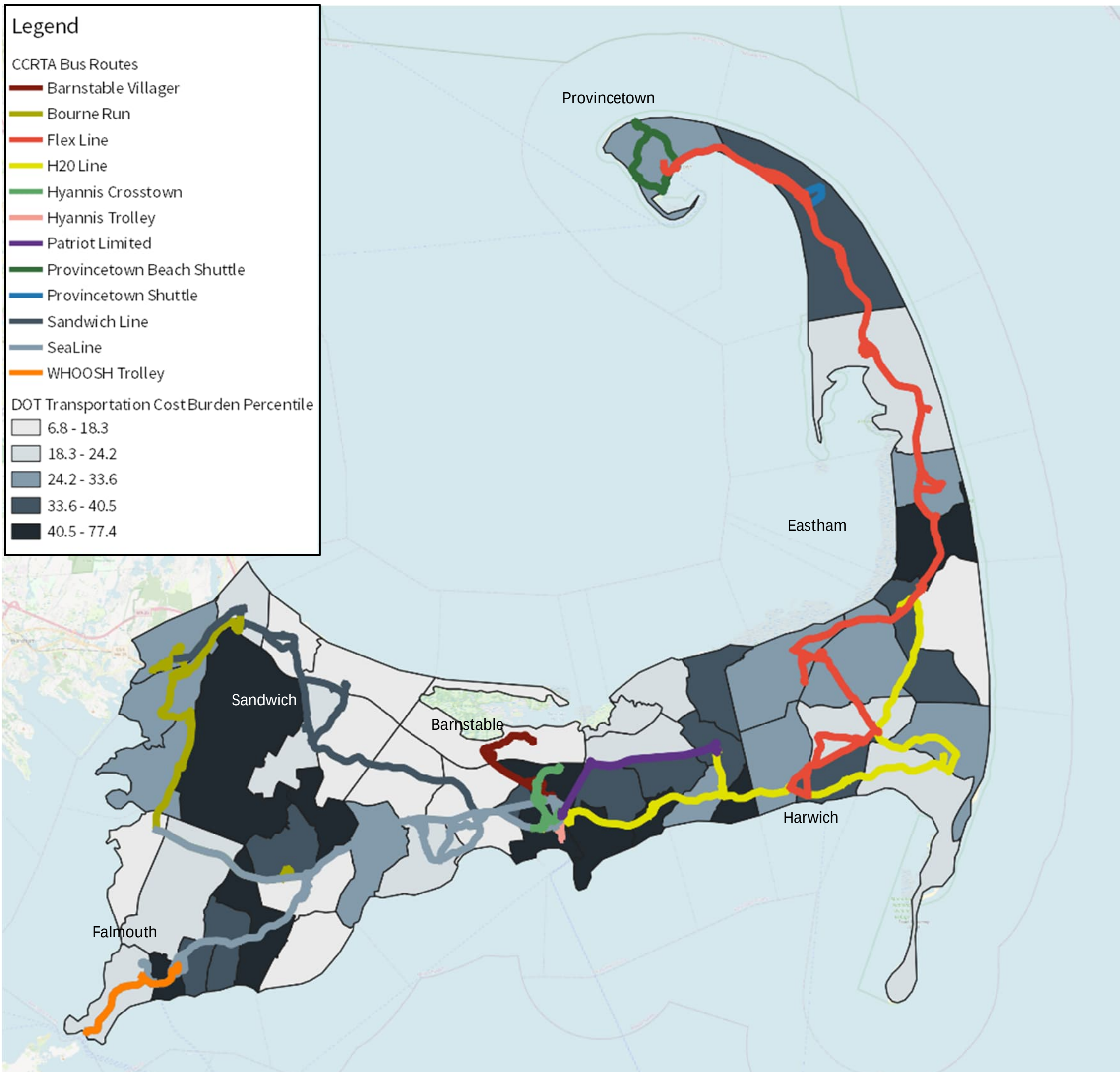


Figure 2 - CCRTA Bus Routes and DOT Transportation Cost Burden Percentile by Census Tract

As shown in Figure 3, the MA EEA program identified EJ Populations clustered within CCRTA's service area, in particular areas in southern Falmouth, at the intersection of the towns of Bourne and Sandwich, Barnstable, specifically near the Cape Cod Airport, and in Eastham. The EJ Populations as defined by MA EEA, include some communities making less than 65% of MA annual median income, and areas where minorities comprise 40 percent or more of the population. Beyond areas with low-income households, some of the EJ Populations within the CCRTA service area experience additional burdens associated with English language isolation or where 25 percent or more of the households lack English language proficiency.

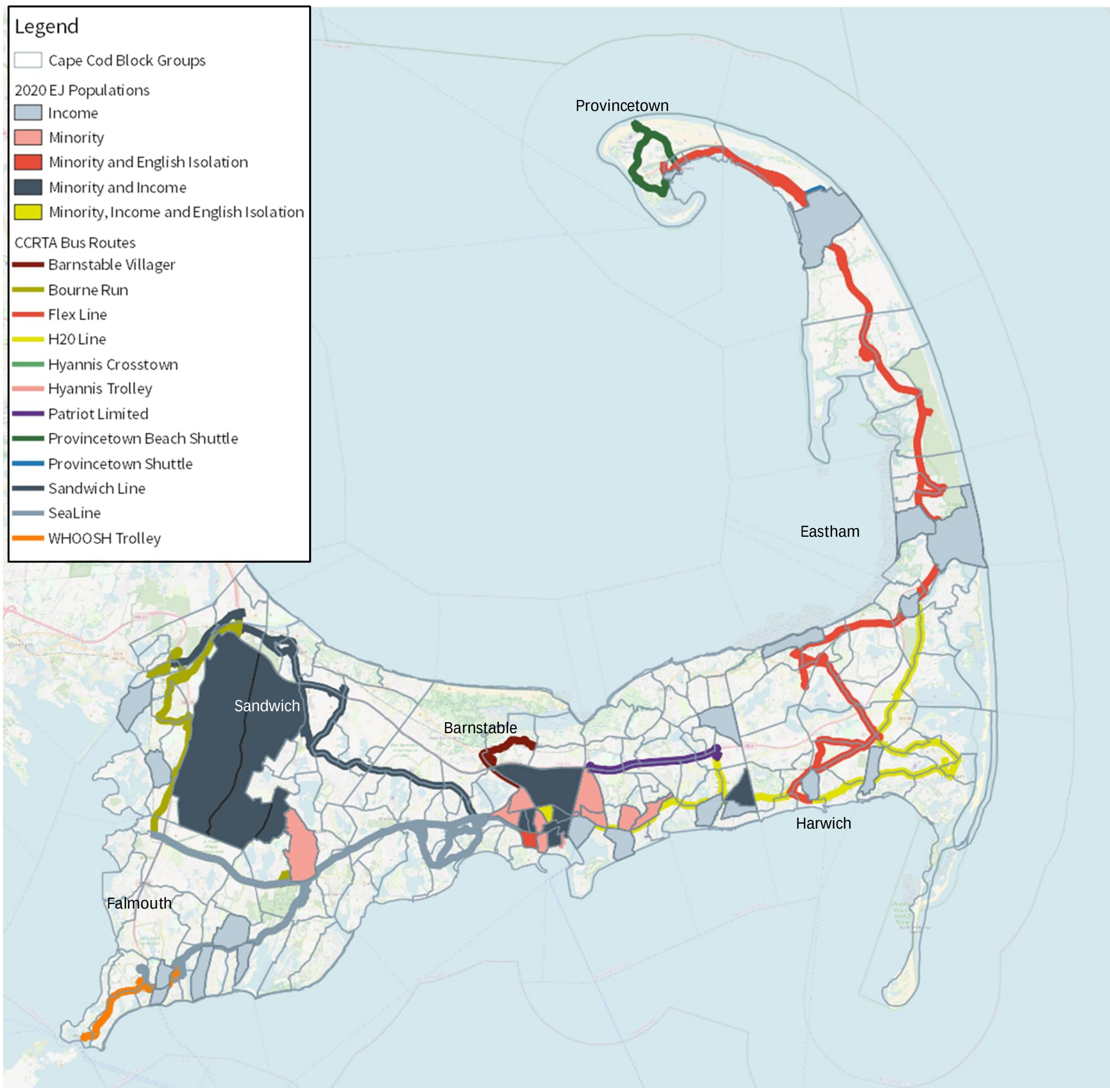


Figure 3 - CCRTA Bus Routes and MA EJ-Designated Census Block Groups

4. Recommendations

EJ considerations were accounted for during CCRTA's ZEV transition planning efforts. The preliminary strategy for electrification calls for the first batch of electric vehicles to be deployed and operated in Barnstable as charging infrastructure is planned for Hyannis Transportation Center (HTC) as early as 2024. Electric vehicles operating to/from HTC are anticipated to contribute less to air pollution; thereby offering the potential to reduce air quality concerns and contributions to greenhouse gas emissions in these communities. The location of HTC will also enable both fixed-route and demand-response vehicles to charge should electric range issues arise and will provide operational resiliency during the early transition period. This should reduce the potential for CCRTA ridership, inclusive of riders from the EJ communities identified above, to experience any changes to their existing service. Future transition planning strategy includes on-route charging locations in other identified EJ communities, like Falmouth, further reducing the likelihood of service disruption or changes to existing service. For identified EJ communities like Bourne and Truro, the CCRTA transition plan recommends phased, operational strategies including: deferring procurement of electric vehicles servicing those routes until improvement in battery technology; adding charging infrastructure in areas where there is significant overlap between the terminals for fixed-route operation and the areas of highest demand-response ridership (such as Mashpee, the terminal of the Bourne fixed route, and Provincetown); and adding fleet vehicles to routes shown to have the largest energy deficits.

To ensure that community considerations are accounted for throughout the transition period and beyond, it is recommended that CCRTA continuously monitor and evaluate the transition plan's potential benefits and adverse impacts to the environment and public health including impacts of recommended infrastructure investments, asset procurement, and changes to services or programs, particularly to EJ communities. In addition, CCRTA should ensure level of service is adequate in EJ communities within the CCRTA service area through each step of the ZEV Transition Planning phase. Similarly, CCRTA should ensure that public participation is encouraged and that the Authority is engaging and consulting with EJ communities, where appropriate, during the planning stages of electrification so that people are aware of the decisions affecting their environment. By planning for continuity, CCRTA will ensure environmental justice is considered beyond the plan development and through implementation.