Electric Vehicle Infrastructure for the Monterey Bay Area

The Association of Monterey Bay Area Governments

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Electric Vehicle Infrastructure for the Monterey Bay Area

Figures & Tables.

Executive Summary

If we are to meet this challenge, where are the likely parking places to "plug-in" to the electric grid, and what other requirements should be in place to meet the expected demand?

This plan outlines the process of creating a vehicle activity intensity analysis to help identify potential charging areas in the Monterey Bay Area. In addition, this document details the status of electric vehicle technology today, and suggests probable infrastructure requirements needed to electrify the transportation sector in the Monterey Bay Area.

In California, Executive Order B-16-2012 seeks to have over 1.5 million Zero Emission Vehicles (ZEVs) on the road by 2025. The Electrification Coalition's *Electrification Roadmap*[1] suggests that to reduce the transportation sector's reliance on oil, 75 percent of light-duty vehicle miles traveled (VMT) should be electrified by 2040. For the Monterey Bay Area, this would equate to more than 18 million daily miles driven by our residents. If we are to meet this challenge, where are the likely places to "plug-in" to the electric grid, and what other requirements should be in place to meet the expected demand?

Table 1. Population & Daily VMT in the AMBAG Region

	15 - 84 aged Population	Daily VMT	75% Electric Daily VMT
2005	565,848	16,073,487	--
2010	599,100	17,565,221	--
2035	722,735	24,394,889	18,296,167

An electric vehicle (EV) operates almost exactly like an internal combustion engine (ICE) vehicle, except for the fuel source. Currently, EVs are in their infancy and are expected to have more efficient batteries in the future that will enable driving longer distances on one charge. The ICE has come a long way since Henry Ford's Model T that had a 10 gallon tank and could only travel 130 miles before refueling. Even today, there are vehicles with extremely low miles per gallon (MPG) that limits how far they drive before refuelling. The size of the fuel tank in an ICE is analogous to the size of the battery in an EV, with larger batteries enabling vehicles to travel farther before recharging. As battery technology becomes more efficient, as did the ICE, EVs will be able to travel further per charge, changing the nature of the recharging process.

The size of the fuel tank in an ICE is analogous to the size of the battery in an EV, with larger batteries enabling vehicles to travel farther before recharging.

This plan takes into account the battery and EV standards that exist today, which equates roughly to a 24 kilowatt hour (kWh) battery being able to travel 100 miles before having to recharge. How drivers recharge an EV is different than refueling an ICE. The possible places for drivers to refuel are not limited to gas stations because we can tap into an extensive existing electric grid to charge vehicles. The time it will take to recharge or refuel is currently longer than the 10 minutes at the gas station, and is determined by the electrical connection type (described in the *State of the Industry* section), which ranges from 30 minutes to 8 hours, with a standard of approximately 4 hours for a full charge.

The possible places for drivers to refuel is not limited to a gas station because we currently have an existing electric grid for EVs to connect to.

The length of time to recharge an EV is considered to be a barrier to widespread EV adoption in the marketplace. However, by strategically placing charging infrastructure where EV drivers are parked for extended periods of

1 Electrification Coalition. (2009). *Electrification Roadmap: Revolutionizing Transportation and Achieving Energy Security.* Washington, DC: Electrification Coalition.

time, “range anxiety,” the fear of not being able to recharge, will be alleviated and even have economic development value. Therefore, understanding the behavior of potential EV owners is paramount to this plan, and as such, this plan takes into consideration activity based charging behavior.

There is no reason that EVs would not be fully charged all the time if the charging stations are located where we already park our cars, given that approximately 95 percent of an automobile’s life is spent parked.[2] The typical amount of time we spend driving a car is 1.2 hours a day – the rest of the time the car is parked. Where we park our cars varies – from home, work, shopping to recreation locations. Our charging infrastructure should go in these same locations.

Approximately 95 percent of the time of an automobile is spent parked.

The other components of EV infrastructure that should be considered are the support systems (mechanics, emergency response, electricians, and back office network management), and the influences on the current power grid. Described throughout this plan are current theories with how to address these infrastructure needs. These vary from the time of day or time of use (TOU) people charge to take advantage of the existing electric supply, to coupling charging infrastructure and solar infrastructure.

Identifying the best way to invest in electrifying our mobility is important. Oil prices continue to increase, and many believe that we have in fact surpassed “peak oil,” and will not have enough oil for the next 50 to 100 years, especially as the demands from developed and developing countries increase. Moving the personal transportation sector away from being entirely dependent on oil will alleviate this demand, and put our transportation system on a path of greater sustainability.

The following pages outline the current state of the EV charging industry, and suggest a coordinated approach to strategically deploying public EV charging infrastructure in the Monterey Bay Area.

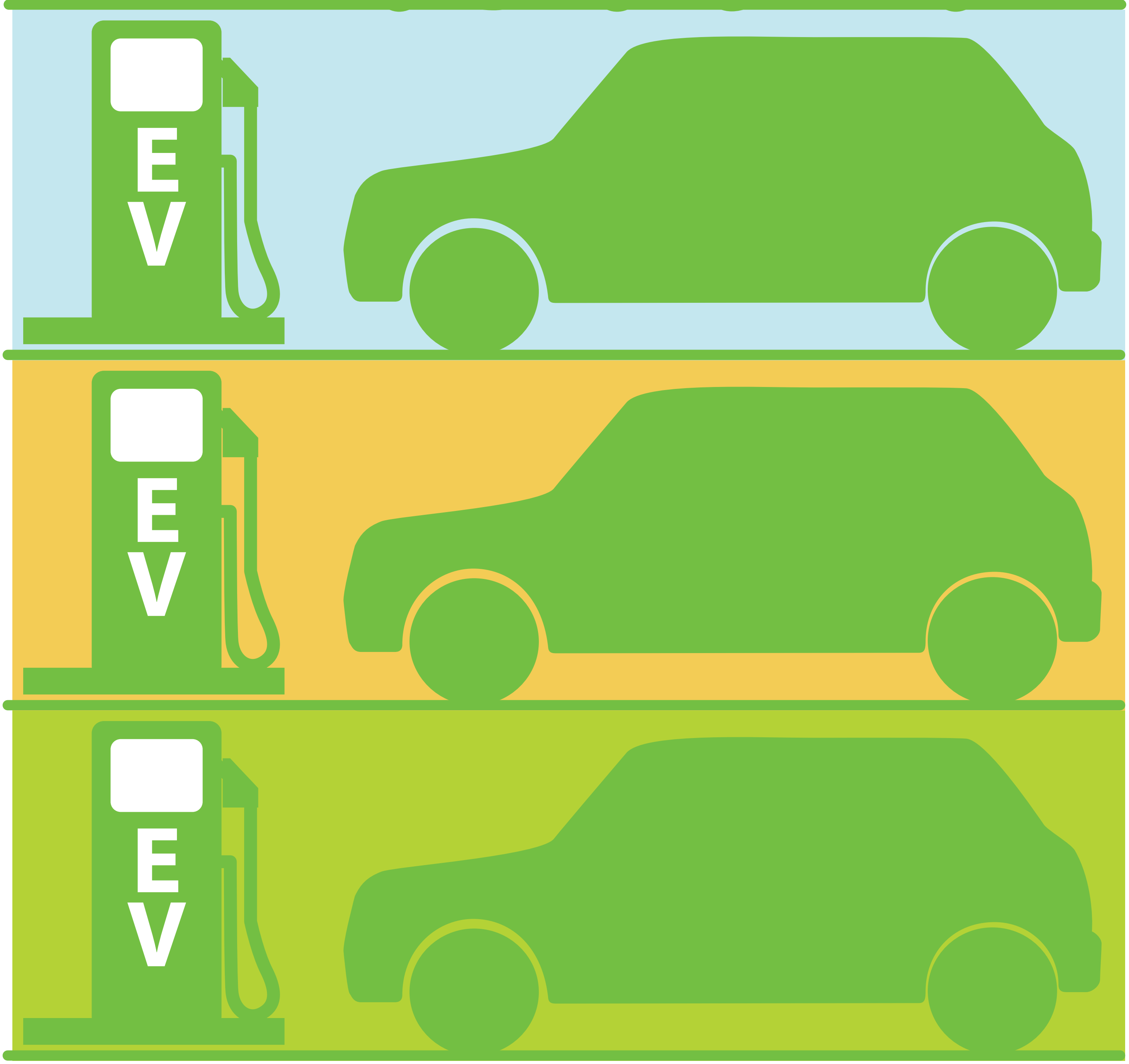
2 Shoup, Donald. 2005. *The High Cost of Free Parking*. Chicago, IL: American Planning Association.

Acronyms & Glossary Terms

AB 32	The California Global Warming Solutions Act of 2006.
AC	Alternating Current; a type of electric power where the charge constantly and cyclically reverses directions.
AFV	Alternative Fuel Vehicle.
AMBAG	Association of Monterey Bay Area Governments.
AMI	Advanced Metering Infrastructure or Smart-Meters.
AMPs	Amperage, or the strength of an electrical current measured in amperes.
BEV	Battery Electric Vehicle.
CAFE	Corporate Average Fuel Economy standards; federal regulations first enacted in 1975 intending to improve the fuel efficiency of cars and light trucks in the US.
CARB	California Air Resources Board.
DC	Direct Current. Electric power commonly found in batteries where the electricity charge flows in one direction.
EPA	Environmental Protection Agency.
EV	Electric Vehicle..
EVSE	Electric Vehicle Supply Equipment.
E-REV	
GHG	Greenhouse Gas Emissions.
HV	Hybrid Vehicle.
ICE	Internal Combustion Engine.
Instantaneous Demand	The maximum electric demand at the instant of greatest load.
kW	Kilowatt; a unit of power measurement. One watt is equal to one joule per second, and 1,000 watts is 1 kW.
kWh	Kilowatt hour; the number of kilowatts action for one hour.
lbs	Pounds.
LCFS	Low Carbon Fuel Standards.
Li-ion	Lithium Ion; a common rechargeable battery technology that uses lithium as a catalyst.
MBEVA	Monterey Bay Electric Vehicle Alliance.

$MMTCO_2E$	Million metric tons carbon dioxide equivalent.
MPG	Miles per Gallon.
MUAPCD	Monterey Bay Unified Air Pollution Control District.
NEV	Neighborhood Electric Vehicle.
NiMH	Nickel Metal Hydride; a rechargeable battery technology that uses mineral nickel and a hydrogen storing ion.
PHEV	Plug-in Hybrid Electric Vehicle.
RFID	Radio-Frequency Identification.
RTP	Real-Time Pricing.
SB 375	Legislation passed in 2008 mandating the coordination of Land Use and Transportation Planning to meet Greenhouse Gas Emissions targets.
TOU	Time-of-Use.
V	Voltage; a measure of electric potential that causes electric energy to flow.
V2G	Vehicle-to-Grid.
VMT	Vehicle Miles Traveled.
ZEV	Zero Emissions Vehicle.

INTRODUCTION



Introduction

Why Electric Vehicles are Important to the Success of the Monterey Bay Region

In 2005 the region drove 16,075,936 miles a day. By 2035, this number is expected to reach 24,394,889 miles a day[4]. This equates to more pounds of pollutants entering the air in the Monterey Bay Area every day from the continued consumption of gasoline to power these miles driven. Specifically, tables 2 and 3 indicate the relation between gasoline derived vehicle miles traveled (VMT) and greenhouse gas emissions (GHG), and fuel sources and their related emissions.

Impacts to the air and water quality in the Monterey Bay Area from this increase in pollutants are driving the need to electrify vehicle miles. Even though EVs produce no tailpipe emissions the electricity used to power them does produce some. Even then, EVs charged in California in off-peak periods reduce greenhouse gas emissions 15% - 50%[5].

Table 2. Projected VMT and GHG Emissions in the AMBAG region, 1990-2035

Year	Daily VMT	GHGs Daily Metric Tons			
		CO_2	CH_4	N_2O	CO_2e
1990	13,829,725	5,799.90	2.10	1.20	6,203.80
2005	16,073,487	6,147.61	0.92	0.52	6,322.38
2010	17,565,221	6,600.76	0.67	0.38	6,729.13
2020	20,876,159	7,787.85	0.38	0.22	7,861.67
2035	25,678,830	9,394.58	0.29	0.17	9,450.64

This table does not account for renewable electricity which would make EVs much more efficient than ICEs. Source: (PMC, 2010)[6]

4 This number is reduced from the modeled 25,678,830 daily miles discussed in the 2010 MTP based on the AMBAG Board adopted -5% per capita reduction in daily VMT, including interregional trips.

5 McCarthy, Ryan W. and Christopher Yang (2009), Determining Marginal Electricity for Near-term Plug-in and Fuel Cell Vehicle Demands in California: Impacts on Vehicle Greenhouse Gas Emissions. Journal of Power Sources 195 (7), 2099–2109.

6 Gärling, Anita. 2000. "Market Segmentation, Marketing Communication Strategies and Electric Vehicle Drive". KFB-Rapport 2000: 18. PMC. (2010). *Final Supplemental Environmental Impact Report: 2010 Monterey Bay Area Metropolitan Transportation Plan.* Association of Monterey Bay Area Governments. Monterey, CA: PMC.

Table 3. Emissions of Different Types of Vehicles and Fuels.

	% Efficiency	SO_2 (g/mile)	NOx (g/mile)	CO (g/mile)	CO_2 (g/mile)	Hydrocarbon (g/mile)
Vehicle Type/Fuel						
Gasoline	10.2	0.20	0.63	3.43	444	0.35
Methanol	8.5		0.86	1.71	408	0.35
Hydrogen	9.4		0.61	0.02	388	0.75
Natural Gas	10.8		0.40	1.70	337	0.16
Ethanol	8.1	0.04	0.52	1.90	44	0.13
EV by source power						
Coal	16.5	1.73	0.81	0.07	485	0.01
Petroleum	14.6	0.93	0.52	0.08	459	0.02
Natural Gas	15.1		0.52	0.09	302	0.01
Advanced Natural Gas	20.0		0.36	0.20	229	0.07
Nuclear	14.4	0.10	0.05		25	

Source: (Gärling, 2000)[7]

One advantage of switching to electric vehicles will be that the power can come from a number of different sources.

Climate Protection Implementation Guidelines

In addition to degrading air and water quality, it is now commonly accepted that GHG emissions contribute to the overall warming of the global climate, and that human activities have increased the rate of which we add GHGs to the atmosphere. As such, many local agencies have supported reducing the amount of GHGs they emit.

California Executive Order B-16-2012

In March 2012, Governor Brown issued an executive order directing state government to accelerate the market for zero-emission vehicles (ZEVs) in California. Advancing electric-drive technologies is a cornerstone of California's long-term transportation strategy to reduce localized pollution and greenhouse gas emissions. Key milestone goals include providing sufficient ZEV charging infrastructure throughout the state to support 1.5 million vehicles by 2020, and putting over 1.5 million ZEVs on California's roadways by 2025. This Executive Order directs state government to begin purchasing ZEVs. 10% of state departments' light-duty fleet purchases must be ZEVs by 2015, climing to 25% of light duty purchases by 2020.

7 Gärling, Anita. 2000. "Market Segmentation, Marketing Communication Strategies and Electric Vehicle Drive". KFB-Rapport 2000: 18.

AMBAG Board

In September 2010 the AMBAG board members adopted a regional GHG target of a 0% gain in per capita GHG emissions by 2020, and a 5% decrease in per capita GHG emissions by 2035.

U.S. Conference of Mayors: Mayors Climate Protection Agreement (6 out of 18 cities)[8]

The U.S. Conference of Mayors is a nonpartisan organization of cities with populations greater than 30,000. Through the Climate Protection Center program, the U.S. Conference of Mayors' Climate Protection Agreement calls for mayors to vow that their cities will reduce their carbon emissions to below 1990 levels in line with the Kyoto Protocol. Currently, six of the 1,044 mayors and former mayors who have signed the agreement are from the Monterey Bay Area. These include:

- Capitola (Dennis Norton)
- Marina (Bruce Delgado)
- Monterey (Chuck Della Sala)
- Pacific Grove (Daniel Cort)
- Salinas (Dennis Donohue)
- Santa Cruz (Cynthia Mathews)

Meeting Climate Change Goals and Diversifying the Transportation Sector

It is in less urban areas that electrification of the personal automobile makes the most sense.

Each region in California must employ different strategies in order to be successful in their efforts to reduce GHG emissions from the transportation sector. While some areas in California already have robust transit infrastructure and are settled in a manner that supports this infrastructure, much of California was built around the personal automobile and personal mobility.   Even though transit infrastructure is, in the long run, much more cost effective due to the number of passengers it can support and its cost sharing benefits, redeveloping urban and rural environments where there isn't transit infrastructure already can be costly and impractical. There are minimum land use densities that are required to make operation and maintenance of transit possible[9] that many rural areas do not meet. It is in these areas that electrification of the personal automobile makes the most sense.

8 www.usmayors.org/climateprotection/cities.asp?state=CA

9 Pushkarev, Boris, and Jeffery M. Zupan. 1977. *Public Transportation and Land Use Policy*. Bloomington, IN: Indiana University Press.

> *Tourism, one of the main industry sectors in the Monterey Bay Area, draws automobile drivers from all over the U.S., but especially areas that would be considered within the current range (100 miles) that an EV can travel.*

The Monterey Bay Area has a unique land use pattern with connections both to its own urban areas and adjacent major urban areas. Tourism, one of the main industry sectors in the Monterey Bay Area, draws automobile drivers from all over the U.S., but especially areas that would be considered within the current range (100 miles) that an EV can travel. Currently, accessing the Monterey Bay Area from outside the region is primarily done by personal automobile as the region has few interregional transit connections. Therefore, it will be important to ensure that tourism centers include EV charging infrastructure as EVs are adopted by the Monterey Bay Area and other major urban areas, such as the San Francisco Bay Area, which has an aggressive EV strategy.

Why Have a Coordinated EV Infrastructure Plan

Historically, EV charging infrastructure has been motivated by the EV owner – installing a station in their home, or by "green" motivations, such as LEED credits for buildings, and city endeavors to set an environmentally friendly tone. However, as with any infrastructure project, sharing infrastructure costs among multiple individuals brings the cost of use down for all, and reduces redundant infrastructure.

> *A coordinated EV infrastructure plan will provide a framework for local governments seeking to expand transportation choices in their cities, and stimulate regional mobility and accessibility.*

With the optimal situation of being able to couple parking and charging infrastructure, travel distances and origin and destination patterns are important to consider when placing stations. Developing an optimal parking and charging strategy will require coordination with cities and local utility companies, as well as considering policies such as shared parking requirements amongst businesses. Furthermore, a coordinated EV infrastructure plan will provide a framework for local governments seeking to expand transportation choices in their cities, and stimulate regional mobility and accessibility. Finally, much of the charging infrastructure is moving toward a networked approach, and a regionally coordinated infrastructure plan will have greater branding capabilities and will be more efficient than each of the 21 cities in the region having their own system.

The Role of Electric Vehicles in Transportation in the Monterey Bay Area in 2035

In 2035 the Monterey Bay Area will have increased mobility for all residents while meeting goals for reduced GHG emissions. The long range transportation plan, *Moving Forward Monterey Bay 2035*, seeks to achieve a coordinated and balanced regional transportation system that includes mass transportation, highway, railroad, bicycle, pedestrian, goods movement and aviation facilities[10]. With the expansion of EVs throughout the country, new infrastructure components will become a part of our coordinated transportation system,

10 AMBAG. 2010. *Monterey Bay Area Mobility 2035*.

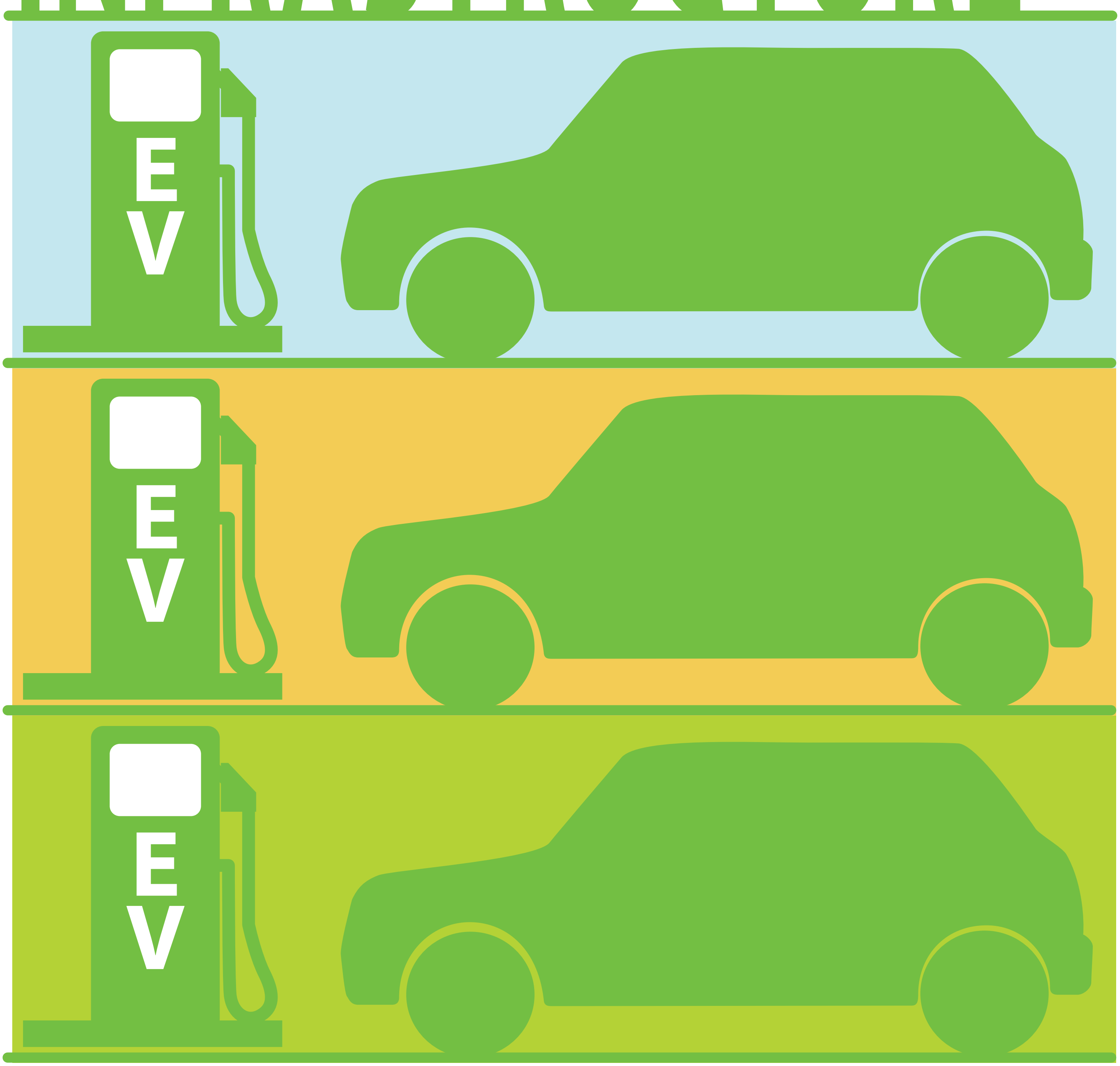
and it will be important to ensure that transportation choices continue to grow. Currently many residents do not feel that they have a choice in the way they choose to travel – trips in the Monterey Bay Area are dominated single occupancy vehicles, most of which obtain their energy via gas. Expanding public charging infrastructure will help diversify the type of fuel that powers the personal automobile.

The future of transportation will always include the personal automobile – it was a great invention that transformed the way cities are built and how people interact with each other. However, the luxury of the personal automobile and the costs associated with it are proving to be extremely high, and these costs will continue to grow as oil becomes scarcer. As with any strategic plan, diversifying a portfolio of options is usually the best way to invest in the future. The task in the Monterey Bay Area will not only be to diversity the modes by which we travel, but the fuel sources that enable mobility as well.

The task in the Monterey Bay Area will not only be to diversity the modes by which we travel, but the fuel sources that enable movement as well.

Throughout the U.S. and the world, the evolution of the personal automobile will include a movement towards electric powered vehicles and eventually drivers may not even have to plug into a station because charging infrastructure will be incorporated into road infrastructure. Being ready to adopt changes will be paramount to the success of the transportation system in the Monterey Bay Area, and the greater mobility of its residents.

ELECTRIC VEHICLE INFRASTRUCTURE



Electric Vehicle Infrastructure

The electric vehicle industry and its supporting infrastructure technology is evolving at a rapid pace. The information presented in this section represents the best available information and best practices available at the time of this report.

Parking Infrastructure

In order to reduce the possibility of EV drivers running out of battery charge on long trips, charging infrastructure will have to be strategically placed at parking spaces where people tend to leave their car for extended periods of time. In the private realm this means installing charging stations at residential locations and at employer provided parking facilities. These applications are easy to manage since the facility is private and the charging population is stable. However, charging stations that are intended for public use require more complex business models. MBEVA lists charging stations throughout the tri-county area on the ReCargo website (http://www.recargo.com/) as they become available. This service provides EV drivers with a centralized search when they are seeking a place to charge.

Private Infrastructure

Given the number of hours spent sleeping and working, our cars are parked for most of the day. These times of the day provide the opportunity to charge a vehicle. Level I and II EVSEs can be installed in residential settings with slight modifications to existing electrical systems. Installation of an EV charger does require a permit. EVSEs can also be easily installed in existing employer owned parking facilities. In both these cases the infrastructure would be owned and operated by the person or company responsible for the maintenance of the property. In residential single family home locations the user would pay for the electricity and maintenance costs.

Residential charging is the most ubiquitous way of charging for PEV owners. Approximately 90% of PEV drivers reported having a dedicated Level II (240 V) residential vehicle charger, and most PEV owners who charge their vehicle at home charge between 6pm and 8am.[11] The advantages of charging at home include low electricity costs, no fees, and convienience. Results from the California Center for Sustainable Energy survey elaborate:

> *For PEV owners in California using standard residential electricity rates, the average cost of electricity used to fuel their PEVs can be as high as $0.24–$0.34 per kilowatt hour (kWh), equivalent to $2.70–$4.70 per gallon of gasoline. However, lower costs are available because utilities across the state are providing customers with rates exclusively for PEVs that utilize time-of-use (TOU) pricing. TOU pricing offers cheaper*

11 California Center for Sustainable Energy (CCSE), "California Plug-in Electric Vehicle Driver Survey Results," May, 2013. 17.

rates during off-peak hours when electricity demand is low and more expensive rates during on-peak hours when there is a greater demand for electricity.[12]

Most early PEV adopters in California use the TOU electricity rate provided by their utility.[13]

Apartment buildings require a different arrangement. There are charging stations available that allow access only to users with a unique user pin. These stations making tracking use simple and they are within the same price range as other charging stations.[14] Owners of apartment buildings can install the EVSEs in existing parking facilities and distribute pin numbers to ensure that only residents of the building can charge their vehicles. The pins allow the owner to identify who is using the charging station and to charge that account or person accordingly. Employers have similar technology available to them that would allow the company to issue codes for the stations to ensure that only employees are able to use the employer subsidized infrastructure. Another option for multi-family residential developments is to develop partnerships with nearby businesses to install charging stations.

Public

Level II and Level III charging are most appropriate for public use, where people are parked for shorter periods of time

Level II and Level III charging are most appropriate for public use, where people are parked for shorter periods of time, because of their ability to deliver a charge quickly. At the time of this study Level III charging is still in testing and there are very few installed stations. There are still safety concerns with using direct current in public locations and most EVs on the road are not compatible with Level III charging. Therefore, Level II charging is currently the most practical application for commercial and public use.

Public use stations require a few more considerations than private stations do. First, they must be placed in locations where people are likely to park for an hour or more in order for the vehicle to receive a significant charge. They also must have a convenient mechanism for payment if payment is required. There are EVSE manufacturers that provide membership cards which allow a user to access the electrical connection. These chargers would require a user to swipe their membership card or call a toll free number if they want to use a credit card. There are also EVSEs that allow the user to swipe their card without calling for access.

There are currently three categories of business models being used for public charging stations. In one model the local jurisdiction provides the infrastructure for free public use and absorbs the cost of operations and maintenance. In the second model, the EVSEs are connected to paid parking infrastructure. The user

12 CCSE 15

13 Ibid.

14 Sebastian Blanco, "Greenlings: What realistic electric vehicle recharging options are there for apartment dwellers?" http://green.autoblog.com/2010/03/18/greenlings-what-realistic-electric-vehicle-recharge-options-are/ (accessed August 25, 2010).

pays for parking and use of the electric charger simultaneously. In the third model the charging stations are installed as their own networked system. They are owned by the jurisdiction, but maintained by a third party. These networked stations allow the user to pay for use of the station in places where parking is free. The stations collect data and store it on the network where it can later be retrieved by the owner of the infrastructure.

Cost of Owning an EV

Electric vehicle technology is rapidly improving to bring down the cost of owning an electric vehicle. However, currently the ownership cost of EVs are high. A majority of the sticker price can be attributed to the battery. There are also components of an EV that do not exist in an internal combustion (IC) vehicle, just as there are components of an IC vehicle that are not used in an electric car. However, the battery in an EV can account for up to $18,000 of the vehicle cost. There is a federal tax credit available for up to $7,500 that helps to shorten the payback period for purchasing an EV, but even with this credit that payback time is still estimated to be 7-8 years.[15] In addition to purchasing the vehicle consumers will likely want to pay for the infrastructure to charge at home. If there is no electrical panel upgrade required, the cost can range from $500-$1,500. If an upgrade is required the installation cost could be as much as $2,500.[16]

Despite these costs, the electricity used to power the vehicle is significantly cheaper than gasoline. To fully charge a 30 kWh battery it would cost $6.00 assuming a conservative estimate of $.20 kWh. Additionally, EVs are more efficient at converting energy into power. If you were to convert gasoline to energy using kilowatt hour (kWh), 10 gallons of gasoline provides 360 kWh of usable energy. However, because IC engines are so inefficient only 20%, or 72 kWh, of this energy is captured.[17]

The Early Adopter Market

There is a specific market for drivers who are ready and willing to buy electric vehicles. Potential early adopters of electric vehicles are generally well educated, high income individuals and are environmentally conscious. A University of Michigan study found that other factors likely to influence a person's choice to purchase an EV are gas prices, access to an attached garage, the number of miles driven and whether those miles are street or highway miles.[18] Residents living in the west and northwest of the United States are more likely to purchase an EV than other regions. Whether a person lives in a suburb or city center does not have a significant effect on the likelihood of purchasing an EV. However, people

15 Electrification Coalition, 79.

16 Pacific Gas and Electric Company, "Electric Vehicle Infrastructure Installation Guide," (March, 1999), 21.

17 Electrification Coalition, "Electrification Roadmap: Revolutionizing Transportation and Achieving Energy Security," (November, 2009), 74.

18 Richard Curtin, Yevgeny Shrago, and Jamie Mikkelsen, "Plug-in Hybrid Electric Vehicles"

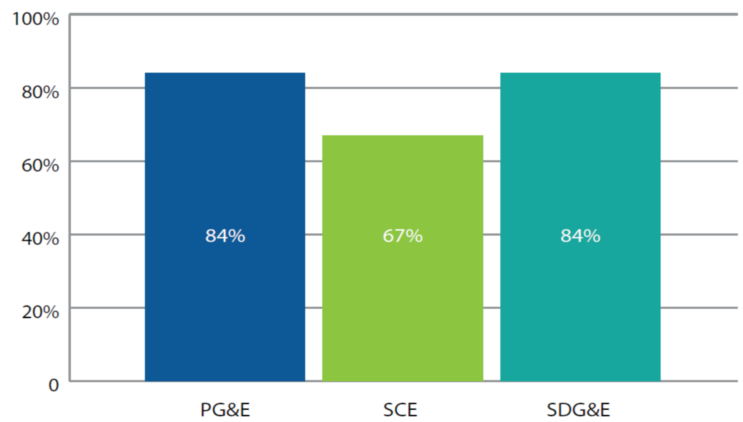
living in rural areas are least likely to favor purchasing an EV.

Electric vehicle technology is progressing at an increasingly rapid rate. Once the costs for battery production are reduced, EVs with become a more viable alternative for a wider range of people. While the early adopter market is limited, it is expected that within the next five to ten years the market range of people willing to invest in an EV will broaden.

Electric Vehicle Driver Consumer Behavior

The possibility of EV drivers running out of battery charge on long trips and the associated concern is known as "range anxiety". Running out of charge on a long trip would leave PEV drivers stranded, causing a major inconvenience for the driver. Nearly 40% of PEV owners expressed some level of dissatisfaction with their vehicle's all-electric range and 90% wanted to have a vehicle range above 100 miles.[19] 57% of PEV drivers expressed a desired range of 150 miles or greater (Figure 1).[20] This exceeds the rated range of nearly all battery electric vehicles currently on the market. While PEV owners want the ability to travel a longer distance on one charge, they do not generally travel such long distances on a daily basis. Two-thirds (67%) of PEV owners who use their vehicle on a daily basis drive an average of only 35.2 miles per day.[21] This suggests that PEV drivers don't necessarily need a long range on their vehicle but, nonetheless, want their vehicle range to be comparable to that of a conventional internal combustion vehicle. As current PEV range is not satisfactory for most drivers, a comprehensive charger network can help mediate this problem.

Figure 1. Importance of Factors Determining When PEV Drivers Charge.



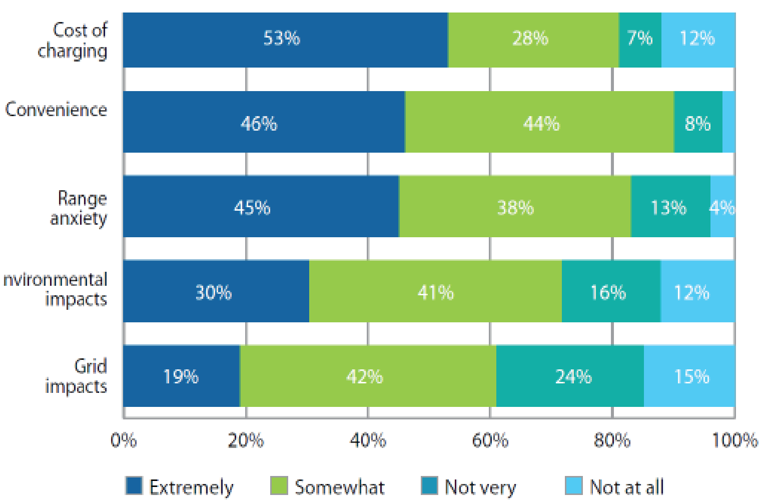
19 CCSE 3

20 Ibid.

21 Davids, Dan. Plug In America., "Web-based Electric Vehicle Consumer Survey". May 4, 2010.

PEV drivers are extremely cost sensitive when it comes to public and workplace charging. In the CCSE study, the most important factor in determining when respondents charge is cost, which 53% rated as extremely important, and 28% rated as somewhat important (Figure 2).[22] 67% of respondents were willing to pay up to $1 per hour for occasional public charging.[23] When the price of charging was raised to above $1 per hour, the proportion of PEV drivers willing to pay to occasionally use public charging went down dramatically. Less than 33% were willing to pay up to $1.50 per hour.[24] For daily charging, 43% were willing to pay $1 per hour of charging, while only 16% were willing to pay up to $1.25 per hour.[25] People willing to pay more for occasional charging, but in all situations, do not want to pay more than $1 per hour to charge. If EV charging infrastructure is expected to be utilized, charging fees must be kept to a maximum of $1 per hour. However, at this rate, and with future energy cost increases, charging station providers will be taking a loss. Going forward, there needs to be a sustainable long-term pricing strategy for charging infrastructure to make it feasible for consumers and providers.

Figure 2. All Electric Range Desired for Extreme Satisfaction Among PEV Owners



Charging Infrastructure

Infrastructure to support EVs has limited availability compared to the supporting infrastructure for internal combustion engine vehicles. In developing charging station technology studies show that the majority of charging will take place at the consumer's home during the night hours when the car is typically idle. In two studies, 77-90% of PEV owners indicated they have installed a residential charger, indicating that home charging is an important to PEV consumers.[26] 81% of PEV owners indicated a majority

22 CCSE 3

23 Ibid.

24 Ibid.

25 Ibid.

26 Ibid. 17, Plug-In 5

To alleviate "range anxiety," charging stations outside of the home should be available. These public stations should be placed where people already park their cars, this way, no extra time or miles will be spent looking for a place to re-charge.

of charging takes place at home.[27] While most PEV charging takes place at home, there still exists a need for convenient charging stations outside of the consumer's home.

A barrier to increased charging away from home is poor public infrastructure. A study by the California Center of Sustainable Energy found that 77% expressed dissatisfaction with public charging infrastructure.[28] 94% of PEV owners also own a conventional vehicle, indicating that they do not use PEVs for long trips, and would rather keep a conventional vehicle on hand for those instances.[29] This is related to the extended time it takes to charge a PEV with the more common Level I and II chargers, and the scarcity of Level III fast charging infrastructure. Unlike gas stations, EV charging stations will have to be located in places where a consumer can leave their vehicle for hours at a time. A lack of Level III charging and limited compatibility with Level III chargers among existing PEVs makes longer multi-hour charging a necessity. Standardization of these stations will be necessary to ensure consistent charging availability and network interoperability.

Electrical Power Supply

Accommodating charging stations with regard to electrical infrastructure would be a relatively simple process and highly beneficial to utility companies. Utilities have the generating capacity to serve EVSEs during the early stages of deployment.[30] However, neighborhood transformers would have to be upgraded to handle the additional demand of plugging in an EV. An electric vehicle charging with a Level II EVSE at 220 V on a 15 amp circuit can draw 3.3 kilowatts of power, the equivalent of a typical household.[31] Although the largest demand would take place during off peak hours, an additional two or three charging stations could exceed the abilities of a typical neighborhood transformer. Therefore it is important to identify the parking locations of EVs so utility companies can upgrade the necessary transformers. Commercial Level III charging stations will require three-phase power, which is typically reserved for heavy load use. Utility companies will have to work with the owners or operators of the charging stations to ensure that upgrades to the system will deliver enough power to the station without effecting neighboring electrical users. Level III charging is not expected to occur at a large scale in the early phases of deployment.

Utility companies will also need to upgrade software and IT requirements in order to allow management of load demand. The capacity to turn vehicle chargers on and off will allow the utility to shape demand and prevent

27 Plug-In 6

28 CCSE 7

29 Ibid. 4

30 Electrification Coalition, 101.

31 Ibid.

overloading. Monitoring use of charging infrastructure will also allow utility companies to use price signals to shape demand. The technology used to manage EVs is in line with other smart grid upgrades and could be integrated into the movement towards a smart grid system.

Charging Stations

The term charging station is misleading, technically the charger is located on the vehicle. The charging infrastructure, referred to as electric vehicle supply equipment (EVSE), is a set of cords with safety features integrated in a box that interfaces with the vehicle. There are three levels of charging provided by EVSEs.

Level I EVSEs can be used with standard 110 volt plug and a dedicated 15 amp circuit. These EVSEs can be installed for home use without many changes to existing electrical. However, at 1.8 kW a 30 kWh battery could take 15 hours to fully charge.[32]

Level II EVSEs use 240 volts and have to be mounted and wired to an electrical panel. This level of EVSE reduces charging time to between four and eight hours depending on the size of the battery in the vehicle. Both level I and level II EVSEs use the same type of connection to the vehicle.

Level III EVSEs charge the vehicle using a different type of technology, called direct current (DC). DC is intended for commercial applications and ranges from 30 kW to 250 kW. The goal for charging time is ten minutes using DC EVSEs. This technology is in its infancy. Only one station has been installed and it is located in Vacaville, California, roughly half way between San Francisco and Sacramento. It should be noted that not all EVs are compatible with Level III fast chargers, espeically the pre-2010 generation of electric vehicles. In the Monterey Bay Area, the Santa Cruz Regional Transportation Commission has grant funding from the Monterey Bay Unified Air Pollution Control District to install a DC fast charger within Santa Cruz County. The location for this charger has yet to be determined.

Table 4. Levels of Charging.

Type	Typical Energy Output	Average Time to Fully Charge
Level I	110V/15amp	8+ hours
Level II	240V/30amp	4-6 hours
Level III (DC Fast)	30kW to 250kW via a direct current	15 - 30 min to 80% full charge

Connector Standardization

The point where the vehicle connects to an EVSE, or the connector, has yet to be standardized globally. There are two widely used types of connectors at the moment: IEC 62196-2 Type 1 (the Japanese/SAE J1772 proposal) and the IEC 62196-2 Type 2 proposal (Europe). Auto manufacturers Audi, BMW, Daimler, Porsche and Volkswagen are proponents of adopting a global standard that is a variation of the Type 2 proposal. Their design would include an extension for DC charging.[33]

J1772 is the new standardized connector, that has a five pin connector that can deliver either 120 V or 240 V.

32 Electrification Coalition, 91.

33 Green Car Congress, " German Auto makers Propsing Integrated Global Standard for a Modular Connector System for EV Charging." http://www.greencarcongress.com/2010/09/

In 2010, the Society of Automotive Engineers (SAE) approved the J1772 standardized connector, or Type 1 proposal, for EV charging. The standard is to be a five pin connector that can deliver either 120 V or 240 V. The standard applies to North America only and covers the general physical, electrical, communication protocol, and performance requirements for the electric vehicle conductive charge system and coupler. By standardizing the vehicle inlet and mating connector, drivers are assured that their vehicles can be charged at any charging station.

Inductive Charging

Another technology being explored for charging EVs is connection-less. Inductive charging uses electromagnetic fields to pass electricity wirelessly between two coils. In this case one coil is located in the charging station and the other is placed in the vehicle charge receptor. Since there are no exposed electrical connectors, inductive charging is actually safer than direct wired contact. However, the energy transfer is less effective than direct current. Better Place and other charging manufacturers have already started integrating the technology into charging station design. In road charging has also been explored by Better Place and other companies such as IAV and HaloIPT. Placing charging systems under roads would allow people to charge in spurts as they pass over a road segment. A road charging system would extend range as well as ease drivers' fear of running out of a charge. While the technology has already been developed, the cost of retrofitting existing infrastructure with road charging systems may be prohibitive. IAV has also noted that the system can be highly sensitive to the distance between the road and the vehicle floor plan.[34] Due to the high costs of installing new road infrastructure on a wide scale, it is more likely that this technology will be introduced in a limited capacity, such as on road segments that run electric trams or buses.

Peer-to-Peer Charging

The typical range of a current market electric vehicle is three to five miles per kWh of energy density. For a 100 mile range an EV would need a battery capacity of 25 kWh.

Peer-share charging stations have the potential to supplement the existing charging network. Peer share charging allows EV owners to make their home charging stations available to the public through services such as PlugShare (http://www.plugshare.com). The advantage of this system is that it provides a good method to provide a wider network of chargers to EV drivers until more comprehensive public EV charging infrastructure is in place. The disadvantage of this approach is that quality control and charger availability may not be as consistent as public charging infrastature. Additionally, charging station providers may opt out of the program at any time, making reliability a potential issue. While this approach should not be the core of a regional charging program, it can provide valuable services to areas underserved by other public charging

charging-20100916.html (accessed November 15, 2010).

34 All Cars Electric, " German Firm Says Inductive Road Charging Of Vehicles Only 2-3 Years Away." http://www.allcarselectric.com/blog/1036051_german-firm-says-inductive-road-charging-of-vehicles-only-2-3-years-away (accessed November 16, 2010).

infrastructure.

Existing Vehicles

The market for electric vehicles is growing as are the number of vehicles available. Many manufacturers are beginning to produce an electric vehicle to lower their overall fleet fuel efficiency average. As the variety of electric vehicles increases the number of choices for battery type, range, top speed and other specifications also increase. In general, the greater the range of the vehicle the higher the cost of purchasing the vehicle. Higher vehicle range is dependent on the type and size of the battery in the vehicle and the larger the capacity of the battery the more expensive it is. Please see *Appendix B. Electric Vehicle Matrix* for a table of the electric vehicles currently available in the United States and European markets. To see new vehicles that may not be included in the appendix, visit:

http://www.driveclean.ca.gov/
http:// www.pluginamerica.org/vehicles

75 kilowatts is equal to 100 horsepower.

Current Battery Technology

Indicators

The key indicators for measuring battery performance according to the United States Advanced Battery Consortium are power, energy, safety, life and cost. Power, measured in kilowatts, is the rate of energy transfer from the battery to the wheels. Higher power rates afford the vehicle greater acceleration propulsion. If you were to convert kilowatts to horsepower, 75 kilowatts is equal to 100 horsepower.[35] Power is often confused with energy. The energy indicator refers to the battery's energy capacity and the length of time the battery can remain in a charge depleting mode.

Cost is one of the most important indicators for making EVs a viable consumer product.

Because batteries store energy and rely on volatile compounds safety is also a major concern and therefore an important indicator of battery performance. The life indicator is measured by both calendar life and cycle life. The calendar life refers to the battery's ability to perform well over time, independent of use. The cycle life measures the number of times a battery can be charged before other indicators such as energy and power are compromised. Finally, cost is one of the most important indicators for making EVs a viable consumer product. Cost varies based on the battery manufacturer and its components. Factors such as labor and capital expenses influence a battery's production cost just as chemistry and technology investment do. Additionally, there is an economy of scale issue at play: to reduce the cost of output, batteries have to be produced in greater quantities.

35 Electrification Coalition, 74.

Existing Battery Technology

Traditionally, the automotive industry used a lead acid battery. These batteries were appealing because they provide short burst of high currents, which is needed to start a traditional internal combustion system. Lead acid batteries are also inexpensive to produce at $100 to $200 per kilowatt hour. However, these batteries are heavy and are inefficient at delivering energy. The next battery technology improvement was a switch to nickel metal hydride (NiMH). NiMH batteries outperform the traditional battery on every indicator, except for cost. These batteries were used in the first generation of electric vehicles and hybrid electric vehicles.

Common Battery Types

- *Lead Acid*
- *Nickel Metal Hydride*
- *Lithium Ion*
- *Lithium Polymer*
- *Sodium-Nickel Chloride*
- *Nickel-Cadmium*

More recently, the focus on battery technology has shifted to lithium-ion batteries. Lithium-ion provide better energy and power density, therefore enabling manufacturers to place batteries with long ranges into vehicles without the same weight and size burdens of previous battery types. Lithium-ion batteries are also the most expensive to produce with an average industry-wide cost of $600 per kWh. [36]

In the development of batteries there is typically a trade off between power and energy. The more power density a battery has, the less energy density it has. In other words, the better acceleration it provides (power), the quicker the depletion of the charge (energy). Energy is measured in watt hours per kilogram (Wh/kg) and power is measured in watts per kilogram (W/kg). The lithium ion batteries perform better than other traditional batteries on both measures.

Table 5. Battery Types and Energy Performance.

Battery Type	Energy Density (Wh/kg)	Power Density (w/kg)	Life Cycles per Battery
Current lead acid	35	150	500
Advanced Lead Acid	48	150	800
GM Ovonic Nickel-Metal Hydride	70	220	600
SAFT Nickel-Metal Hydride	70	150	1,500
SAFT Lithium Ion	120	230	600
Lithium Polymer	150	350	600
Zebra Sodium-Nickel Chloride	86	150	1,000
USABC mid-term goals	80	150	600
USABC long-term goals	200	400	1,000

Source: U.S. Department of Energy, 2010.

The lithium-ion battery has mixed results with regard to the life indicator. There is no market data available on battery life, though there has been extensive

36 Electrification Coalition, 75.

laboratory testing. In California, regulations require that manufacturers warranty battery life for 10 years or 100,000 miles. A lithium-ion battery's health is compromised when they are deeply discharged or when they are kept at a high charge for a long period of time. To counter this effect, manufacturers over-specify battery capacity to maintain a reserve at the top and low ends of the charge and achieve the 10 year life requirement. This practice of over-specifying battery life or energy density adds a significant costs to the battery.

Temperature can also affect the life of a battery. Batteries need to be kept cool not only while in operation, but while idle as well. A study by the National Renewable Energy Laboratory showed that raising the ambient temperature by 20°C to 30°C can cut in half the time it takes for a battery to lose 30 percent of its power density.[37]

One of largest hurdles to overcome for the EV industry is the cost to the consumer, and batteries constitute a significant portion of the total cost of an EV.

Battery Cost

Currently, one of largest hurdles to overcome for the EV industry is the cost to the consumer. Batteries constitute a significant portion of the cost of an EV. With an industry average of $600 per kWh, that translates to an $18,000 battery.[38] The raw material is the most expensive part of battery production. While the chemistries vary, nickel and cobalt are typically used with lithium to form the cathodes of a battery, which are the largest contributor to battery cost. Much of the EV battery industry research is geared at changing the chemistry of batteries to reduce the cost of the raw material components.

Additionally, some have made the argument that, like oil, dependency on a foreign non-renewable resource such as lithium puts the country at risk and could create a market with rising lithium costs. However, lithium, is a renewable resource in that it can be recycled, even though it is true that is also a resource held by only a few countries. Ensuring a safe and adequate supply of lithium during the initial phases of production will be important to acquiring a longer term recyclable supply of the resource. The Electrification Coalition has emphasized the importance of recycling lithium for the long-term benefit of the consumer and the market. Currently, lithium used in consumer electronics is not recycled.[39]

An additional contributing factor to the cost of batteries is the scale of production. A manufacturing plant that produces 10,000 units per year will have costs as much as 60 to 80 percent higher than a plant that produces 100,000 packs per year.[40] Until EVs are produced on a large scale and market demand increases for batteries, large scale production of these batteries is unlikely to happen. Therefore manufacturing capacity will continue to

37 Ahmad A Pesaran, National Renewable Energy Laboratory, "Battery Pack Thermal Issues and Solutions for PHEVs," presentation given at Plug-in 2009, Long Beach, CA.

38 Electrification Coalition, 79.

39 ibid., 80.

40 ibid., 86.

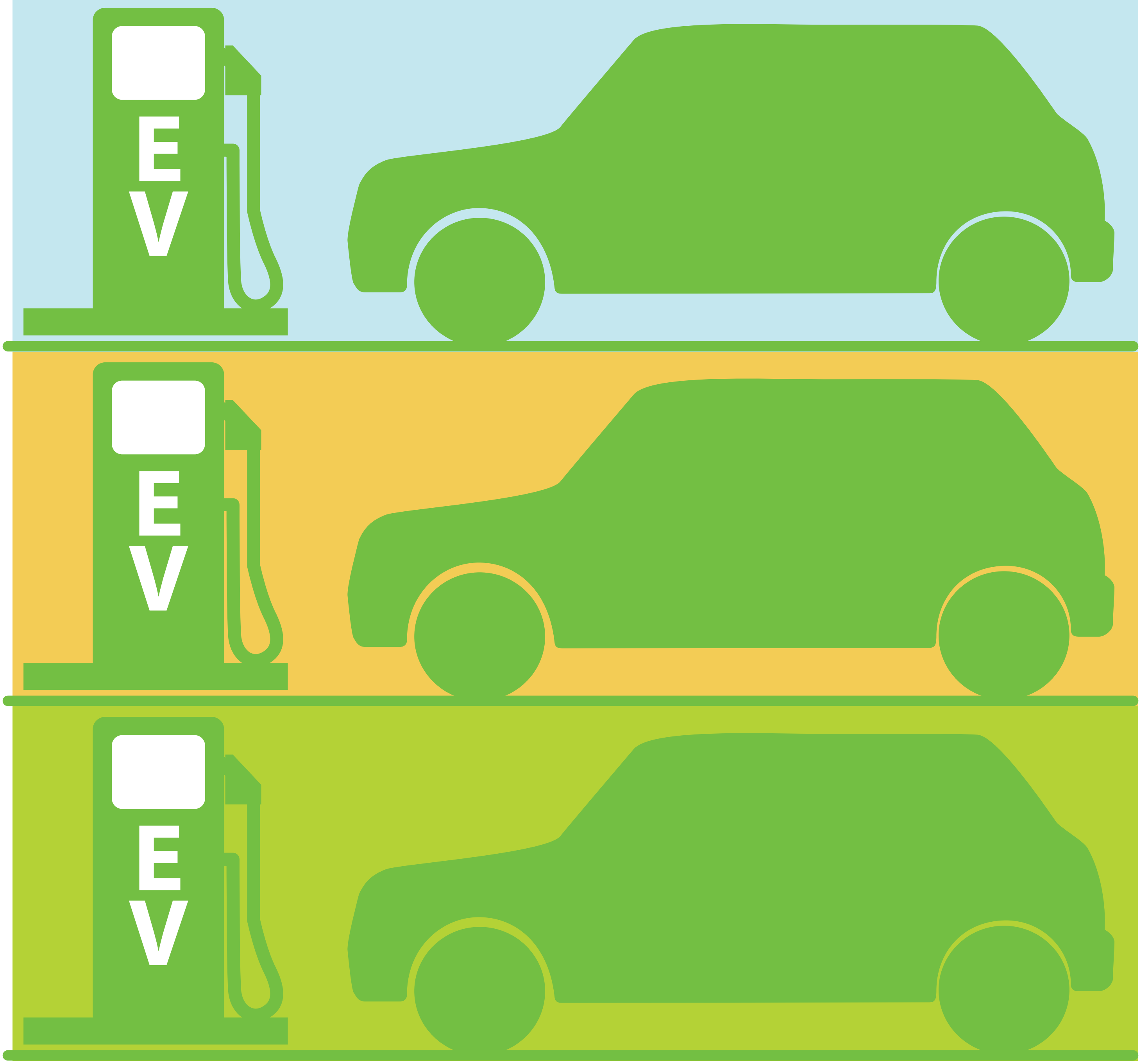
contribute to the high costs of purchasing an EV.

Range

The range of an electric vehicle is highly dependent on the battery technology, though other standard driving conditions, such as climate, terrain, and driving style, play a role in EV range just as they do with the mileage of an internal combustion engine vehicle. The typical range of a current market electric vehicle is three to five miles per kWh of energy density.[41] For a 100 mile range an EV would need a battery capacity of 25 kWh. Many of the EVs on market have a battery specification of 30 kWh. Manufacturers build a reserve into batteries to prevent deep discharging of the battery and maintain a 10 year battery life as required by California regulations. To see the wide variety of range available in current EVs see *Appendix B. Electric Vehicle Matrix*.

41 ibid., 77.

POTENTIAL STATION AREAS



Vehicle Activity Intensity Areas

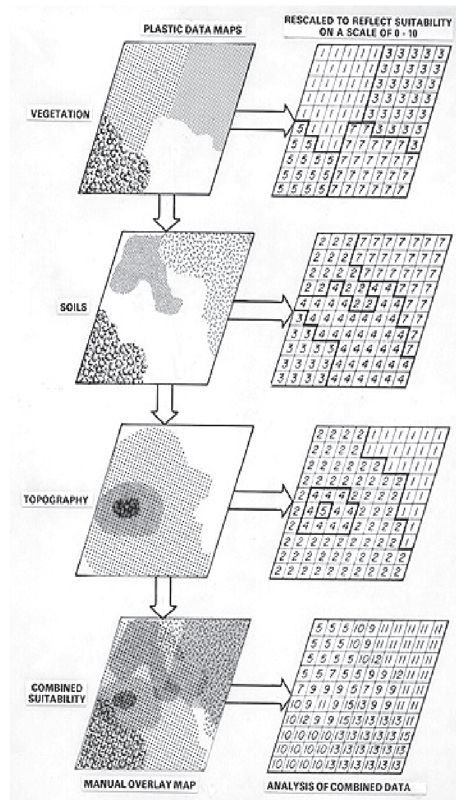
The following analysis is one way to identify potential locations for EV charging infrastructure, but it is by no means the only way to identify good charging sites. While this methodology identifies convenient locations in population centers, it does not identify potential charging areas in more rural areas, nor does it identify gaps between population centers where charging stations might be well placed to serve remote highway locations and long distance PEV drivers. The following section describes the methodology used to identify potential sites for charging stations within population centers.

Question:
Where are the areas in the Monterey Bay Area where people are already parking to engage in activities where they leave their car parked for at least two hours?

Methodology

The underlying assumption of this analysis is that EV charging infrastructure should be conveniently located where existing vehicles congregate. EV drivers are expected to follow the same patterns of conventional vehicle drivers, commuting to and from work, running errands, and visiting business centers. In order to determine potential areas for electric vehicle charging stations, a vehicle activity intensity analysis was developed to identify where existing vehicles are parked for 1-3 hours per day. This analysis was accomplished through a systematic, multi-factor analysis from a set of model inputs.

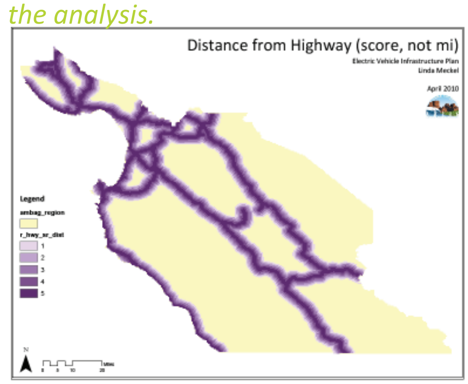
Figure 3. Example of how a vehicle activity intensity analysis works.



This section outlines the results of efforts to model areas of activity, popularity, and places where it is reasonable to assume that an EV owner would be for one to three hours, or enough time to receive a significant charge at a Level 2 charging station. For much of the Monterey Bay Area, parking for two to three hours in downtown areas or other activity is allowed, and would support this charging time frame. One company, eTec has been developing general guidelines for charging station areas within the Pacific Northwest. They include as locations where EV owners are parked for one to three hours as being restaurants, theaters, shopping malls, governmental facilities, hotels, amusement parks, public parks, sports venues, arts productions, museums, libraries, outlet malls, airport visitor lots and major retail outlets.[29] The following methodology seeks to determine these one to three hour activity locations within the Monterey Bay Area, to find places where EV owners would likely need to park and partially charge their vehicles. These are popular destinations for all vehicle types, and placing EV charging infrastructure in these areas will alow EV drivers to use their cars just like mainstream vehicles. The following data inputs were used in the suitability analysis:

- ESRI Business Analyst 2008 (infoUSA, Inc., ESRI, 2009)[30]
- Assessor Parcels (Counties of Monterey, San Benito, Santa Cruz)
- AMBAG Regional Travel Demand Model 2005 (Association of Monterey

Figure 4. Example of AMBAG input for the analysis.



29 Electric Transportation Engineering Corporation (eTec), April 2010
30 infoUSA, Inc., ESRI. (2009, 5 15). ArcGIS 9.3.1 Business Analyst . Readlands , CA, USA: ESRI.

Bay Area Governments, 2005)[31]

» Road Network

» Traffic Analysis Zones

31 Association of Monterey Bay Area Governments. (2005). Regional Travel Demand Model files.

Table 6. Data Collection & Preparation

Model Parameter	Initial Data and Treatment
Existing Parking Locations	Since no precise data exists on existing parking locations, streets with parking (as designated in the AMBAG model), and business locations (which assumes that businesses have parking due to current zoning regulations) are used as a proxy. Additional data, in the form of Impervious Surfaces, would make this portion of the model more accurate.
Activity Locations	• Assessor Parcels for Businesses with a NAICS classification of 71 (Arts, Entertainment and Recreation) were selected. • Library locations were geocoded, and assessor parcels selected. • NAICS codes were also used to determine the locations for Food and Beverage Stores, Food Service businesses, and Grocery Stores.
High Visibility Locations	Business Districts were determined using the Kernel Density function in GIS. Points from the ESRI Business Analyst data set were used to determine clusters of businesses, which were weighted by the number of employees for that business. The "point density" function was also used to compare the two outputs.
Tourism Attractors	TAZs where "visitors" are attracted were selected. These TAZs have one or more tourist attractions.
Distance from Highway	State Routes and Highways in the region were buffered with a 0.5, 1, 1.5, and 2 mile radius.
Route popularity	The daily volume for each road segment, as determined by the AMBAG regional travel demand model, was used as the basis for the Line Density function in ArcMap. This function essentially was used to approximate the popularity of the area around the road segment. This technique takes into account the fact that the destinations are not on the roads themselves, but in the vicinity of said road segment.
Gas Station Locations	Assessor Parcels for Businesses with a NAICS classification of 447 (Gasoline Stations) were selected.
Large Employers	From NAICS employer classes (A-I), classes E-I were selected. This includes all Business Parcels with greater than 50 employees.

Table 7. Early Adopter/Phase I Refinement Criteria:

Model Parameter	Initial Data and Treatment
Demographics	• High Household Income areas (by TAZ) • Cars per Acre (by TAZ)
CEC Grant Applicant Business	Addresses of businesses were geo-located and joined to their associated parcels.
Existing Station Locations	Using latitude and longitude inputs from the EVChargerMaps (EV Charger News, 2009)[1], the existing station locations were geocoded. Next, using the Network Analyst tool, the "range anxiety" for each station was modeled at 30, and 70 miles to determine catchment areas for each existing station.
Range Anxiety	**Distance between Home & Work, Home & Activity -** The business point locations from the ESRI dataset were used to create density cluster spheres, indicating the business districts in the region. Network Analyst was used to determine "service areas" for each of the business district density clusters. From each district 30 and 70 mile service district areas were used to approximate "range anxiety."
Distances between Chargers	(no current data – need Network Analyst to determine actual distance between possible locations, for example, existing businesses)

- EVChargerMaps (EV Charger News, 2009)[32]
- Municipal Facility locations (libraries, parks, city and county administration buildings) (Association of Monterey Bay Area Governments, 2010)[33]

32 EV Charger News. (2009, October 21). *EVChargerMaps*. Retrieved July 8, 2010, from EV Charger News: http://www.evchargermaps.com/?Address=Anaheim&Want=SPI%20LPI%20AVC%20OC&Zoom=9

33 Association of Monterey Bay Area Governments. (2010, July). Municipal Facility locations shapefile. Marina, CA: AMBAG.

Table 8. Input Values and Scores.

Input	Activity Weighted Scoring
yes, it is in the **AMBAG region**	1
it is in a **business district** and is scored based on the density of businesses	17
yes, it is in a **business district**	1
yes, it is a **business parcel**	1
yes, it is an **accommodation or food service business** (NAICS 72) point	5
yes, it is a **arts, entertainment, recreation business** (NAICS 71) point	5
yes, it is a **business point** (500 m cells)	1
yes, it is a **gas station business point** (NAICS 447)	1
yes, it is a **grocery store business point** (NAICS 4451)	5
yes, it is a **hotel motel** business point (NAICS 72111)	1
yes, it is a **large employer** (over 50 employees) business point	1
yes, it is a **library facility** point	5
yes, it is a **retail or trade business** point (NAICS 44, 45)	5
scored based on a jenks distribution of **populations within cities**	9
yes, it is **in a city**	1
yes, it is **on a street with parking**	1
it is **within a 2.5 mile distance from a highway, scored by closeness** by 0.5 mi (0.5 mi = 5, 1 mi = 4, etc)	5
Score of 1-9 based on the Line Density function around the Daily 2005 **Road Volumes** from the AMBAG RTDM road file. This score the popularity of the areas near busy roads based on vehicle road volumes.	9
yes, it is **in an area with businesses**	1
yes, it is **in an area with hotel/motels**	1
yes, it is **in an area with visitor attractions**	1
	77

Figure 5. More examples of AMBAG input for the analysis.

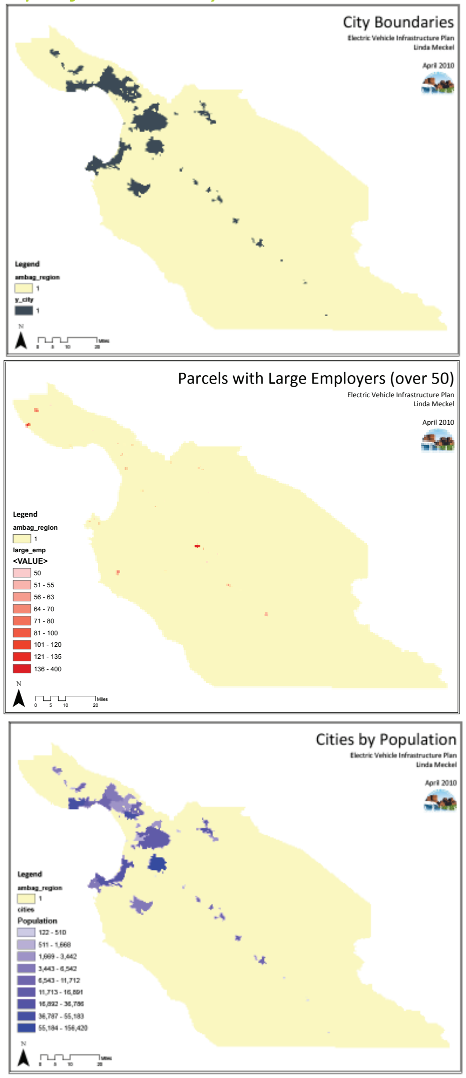


Table 9. Other Weighting Evaluations by Group

Group	Activity Weighted
AMBAG	1.3%
Business Districts	23.4%
Business Parcel	1.3%
Business point	37.7%
Business point - old	0.0%
Population	13.0%
road	19.5%
TAZ	3.9%
Grand Total	*100.0%*

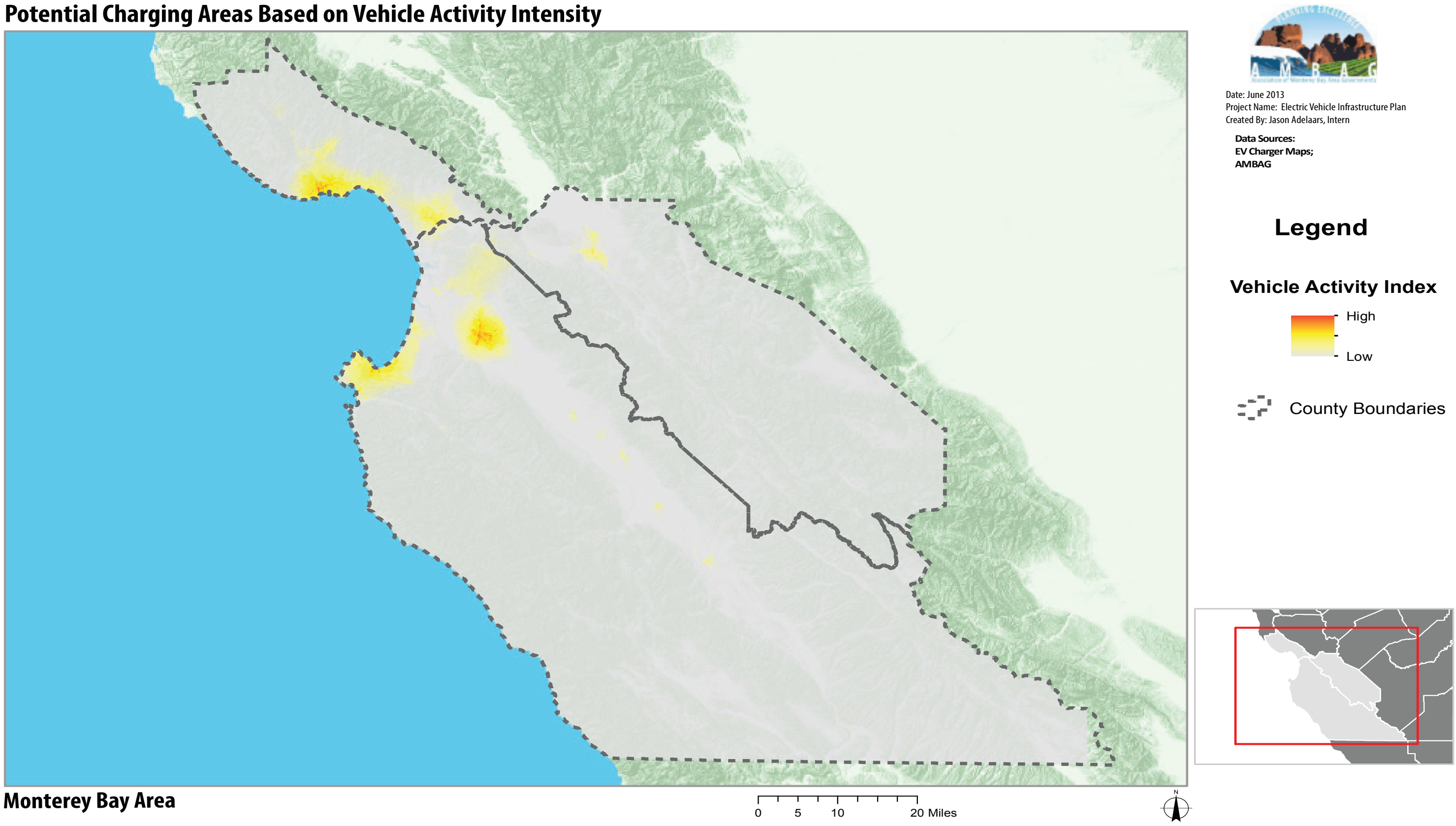
Tables 6 and 7 show the model parameters and how the data was prepared for the suitability analysis. Overall, forty-five different indicators were evaluated in the suitability analysis as inputs into the model. Those parameters in Table 7 were not input into the model, but were examined and should be further evaluated to refine where future stations could be sited.

Table 8 indicates how the inputs were weighted in the suitability analysis, as different weights influence more important aspects for where stations could be sited. For the purposes of this model, business districts, business points, location in a city, distance from a highway, and road volumes were weighted disproportionately compared to the other inputs. Based on literature review, available data, and where parking already exists, these inputs were considered more important than other inputs.

Several other scenarios were tested and evaluated before deciding to weight more important inputs. These included, summing the values, asking a yes or no (0 or 1) for each input and grid cell, normalizing the values, normalizing the "yes" inputs, and weighting certain parameters.

Each type of scoring index was evaluated by the group of input parameters to see what criteria was influencing the output scores the greatest. This sub-grouping for the inputs was extremely valuable to parse down different types of information. Table 9 above shows the group of input information that was contributing most to the output scores. The Activity Weighted Scoring takes advantage of the business point information. As noted in Table 6, Activity Locations, were determined by different business types locations. This weighting pays particular attention to the types of businesses, and

Figure 6. Potential Charging Areas in the AMBAG Region.



secondarily to the clustering of those businesses as "business districts." It was concluded that this approach was most appropriate for this study to evaluate the parameters given the nature of coupling charging with two to four or more hour activities, would be to weight the inputs that contained those values.

The resulting map in Figure 4, shows the scores of all the locations in the region based on the Activity Weighted Scoring system. The green areas are those that scored the least, while the dark brown to white areas are those that scored the highest. For more detailed maps of individual counties, cities, and other locations throughout the region, see *Appendix A. Map Book of Monterey Bay Area Jurisdiction Potential EV Charging Areas.*

Limitations of the Study

While this analysis identifies convenient locations in population centers, it has some shortcomings. It does not identify potential charging areas in more rural areas, it does not identify gaps between population and business centers, nor does it account for potential charging areas that are not associated with clustered business and population centers. This section explores these shortcomings, and presents some supplementary analysis to mediate these issues.

Figure 7. More examples of AMBAG input for the analysis.

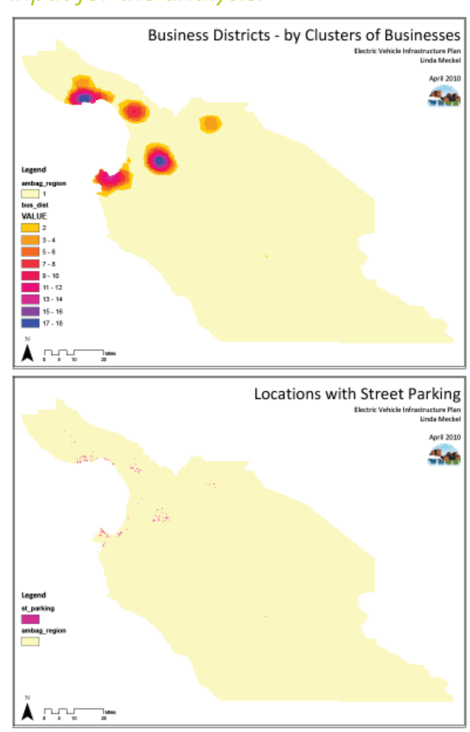


Figure 8. UC Berkeley Global Venture Lab - User Model Personas, 2008.

Persona	Green awareness	Concern with cost-effectiveness	Average mileage	Disposable income	Willingness to try new technologies	Approx. number of individuals (top 3 counties, 2000) ***	Infrastructure location requirement
High tech professional (drives)	High	High	High	High	Very high	890K	Charge: home and work Swap: daily route
Professional (drives + public transportation)	High	Low	High	High	High	125K	Charge: home, BART, Caltrain Swap: highways, travel route
Taxi driver	Very Low	Very High	Very High	Low	Very Low	~7K	Charge: garage Swap: central, airports
College student	High	Very High	Very Low	Low	High	304K	Charge: home and school Swap: central, highways
Homemaker in a high-income household	Low	High	Low	Low	Low	618K	Charge: home, supermarkets, outlets Swap: central, highways

It is important to note that this analysis is designed for Level I and Level II chargers, which require a number of hours to impart a significant charge. As such, this analysis identifies locations where vehicles are expected to be parked for multiple hours. This is not necessarily the best approach to identifying potential locations for the newer Level III fast chargers.

Newer Level III chargers can impart a full charge to an EV in less than an hour. This makes them more comparable to conventional gas stations where EV drivers can pull in and charge for 15-30 minutes, then move on. As such, these stations may be better suited for placement near highways, and their placement should not be limited to population centers. Additional analysis should be done to identify the best way to site these stations.

While this analysis identifies places where people park and conduct their business, it may not identify areas where large numbers of people gather on a more infrequent basis, such as on evenings and weekends. This includes fairgrounds, non-urban parks, golf courses, racetracks, and similar facilities. This also includes popular destinations such as Big Sur State Park, the Big Basin Redwoods State Park, Pinnacles National Park, and the area's many

Figure 9. Parks and Recreational Areas In the Tri-County Area May Be Good Sites for Charging Infrastructure

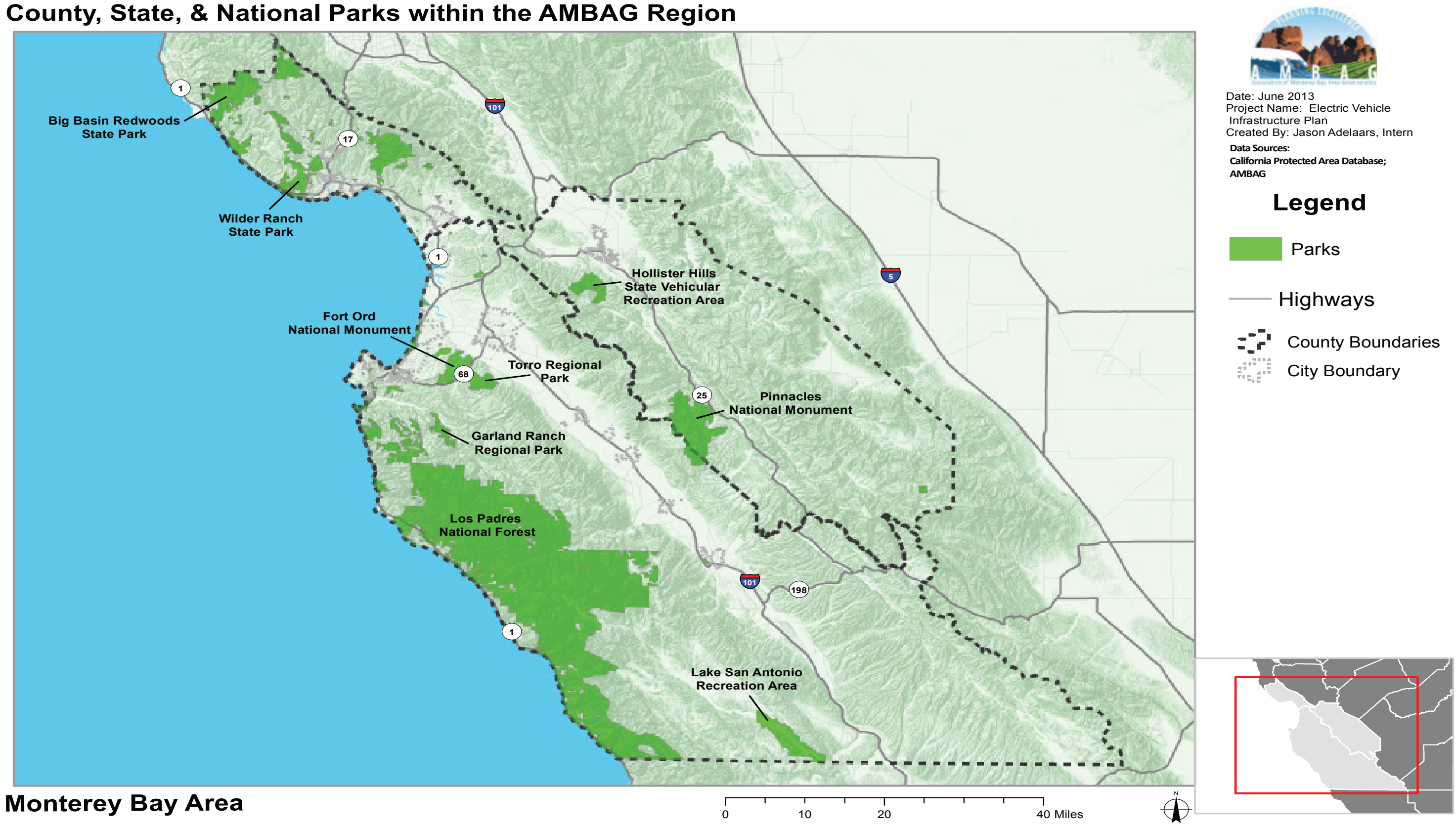
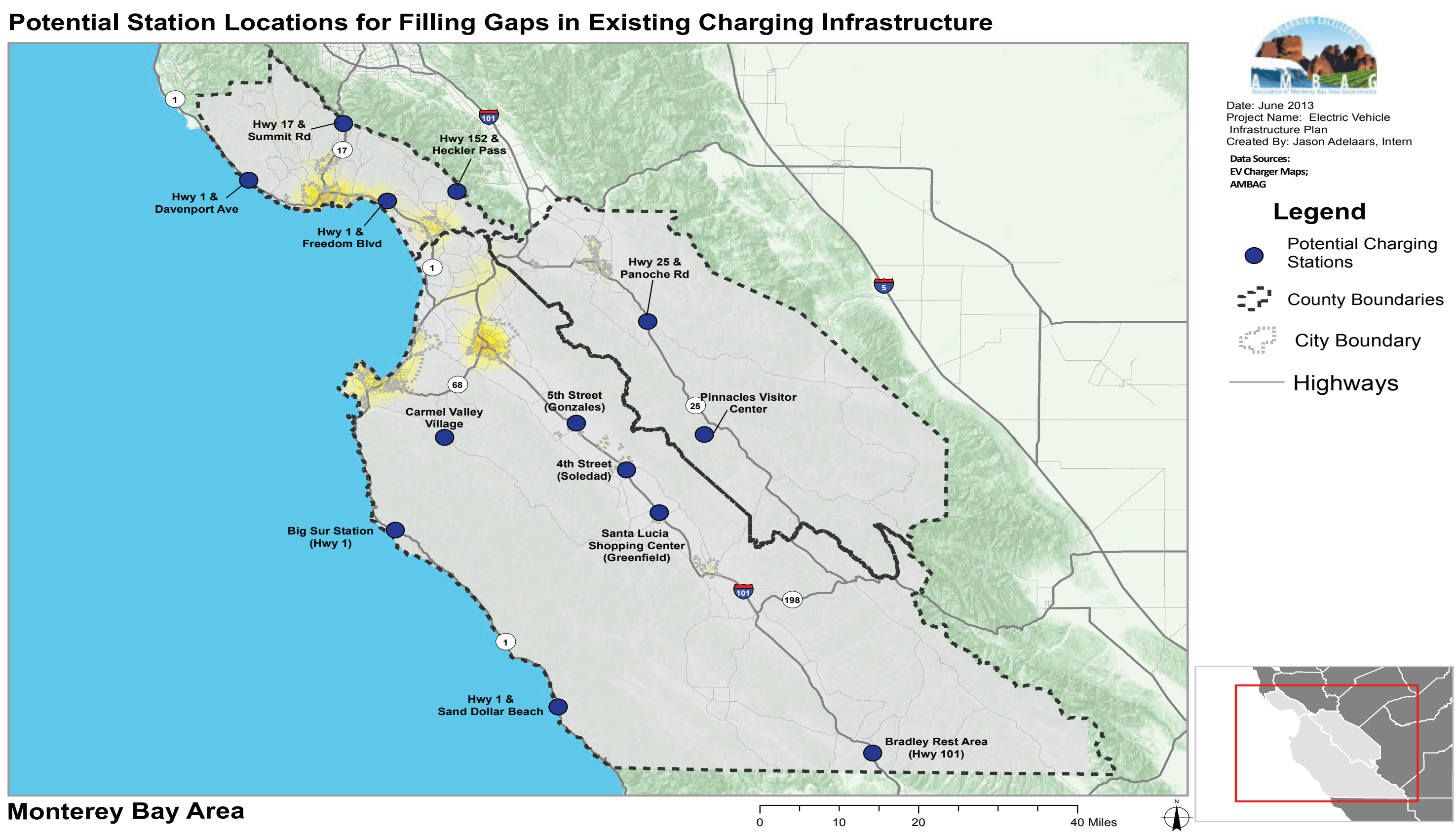


Figure 10. Potential Station Locations for Filling Gaps in Existing Charging Infrastructure



county parks. Figure 9 provides a map of the parks and recreational areas in the tri-county region. These sites may be good locations for EV charging infrastructure as they attract moderate crowds, especially on weekends and holidays. Figure 10 provides a map of potential charging locations which would fill the gaps between existing charger locations, assuring that there is at least one charger available every 30 miles along major highways. These would also be good potential locations for Level III fast chargers to accommodate the PEV driver who is travelling long distances in one trip.

Fleets

Fleet vehicles are necessary in conducting the daily operations of many organizations. These vehicles allow employees to perform the travel requirement of their jobs without using their personal vehicles. Many fleet vehicles are specialized for a specific task, such as law enforcement vehicles and postal trucks. There are numerous types of vehicle fleets that operate on a daily basis within the AMBAG region. Identifying the operators and locations of these fleets would provide a valuable list for decision-makers interested in siting EV charging stations and working with fleet managers to add EVs.

Based on research into fleet vehicle locations within the AMBAG region, the following businesses, organizations, and institutions are likely to have a large fleet of vehicles.

- Universities – Including University of California, Santa Cruz, California State University Monterey Bay, Monterey Peninsula College, Cabrillo College, Monterey Institute of International Study, the Naval Postgraduate School, and the Defense Language Institute.
- Local Jurisdictions – Including police, fire, code enforcement, parking enforcement, and employee transport.
- County/State Organizations – Including the California Department of Fish and Wildlife, Monterey Bay Unified Pollution Control District, and California State Parks.
- Federal Organizations – Including the United States Postal Service, United States Geological Survey, and the National Marine Fisheries Service.
- Transit – Including Monterey-Salinas Transit, Santa Cruz Metro, and San Benito County Express.
- Utilities – Including Cal-Am Water, Pacific Gas & Electric, Santa Cruz Municipal Utilities, California Water Service Co., Monterey Peninsula Water Management District, Marina Coast Water District, and the San Benito County Water District.
- Private Transport Companies – Including Yellow Cab, Early Bird Airport Shuttle Service, Monterey Airbus, Santa Cruz Airport Shuttle, and Coastal Yellow Cab.

- Rental Car Companies – Including Enterprise, Hertz, Avis, Budget, and Auto World Santa Cruz.
- Other Private Companies – Including Fresh Express, Dole Fresh Vegetables, and the Monterey County Herald.

PEVs have the ability to meet the needs of many vehicle fleet services within the AMBAG region. As PEV charging infrastructure continues to expand, these vehicle fleets can be augmented by PEVs. Targeting vehicles fleets for PEV replacements and upgrades would increase regional adoption of EVs and increase demand for charging infrastructure.

A number of PEVs are already in use in fleets in the tri-county area. According to the University of California Santa Cruz (UCSC) Fleet Services website supports a fleet of over 700 vehicles, which include rental compact sedans, and short trip cart vehicles. The University is currently researching the capacity to power the fleet using alternative energy sources. Similarly, the City of Monterey Fleet Services operates over 220 vehicles, including small short trip vehicles, and hybrid and electric vehicles. Finally, Yellow Cab is a locally owned cab service in the Monterey, Salinas, and Hollister areas, maintaining a fleet of EV sedans.

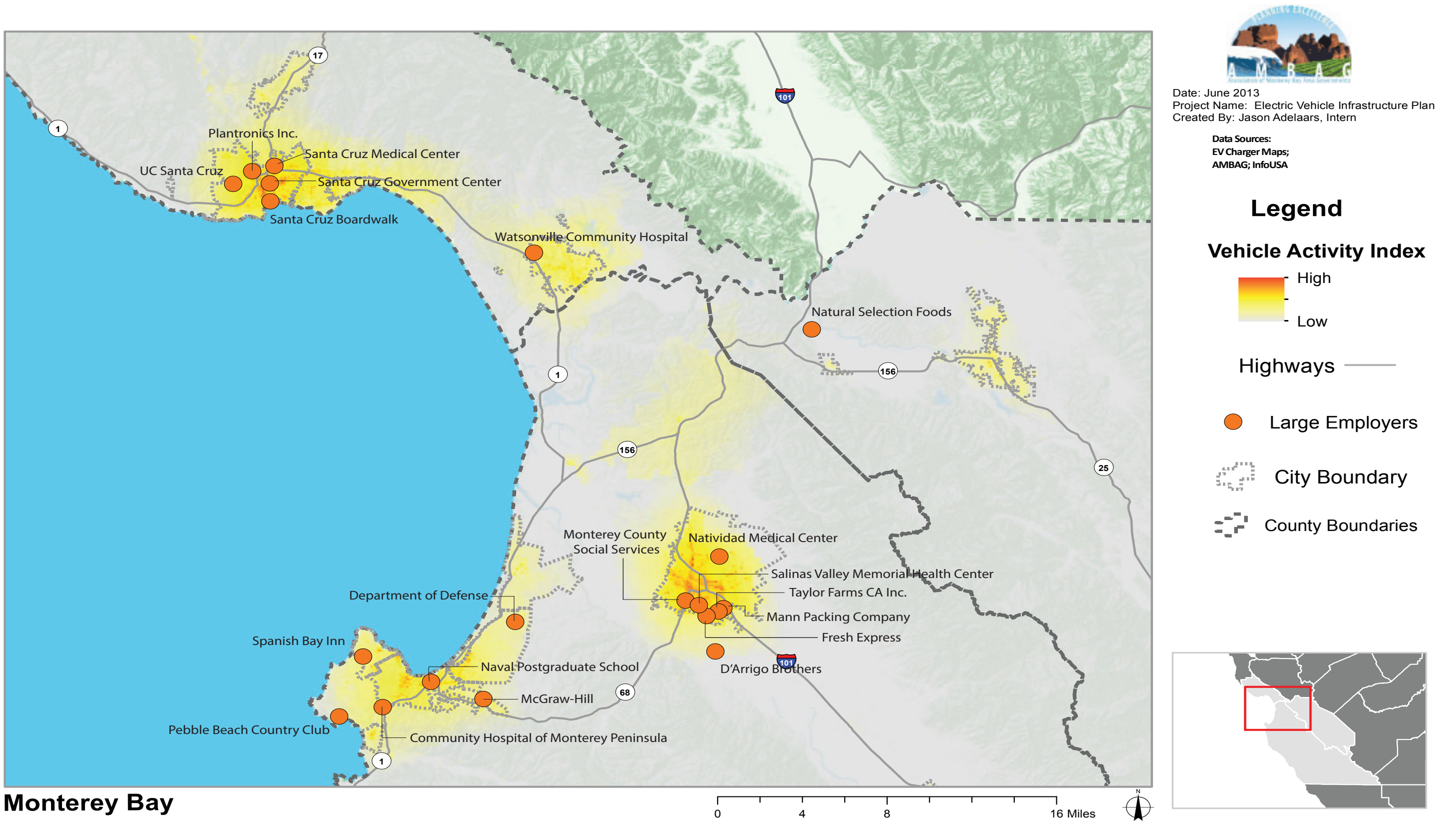
Other Methods to Site EV Stations

Several studies have been conducted to see who is most likely to purchase electric vehicles first, and to use these parameters as a way to phase the EV charging infrastructure rollout. These approaches, while innovative for their own uses, were more focused on early adopters than on general best locations. The following is a summary of these other approaches.

The UC Berkeley Global Venture lab identified five different "personas" as user models for early adopters of EVs. These included High tech professionals, other professionals, taxi drivers, college students, and homemakers in a high-income households (Cheng, et al., 2008)[34]. These personas, as seen in Figure 8, were evaluated based on census data, green awareness, concern with cost-effectiveness, average mileage, disposable income, willingness to try new technologies, and approximate number of individuals in each category. Each persona was assigned location charging requirements. Next, the Global Venture lab extrapolated these locations to a 4:1 charging station to electric vehicle ratio for the first year, and a 2.5: 1 station to vehicle ratio by year 5. Their analysis also included battery swapping stations at a constant 10:1 station to vehicle ratio over the entire five-year rollout.

34 Cheng, I. (., Desai, D., Koudigkelis, K., de Vasconcellos, P., Kaminsky, P., Sidhu, I., et al. (2008, November 21). Electric Vehicle Charging Infrastructure Rollout Strategy. *Global Venture Lab Technical Brief* . Berkeley, CA: U.C. Berkeley.

Figure 11. Top 20 Employers in the Santa Cruz, Monterey, and San Benito Counties Area



The analysis expects that 50% of charging will occur at home, secondary charging will occur at work, BART and Caltrain stations, and at selected malls, stadiums, and hospitals. Finally, swapping stations should be located along main highways in selected counties. By year five they expected additional employers, more homes, 50% of all available station parking spots, on-street charging, and private and public parking structures to have charging stations.

The Center for Entrepreneurship & Technology identified four types of transportation sectors likely to adopt EVs as a follow-up to the UC Global Venture roll-out study. These included private vehicle commutes to companies, regional freight delivery operations, last-mile companies, and governmental fleets (Chavis, et al., 2009)[35]. Their analysis focused on large employer locations, logistic company locations, car-sharing companies, and governmental fleets. Figure 11 provides a list of the largest twenty employers in the tri-county region as potential sites for employer-based charging. These locations would be particularly well suited for Level I and II chargers since most workers are expected to be at their place of work for a number of hours.

35 Chavis, C., Kanairo, K., Samartino, A. L., Sathaye, N., Sidhu, I., Kaminsky, P., et al. (2009, September 18). Strategies for Electric Vehicle Deployment in the San Francisco Bay Area. *Center for Entrepreneurship & Technology Technical Brief* . Berkeley, CA: University of California, Berkeley.

Additionally, a University of Michigan study looked at the purchase probabilities of PHEVs, the correlating demographics and purchase probability based on charging behavior (Curtin, Shrago, & Mikkelsen, 2009). This study informed many of the early adopter attributes used in this suitability analysis. However, because the University of Michigan study was focused on PHEVs that have a much larger range than pure EVs, it is expected that some characteristics of these early adopters may not be consistent with EV early adopters.

Another study from the Puget Sound Regional Council (PSRC) in 2010 looked at origins and destinations of likely EV owners, major regional destinations and other siting factors as a strategy to deploy charging stations[36]. These trips were divided into work and non-work trips and relied heavily on information from the PSRC regional travel demand model. Of particular interest were the supplemental factors, which included, regionally desired growth centers, manufacturing-industrial centers, other sub-regional centers, major transportation facilities, park and ride parking lots, parking lots in general, household density, employment density and median household income. AMBAG evaluated as many of these parameters as possible based on the data available in the Monterey Bay Area region.

As more EVs enter the market and charging patterns of early adopters are studied, more models for strategic infrastructure deployment will be developed. It is important for users of these models to understand the intricacies of what parameters are being evaluated. Future parameters that should also be considered, if available from the utility companies, are the locations and load allowances of energy infrastructure. The adoption of this new technology relies on understanding the implications of EV use on our electric infrastructure. Other Methods to Site EV Stations

Best Practices in Electric Vehicle Charging Station Siting

Plug-In America reccommends that organizations observe twelve best practices when siting EV charging stations:[37]

- Site location – Evaluate the site giving consideration to its perceived relative importance and usage compared to other nearby sites.

- User base – Evaluate the charging needs for potential users of the site. This evaluation should include how far users drive to get to the site and how long they are most likely to leave their vehicles parked there.

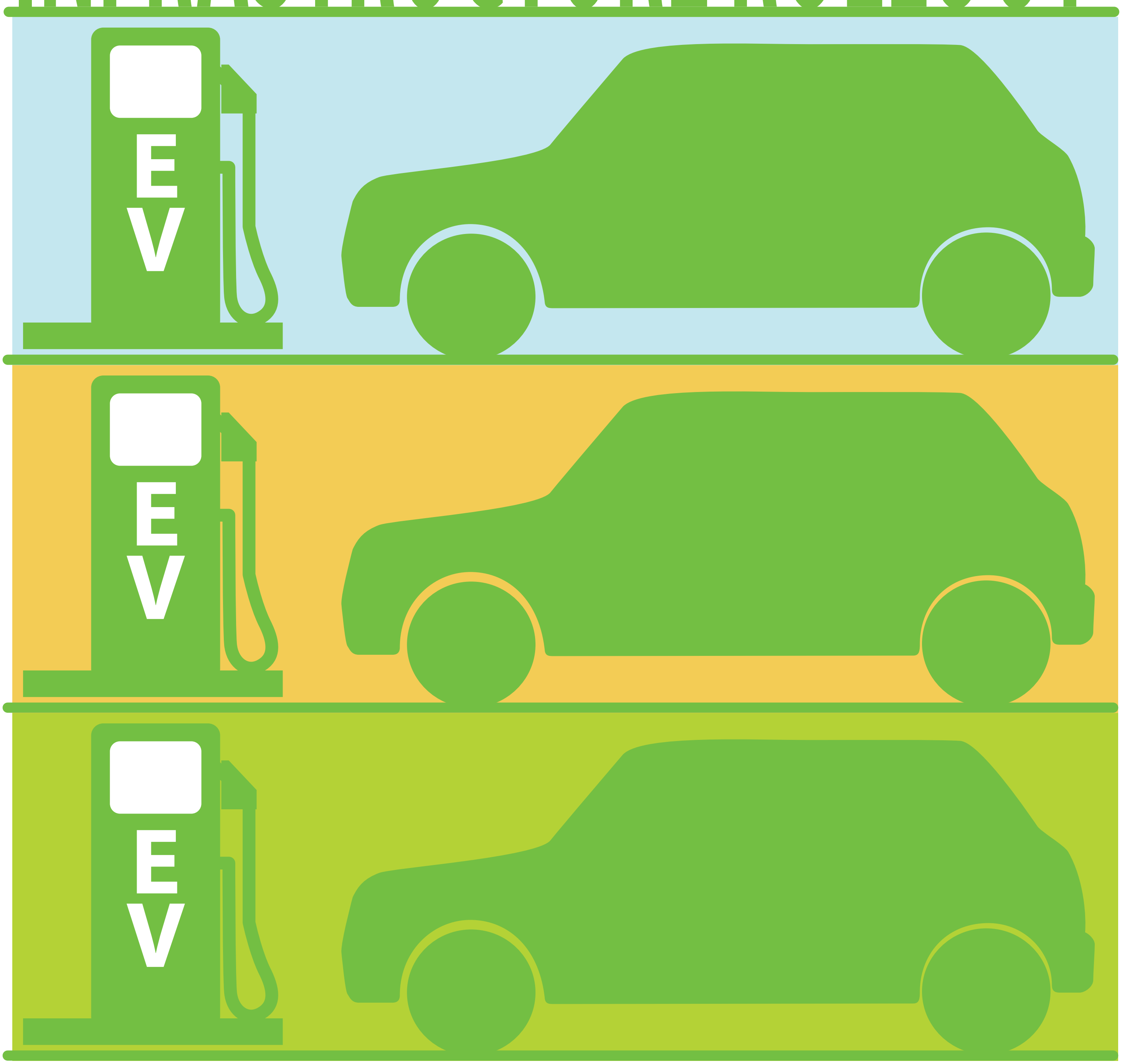
- Charging level(s) – Plan for and match charging levels (1, 2 or 3) to the user base for the site. (For example, Level 1 for parking times typically greater than 3 hours, Level 2 for shorter times.)

36 Miller, Ivan, and Carol Naito. Electric Vehicle Infrastructure: Regional Station Siting Analysis. Presentation. Puget Sound Regional Council, July 2010.

37 Plug-in 12

- Parking and Charging spaces – Locate, whenever feasible, EV charging and parking spaces away from prime locations in lots and in front of businesses.
- Parking and Charging spaces – Locate, whenever feasible, EV charging and parking spaces away from ADA parking.
- Parking and Charging spaces – Locate EV charging and parking spaces in reasonable proximity to the main electrical supply or service panel(s) for the facility.
- Electrical Wiring – In the case of Level 1 charging stations, consider installing conduit and supply capacity that allows for future upgrading to Level 2 charging at minimal additional circuitry expense.
- Signage – Install recommended wayfinder and charging station signage. This signage is both for locational and enforcement purposes.
- Signage – Install usage signage appropriate to the type and level of charging provided, including contact information to report vandalism and out-of-order conditions.
- Maintenance – Document and commit to an ongoing plan for oversight, repair, and maintenance of installed charging stations. This plan should include training of relevant site personnel with the goal of maximizing operational readiness for all installed charging stations at the facility.

INFRASTRUCTURE ROLLOUT



Infrastructure Rollout

Electrifying 75 percent of the VMT in 2035 will require approximately 4.4 million kWh of energy per day being dispensed through chargers, homes, businesses, and public areas. While it is expected that this number will decrease as car manufacturers increase the efficiency of the batteries, thus increasing vehicle range, still a substantial number of chargers will need to be installed.

How will we comply with the Governers Executive Order to put 1.5 million ZEVs on California's roads by 2025? What will it take to reach a goal of 75 percent electrified VMT by 2035? How will the Monterey Bay Area align with the rest of California and the U.S.? The following provides a rough outline of the 2011 AMBAG Pilot Project, other grant activities and needs in the region to achieve this goal, and the combined regional infrastructure needs through 2035.

Case Study: AMBAG's 2011 EV Charging Station Project

In 2011, grant funding from the MBUAPCD allowed AMBAG to place four public EV charging stations in the cities of Salinas, Watsonville, San Juan Bautista, and Carmel. The four cities were selected based on their scores from the vehicle activity intensity analysis. After a competitive request for proposals, the company ECOtality North America responded with an offer to provide a total of four stations, including installation and warranty, for $25,000.

Figure 12. Station Installation.

Gabriel of Regalado Electric installing the Blink Station at the Sunset Center in Carmel.

In return for the station, AMBAG asked each city to provide AMBAG and MBUAPCD access to all the data collected from each charger for the lifetime of the charger, waive all permitting fees associated with the installation of the public EV charging station, and pay the remaining four years of associated networking fees[37]. The legal process of transferring each station to each city was more lengthy than expected. One city even declined the station due to the transfer contract. A lesson learned from this experience is that each city has specific concerns, such as ongoing networking fees, and it may be more efficient to engage the city attorney to help write the contract rather than having them respond to boiler plate language. This will assure that the partner agency concerns are addressed, and result in a more collaborrative contract process.

In some cases, presentations were made to city councils and planning commissions to accept the station and approve the location of the station. Several elected officials and commissioners voiced concerns about changing the image of the city, the payment system, the design aesthetics and losing parking

37 The networking fee is $20 per month, and provides back office payment, customer, and technical support.

spaces in front of key businesses. These concerns need to be addressed early in the project planning process to assure that the concerns of the community are addressed, and charging stations are installed expediently. AMBAG found that while addition of a new technology can be troubling to elected officials, generally, councils and commissions were excited to be part of the projects for a nominal cost to their city.

The process of identifying suitable station locations within each city was guided by the vehicle activity intensity analysis, the location of a sufficient power supply (240V/30amps), visibility to pedestrians for potential marketing, the location of city property or city rights-of-way, and whether the city was willing to allow parking at the location for 2-4 hours.

Several locations were evaluated in

Figure 13. City of Salinas project Location and Site Plan

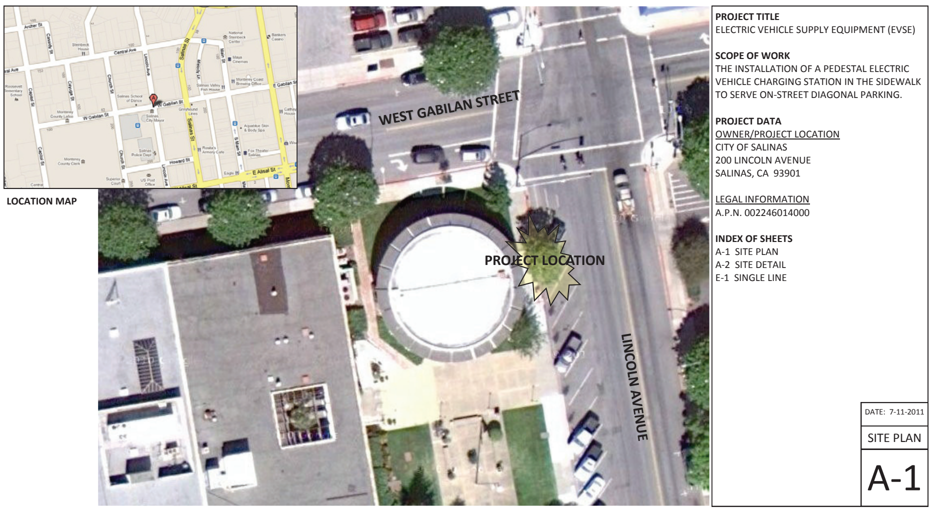
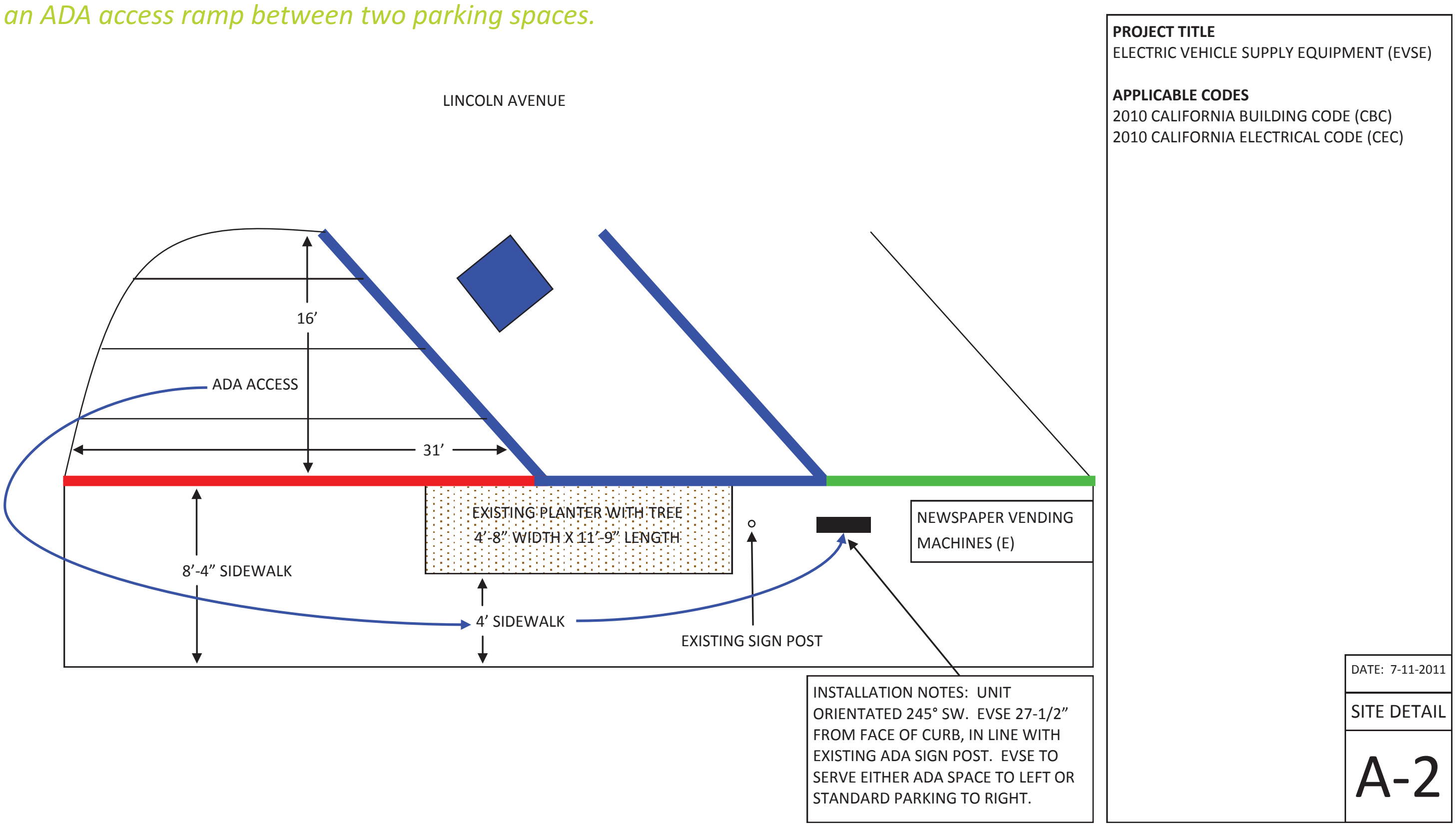


*Figure 14. City of Salinas Initial Site Plan.*plan was eventually modified by the city to include an ADA access ramp between two parking spaces.*



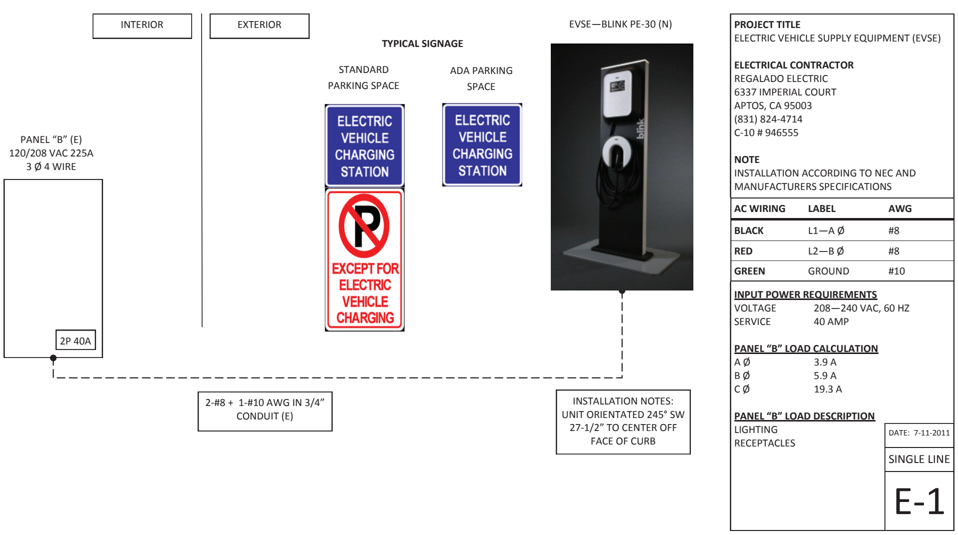
each of the selected cities. After visiting the sites[38], a site plan was developed (see Figures 8, 9 and 10) and submitted to each city's permitting department. Each site plan included a project location, detailed site plan, and electrical plan. Each permitting department handled these plans differently, suggesting that common guidelines for on-street public charging stations need to be developed. While each site plan took into account ADA accessibility, there is no clear state or federal standard for public EV charging stations and ADA accessibility. Further, in some cases, existing ADA spaces in some cities required retrofitting to meet general ADA requirements. Going forward, jurisdictions should develop guidelines for how ADA accessibility and public EV charging station accessibility be combined.

The actual installation for each station was relatively simple, as each location had been selected partially because of its proximity to the necessary power supply and therefore required minimal trenching and concrete patching. The more expensive installations were those where there was more extensive trenching and concrete repair, and where longer electrical conduit had to be run to meet the panel. Fortunately, no transformers required additional capacity, as that would have increased the installation price greatly.

The installed stations underwent safety testing and are connected to the "network" via a CDMA (a type of channel access method) connection. This allows users to know, before arriving at the station, if the station is in use (see Figure 11), and to process payments off-site.

38 Thanks go to Andy Hartman of Local IBEW 234 for visiting all the proposed site locations and creating the charging station site plans.

Figure 15. City of Salinas Electrical Installation Plan.



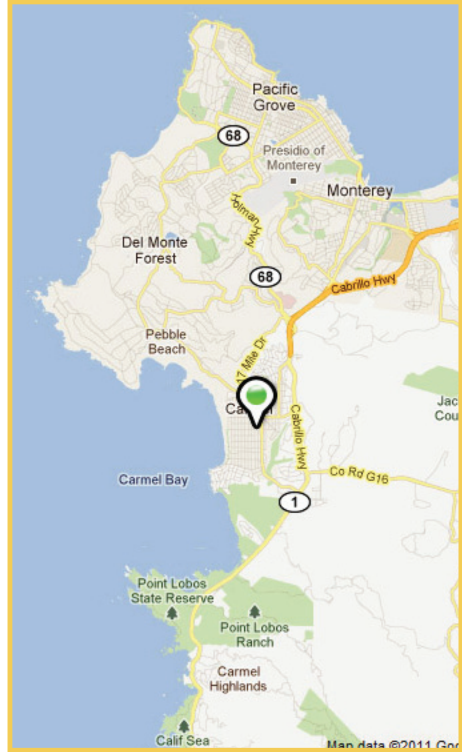


Figure 16. Online BlinkMap.

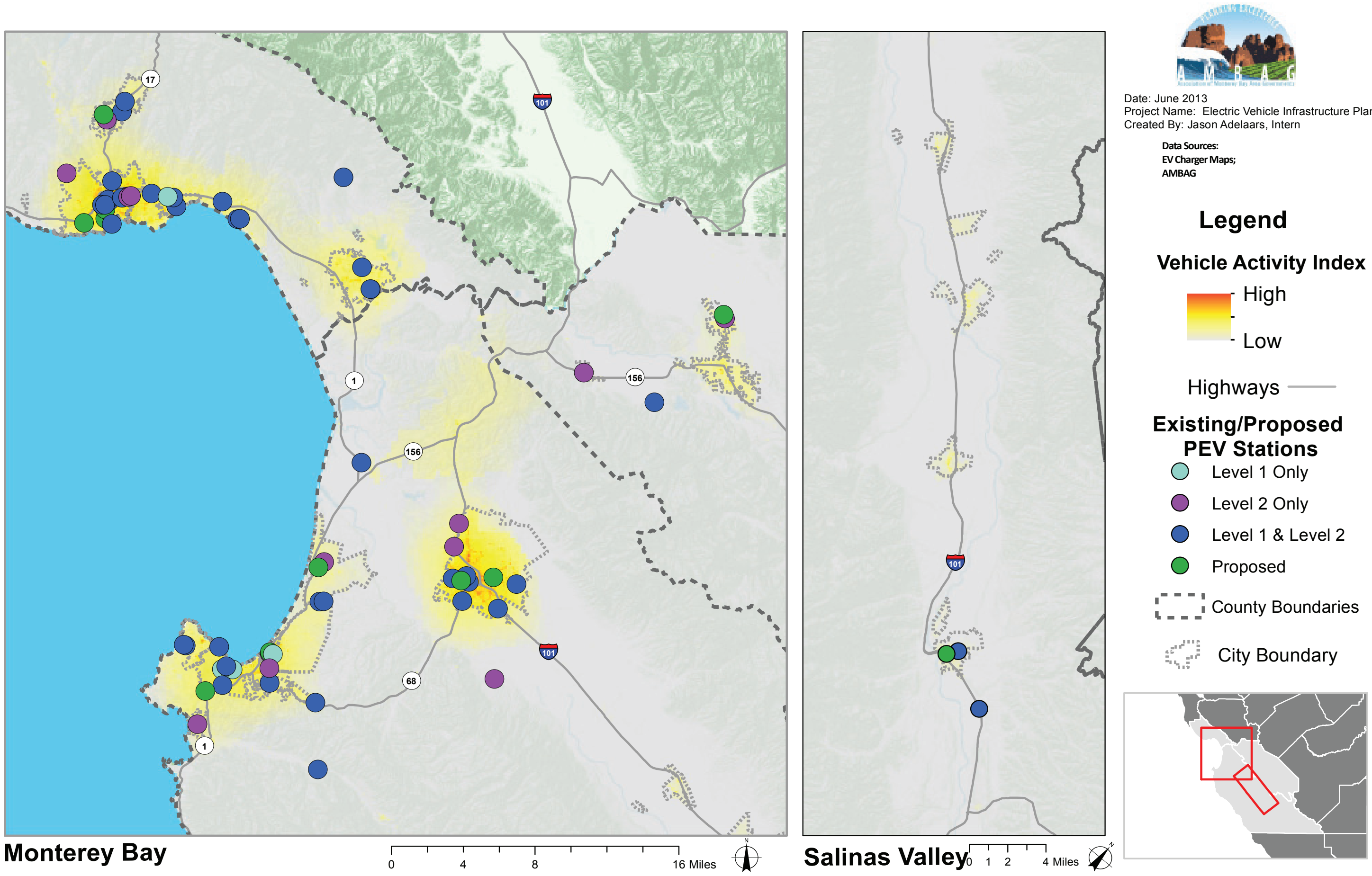
Drivers will know where the station is through maps such as the Blink Locator map.

www.blinknetwork.com/locator.html

Figure 17. The Sunset Center Station.

The installed station at the Carmel Sunset Center can be accessed by both an ADA accessible and regular parking spot.

Figure 18. Locations of Existing and Planned Stations in the Monterey Bay Area, June 2013.



Future EV Infrastructure Activities

Public Charging Station Locations

Using the vehicle activity intensity analysis, locations containing approximately 1,774 acres were identified as priority locations to site public charging stations. This area covers over 5,800 parcels that include a total of 5,273 businesses. Locations in the public right-of-way include on-street or curbside parking spaces and public garage and lot parking spaces. The private sector will govern commercial, industrial, and residential locations including private lots and garages. Installation of private charging stations on a massive scale will require local jurisdictions to have a well thought out and streamlined permitting process.

2012 Grant Activities

By 2012 the CEC and CARB placed hundreds of EVs and thousands of PHEVs throughout California, and many "early adopters" purchased EVs such as the Nissan Leaf or PHEVs like the Chevy Volt and Toyota Plug-In Prius.[39] Within the

39 California Air Resources Board. (2008). *Climate Change Scoping Plan: A Framework for Change.* Sacramento: State of California.

Table 10. Number of Level 3 Chargers Needed in the Monterey Bay Area in 2035.

Table assumes an average battery size of 24kWh, an average range of 100mi, and 0.24kWh/mi.

	15 - 84 aged Population	75% Electric Daily VMT in 2035	Daily Energy Needed (kWh)	# of Full Charges per Day	# of Charges occurring at home (50%)	Number of Public/ Work Chargers (Level 2 @ 4hours per charge)	85% Always in Use Assumption	Number of Level 3 Chargers
AMBAG in 2035 with SB 375	722,735	18,296,166	4,391,080	182,962	91,481	15,247	17,937	1,906
AMBAG in 2010	599,100	13,173,916	3,161,740	131,739	65,870	10,978	12,916	1,372

This table estimates, based on AMBAG population and RTDM VMT forecasts, the amount of energy, full charges (see assumptions above), and subsequent number of charging stations needed for the Monterey Bay Area by 2035. The number of full charges from this table was then used to estimate the approximate cost of infrastructure needed to meet an 75% electric VMT future in Table 11.

Monterey Bay Area more public charging equipment will be installed by TAMC, ChargePoint (as part of the San Francisco Bay Area), the City of Santa Cruz, private employers, and through CEC grants obtained by the Monterey Bay Electrical Vehicle Alliance (MBEVA). Figure 13 maps existing and proposed stations as of June 2013.

To encourage more stations coming into the region, MBEVA obtained $200,000 in grant money from the CEC for a "Community Readiness Plan," which should aid local jurisdictions to develop streamlined permitting processes and plan for electrification of key areas in the region.

It is expected that the Monterey Bay Area will be subject to more grant attention as a connector region between the major EV deployment areas of San Francisco and Los Angeles (see Table 12 for more on the national EV deployment projects). This would mean potentially collaborating with other central coast counties and cities to create an EV charging network along Highway 101 and Highway 1 between the San Francisco and Los Angeles areas.

Key Future Milestones and Timeline for Deployment

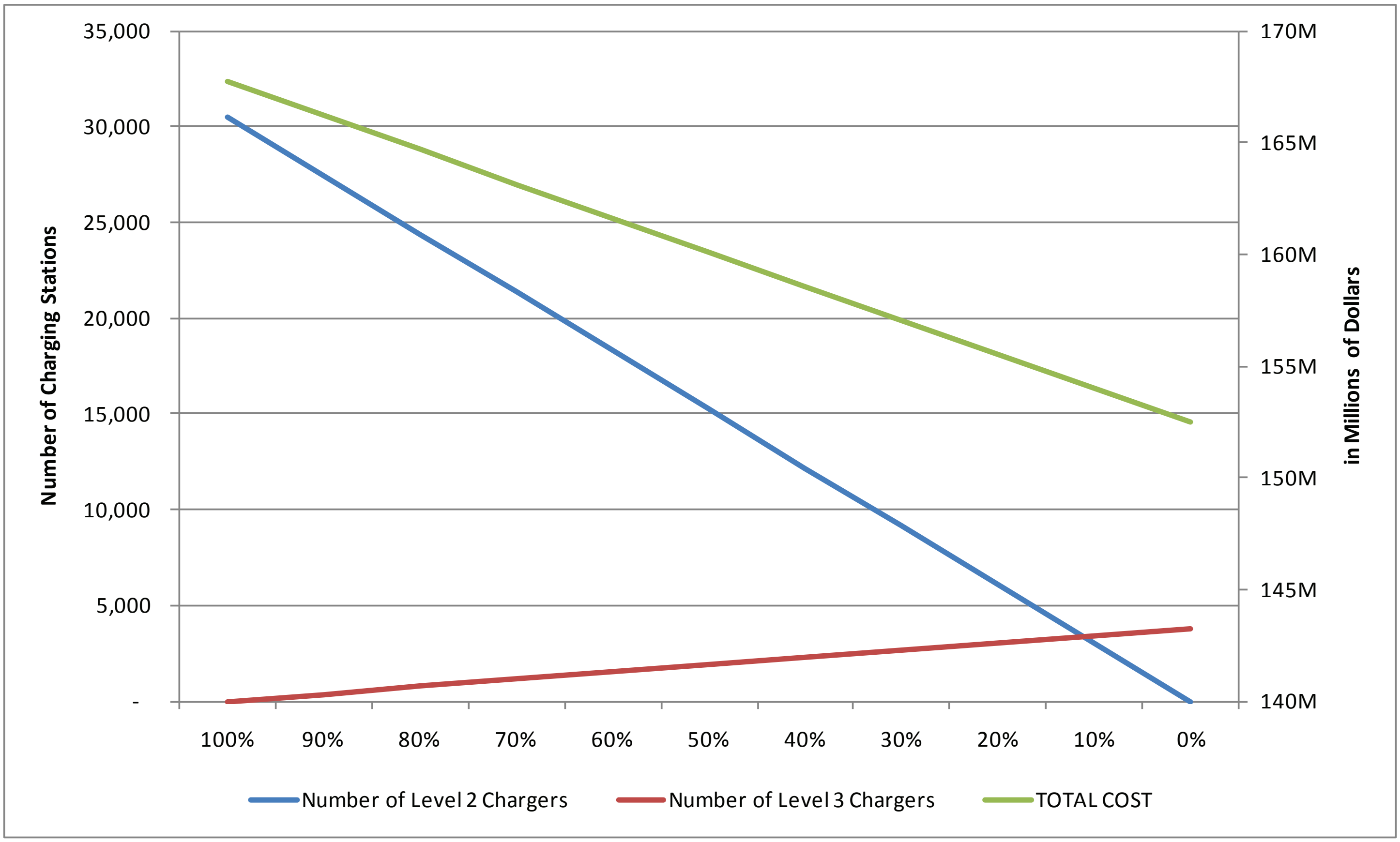
From now until 2050 there are a number of milestones that relate to EV infrastructure development or greenhouse gas emissions produced by the

Table 11. Number of Chargers and Cost of Infrastructure to Electify 75% of VMT by 2035.

Assumes there are a total of 182,962 full charges per day required in the AMBAG Region in 2035.

% Charges @ Level 2	100%	90%	80%	70%	60%	50%	40%	30%	20%	10%	0%
% Charges @ Level 3	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
# of Level 2 Chargers	30,494	27,444	24,395	21,346	18,296	15,247	12,197	9,148	6,099	3,049	-
# of Level 3 Chargers	-	381	762	1,144	1,525	1,906	2,287	2,668	3,049	3,431	3,812
Total chargers	30,494	27,825	25,157	22,489	19,821	17,153	14,484	11,816	9,148	6,480	3,812
Estimated Costs (millions)											
Level 2 @ $5,500	$168M	$151M	$134M	$117M	$101M	$84M	$67M	$50M	$34M	$17M	-
Level 3 @ $40,000	-	$15M	$30M	$46M	$61M	$76M	$91M	$107M	$122M	$137M	$152M
TOTAL COST	***$168M***	***$166M***	***$165M***	***$163M***	***$162M***	***$160M***	***$159M***	***$157M***	***$156M***	***$154M***	***$152M***

Figure 19. Graph of the Number of Chargers and Cost of Infrastructure.



Monterey Bay Area. They are as follows:

2015

- CEC & CARB Targets: Increases in amount of EVs and PHEVs
- Note: Phase II of EV Roadmap – expand electrification ecosystem program by 20 to 25 cities.

2020

- Regional Target I: for Regional GHG emissions – no per capita change in GHG emissions from 2005 levels. This is only based on VMT, not on general GHG emissions.
- State target I: at 1990 GHG emission levels
- California Executive Order B-16-2012
  - State's ZEV infrastructure will be able to support up to 1 million vehicles
  - The costs of ZEVs will be competitive with conventional combustion vehicles and they will be accessible to mainstream consumers, facilitating widespread adoption
  - There will be widespread use of ZEVs for public transportation and freight transport

2025

- California Executive Order B-16-2012: Over 1.5 million ZEVs wil be on California roadways and their market share will be expanding

2035

- Regional Target II: for Regional GHG emissions –(-5% per capita reduction in GHG).
- Coordination with the 2035 Long Range Plan Metropolitan Transportation Plan.

2050

- Target II for State – 20% below 1990 GHG emission levels.
- Achievement of 75% electric VMT.

For the purposes of this plan, the 2035 Long Range Metropolitan Transportation Plan has been used to estimate the number of chargers needed and the possible cost of that infrastructure (see Tables 10 and 11). It should be noted that the assumptions in these tables that will change as the industry continues to grow in the next five to ten years.

What should be noted about these tables is the differential in both the cost of Level 2 vs. Level 3 chargers, and how many stations in general are needed to meet the overall charging needs of the region. These projections includes the total number of charging stations, whether home, private, or publicly available charging stations. Ultimately, there will be a mix of all types of charging locations throughout this region. The ability of public agencies and private entities to pay for the infrastructure will influence this distribution greatly. It is unknown what the exact amount of electric VMT the region can achieve given both the availability and ability to purchase EVs in the future.

Other Major EV Activities in the US

Around the U.S., Electrification Ecosystem Communities, places where EV infrastructure and EV deployment will be targeted, will receive an influx of charging stations, vehicles, and technical support. Three different projects exist – Project Get Ready, The EV Project, and ChargePoint America. Table 12 illustrates the different cities and the extent to which each project will strategically deploy infrastructure or collaborate with partners.

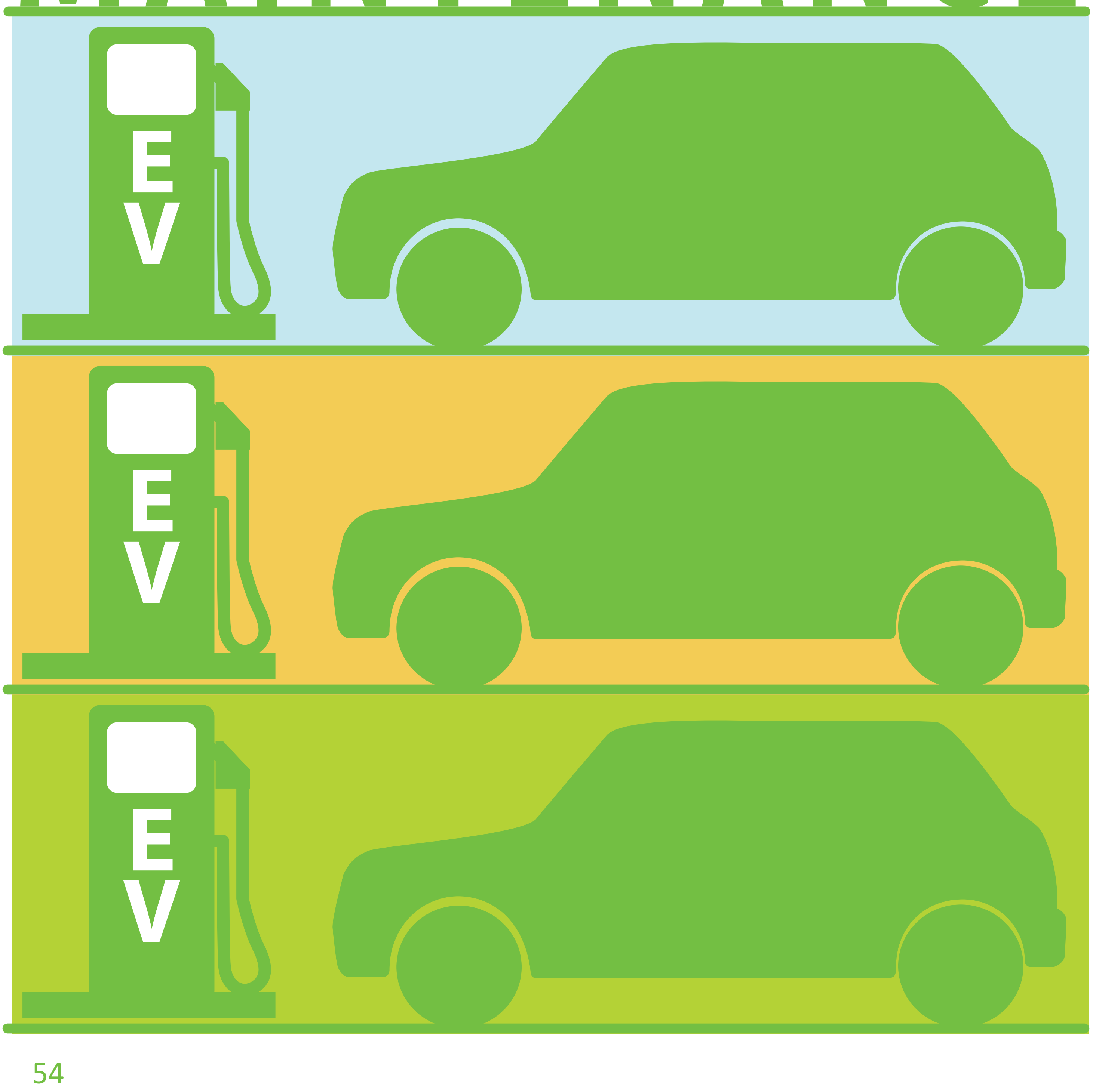
Table 12. Nationally funded EV Infrastructure Deployment Programs.

Project Get Ready http://www.projectgetready.org	The EV Project http://www.theevproject.com	ChargePoint America http://chargepointamerica.com
• Create a dynamic "menu" of strategic plug-in readiness actions including the "business case" for each action. • Provide a web database of American and international plug-in readiness activities. • At least 20 cities • Discuss their lessons learned and best practices, and report these conversations on their website and materials.	• 14,650 Level 2 (220 V) Chargers • 310 DC Fast-Chargers • 40+ Project Partners • 5,700 Nissan LEAF Cars • 2,600 Chevrolet Volt Cars • 1,200 New Jobs by 2012 • 5,500 New Jobs by 2017 • 16 Major Cities	• Sponsored by Coulomb Technologies • 9 selected regions in the US. • 5,000 fully networked Level II (220v) ChargePoint Networked®, home and public/commercial. • Objective is to place charging stations strategically across the metropolitan areas in a variety of settings including public places, private garages, airports, train stations, malls, movie theatres, rental car agencies, restaurants, and other likely locations where owners of electric vehicles park their cars and need to charge.
	Arizona	
	Phoenix, Tucson	
	California	
Los Angeles (Active City in the Plug-in Space), San Francisco Bay Area (Active City in the Plug-in Space)	Los Angeles, San Diego	Los Angeles, Sacramento, San Jose - San Francisco Bay Area
	Colorado	
Greater Denver		
	Washington, D.C.	
	Washington D.C.	Washington D.C.
	Florida	
Tampa Bay, Central Florida		Orlando
	Hawaii	
Hawaii (Active City in the Plug-in Space)		
	Illinois	
Chicago, IL (Active City in the Plug-in Space)		
	Indiana	
Indianapolis Region		
	Kansas, Missouri	
Kansas City		
	Michigan	
		Detroit
	New York	

Table 12. (cont.)

Project Get Ready http://www.projectgetready.org	The EV Project http://www.theevproject.com	ChargePoint America http://chargepointamerica.com
New York City, NY (Active City in the Plug-in Space)		New York City
	North Carolina	
Raleigh & Research Triangle		
	Oregon	
Portland	Portland, Corvallis, Eugene, Salem	
	Rhode Island	
Rhode Island		
	Tennessee	
	Chattanooga, Knoxville, Nashville	
	Texas	
Houston	Houston, Dallas, Fort Worth	Austin
	Washington	
	Seattle	Bellevue-Redmond
	Virginia	
Richmond		
	Canada	
Vancouver, Toronto		
	Europe	
Amsterdam (Active City in the Plug-in Space)		
	Stations; Cars; Other	
Rocky Mountain Institute, The Lemelson Foundation, See New Media, Ohio State University, AAA, HelloElectric.org, Dominion, Power Tagging, Mitsubishi Motors, ECOtality, GE, Park Pod, Nescaum, ESource, UL, Carnegie Mellon, EMPower, Bright Automotive, Coulomb Technologies, Portland State, BPA, CalCars, UC Berkeley, SDGE, ESMT, P&G, UC Davis, Progress Energy, EV-Charge America, Nissan, NREL, Walmart, Sams Club, Plug-In America, Portland General Electric, RIT.	Watt Station; Blink	Coulomb Technologies
	Nissan; Chevrolet; Ford	Ford, Chevrolet and smart USA Chevrolet Volt, Ford Transit Connect, Ford Focus BEV and smart fortwo electric drive
	US DOE, Idaho National Laboratory (INL)	Sponsored by the American Recovery and Reinvestment Act through the Transportation Electrification Initiative administered by the Department of Energy

OPERATIONS & MAINTENANCE



Operations & Maintenance

After EV infrastructure is installed it must be operated and maintained. Who owns the infrastructure determines who will operate and maintain the infrastructure. It is expected that EVSE equipment will be owned by individuals at private residences, by private companies at employment centers, and by municipalities in public locations.

Operation Business Models

Where stations are available for public charging, there are several business models that can be deployed to collect payment while still having the safety features necessary for publicly accessible infrastructure. These models include EV Promotion/Least Involvement, Pay-Parking Infrastructure Reliant, and Third Party Operation.

Bill Boyce, in a 2009 Sacramento Municipal Utility District (SMUD) presentation[40] included additional models: Utility Bundled Service, Turnkey Infrastructure Service Providers, and Centralized/"Gas Station" Operations. Utility Bundled Services make use of existing contractor networks and are bundled with other electrical service to spread cost, while Turnkey Infrastructure Service Providers provide hardware, installation, operations and maintenance, and billing. Finally, the Centralized / "Gas Station" Operations model describes fast charging scenarios. For this study, the Turnkey Infrastructure Service Provider and Third Party Operation models are similar. It is expected that as EV charging system technology becomes more sophisticated there will be other business models that evolve.

EV Promotion/Least Involvement

In this model, the charging stations are purchased and installed, and there is no capability to charge customers who use the station. These stations still employ safety features, and can monitor energy use. If the owner wanted to collect payment, another system, such as a parking pay station, would have to be put in place. This model is analogous to most of the first generation charging stations in place prior to 2010. Overall, the major difference between this and other models, is that these stations are not networked and the only operation cost is electricity.

40 Bill Boyce, S. M. (2009). Electric Vehicle Infrastructure: Market History and Observations. *September 23, 2009 EV Charging Public Meeting.* Sacramento: California Air Resources Board.

Table 13. Business Model 1: EV Promotion

EV Promotion/Least Involvement	
Pro	***Con***
• Minimal operational involvement. Station owner only pays for electricity.	• No possible revenue streams. • Each station will have to be monitored individually. • Less networking advantages, like knowing if in-use at a specific time. • Maintenance and monitoring will be up to the station owner.

Pay-Parking Infrastructure Reliant (pre-pay)

These parking stations rely on existing or new pay-parking infrastructure, such as a centralized pay station. Each customer recieves a code that will operate the station, and customers can pre-pay. The key difference to this model is that it is integrated into a pay-parking system. This model works best in a centralized location where customers are paying to park at a given location.

Table 14. Business Model 2: Pay-Parking Infrastructure Reliant

Pay-Parking Infrastructure Reliant (pre-pay)	
Pro	***Con***
• Integrates with existing pay parking kiosk infrastructure. • Ties into an overall parking management plan/system. • User friendly, especially because most "parkers" are familiar with pay-to-park systems.	• Each station will have to be monitored individually. • Additional, supporting infrastructure is required. • Less networking advantages, like knowing if in-use at a specific time. • Maintenance and monitoring could be up to the organization, but is part of the overall parking program.

Third Party Operation

This is a system of public networked EV charging stations. Each station is part of a networked system that is integrated with a separate third-party operation system. There is a dynamic exchange of information available between each charger and the overall system, including reserving stations, collecting data, and knowing where stations are in use. In this model, many stations are deployed over a large area, and all are operated through the same third-party portal.

Figure 20. Analysis of different available business models for EV payment systems.

TYPE	Charger Cost	Additional Infrastructure requirements?	Installation Cost	Maintenance & Support Fee	Cost of Power	Warranty	Network Fee	Transaction Fee	User fee	Revenue Generating?	Data Collection capabilities/cost
EV Promotion, Least Involvement	Yes	-	Yes	Maybe	Yes	Maybe	-	-	-	-	Each station will have to be monitored individually
Pay-Parking Infrastructure Reliant	Yes	Yes, parking infrastructure	Yes	Maybe	Yes	Maybe	-	Yes	Yes, via parking infrastructure	Yes	Each station will have to be monitored individually
Third Party Operation	Yes	No	Yes	Maybe	Yes	Maybe	Yes	Yes	Yes, via direct payment or subscription fee	Yes	Third Party provides information from charger; included in network fee

Table 15. Business Model 3: Third Party Operation

Third Party Operation	
Pro	***Con***
• Most sophisticated system. • Very user friendly. • Users can do a subscription. • Little operation required by the site owner besides paying the network and maintenance fees. • Stations take credit cards.	• Continuing operations fees and contract renewals to be part of the network. • Existing companies do not share network information, requiring consumers to use multiple networks to locate stations.

Setting the Price to Re-Charge a Vehicle

Figure 20 was created to help guide organizations as they determine what price they should charge customers to use a public charging station. Since it is expected that usage of the stations will be minimal until more vehicles enter the area, it is important for organizations to know at what price they will break even or make a profit. The price varies from a once a month plug-in session

Table 16. What Should Station Owners Charge to Break Even?

Number of Charges per month per station (assuming 4hrs per charge)	Cost of Electricity (per kwh)	Annual Max Energy Used	Annual Estimated Electricity Cost	Minimum Fee Charged to Break Even	Annual Cost
1	$0.12	346	$41.47	$23.46	$281.47
5	$0.12	1,728	$207.36	$7.46	$447.36
10	$0.12	3,456	$414.72	$5.46	$654.72
15	$0.12	5,184	$622.08	$4.79	$862.08
20	$0.12	6,912	$829.44	$4.46	$1,069.44
25	$0.12	8,640	$1,036.80	$4.26	$1,276.80
30	$0.12	10,368	$1,244.16	$4.12	$1,484.16
35	$0.12	12,096	$1,451.52	$4.03	$1,691.52
40	$0.12	13,824	$1,658.88	$3.96	$1,898.88
45	$0.12	15,552	$1,866.24	$3.90	$2,106.24
50	$0.12	17,280	$2,073.60	$3.86	$2,313.60
55	$0.12	19,008	$2,280.96	$3.82	$2,520.96
60	$0.12	20,736	$2,488.32	$3.79	$2,728.32
65	$0.12	22,464	$2,695.68	$3.76	$2,935.68
70	$0.12	24,192	$2,903.04	$3.74	$3,143.04
75	$0.12	25,920	$3,110.40	$3.72	$3,350.40
80	$0.12	27,648	$3,317.76	$3.71	$3,557.76
85	$0.12	29,376	$3,525.12	$3.69	$3,765.12
90	$0.12	31,104	$3,732.48	$3.68	$3,972.48
95	$0.12	32,832	$3,939.84	$3.67	$4,179.84
100	$0.12	34,560	$4,147.20	$3.66	$4,387.20
110	$0.12	38,016	$4,561.92	$3.64	$4,801.92
120	$0.12	41,472	$4,976.64	$3.62	$5,216.64
130	$0.12	44,928	$5,391.36	$3.61	$5,631.36
140	$0.12	48,384	$5,806.08	$3.60	$6,046.08
150	$0.12	51,840	$6,220.80	$3.59	$6,460.80
160	$0.12	55,296	$6,635.52	$3.58	$6,875.52
170	$0.12	58,752	$7,050.24	$3.57	$7,290.24
180 *	$0.12	62,208	$7,464.96	$3.57	$7,704.96

** 180 max would be 6 per day assuming 24 hours of non-stop charging.*

Assumptions:

Annual Blink Networking Fees: $240.00

Blink Electrical Draw (kWh): 7.2

at $23.46 to the station being used six times a day at $3.57. Figure 21 graphically displays this information as well. It should be noted that these tables take into account the Blink specific networking fee of $20/month, and the Blink electric draw of 7.2kWh.

Charging System Maintenance

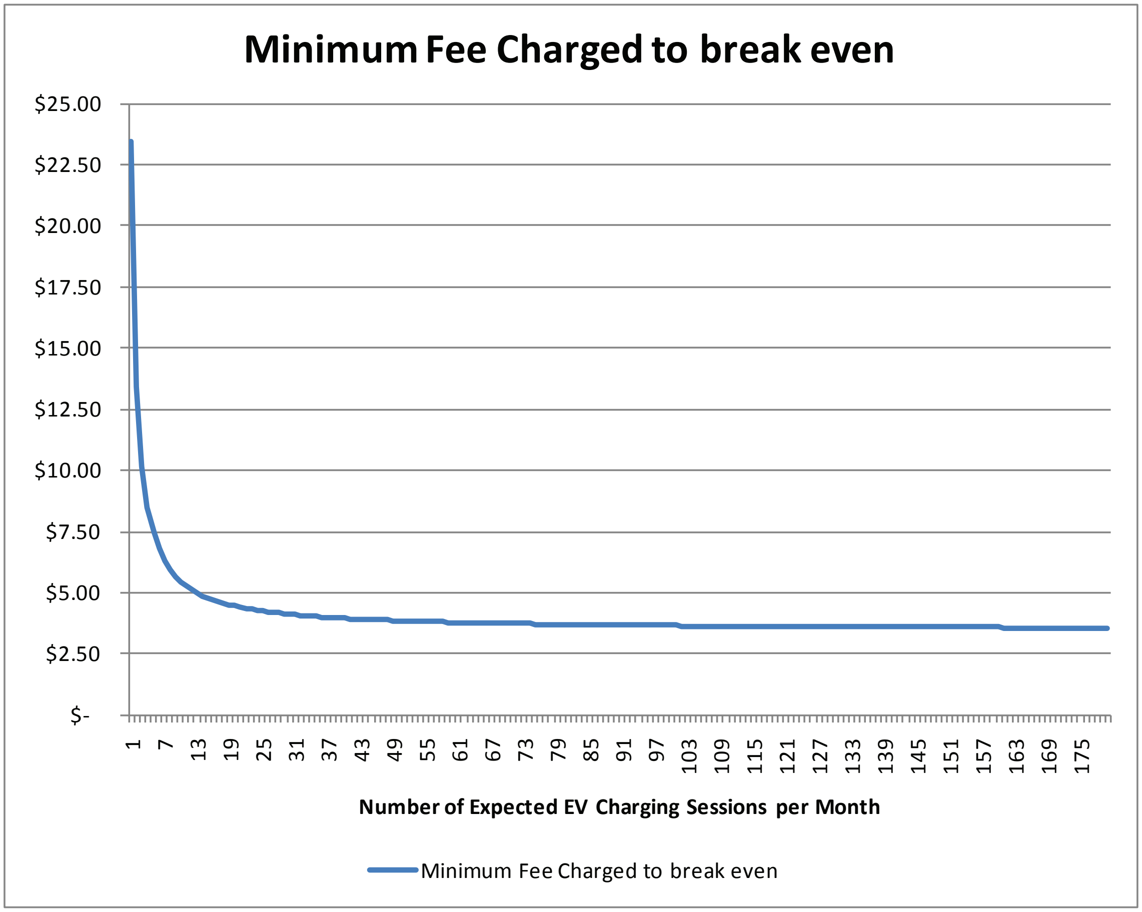
The cost to maintain the charging stations should be minimal, and are similar to maintaining other electrical systems in a household. These stations will be required to be repaired on site by a qualified electrician or EVSE certified contractor. Certified contractor programs are being developed by different charging station manufacturers who are in turn training local electricians, through groups like IBEW.

Several organizations in the Monterey Bay Area voiced concern that public EV charging stations could be subject to vandalism, mainly by cutting the cord that connects the station to the vehicle, or by users trying to disassemble the stations for copper conduit. This would be an additional repair cost, but like any other piece of infrastructure in the public realm, there is always a risk of vandalism.

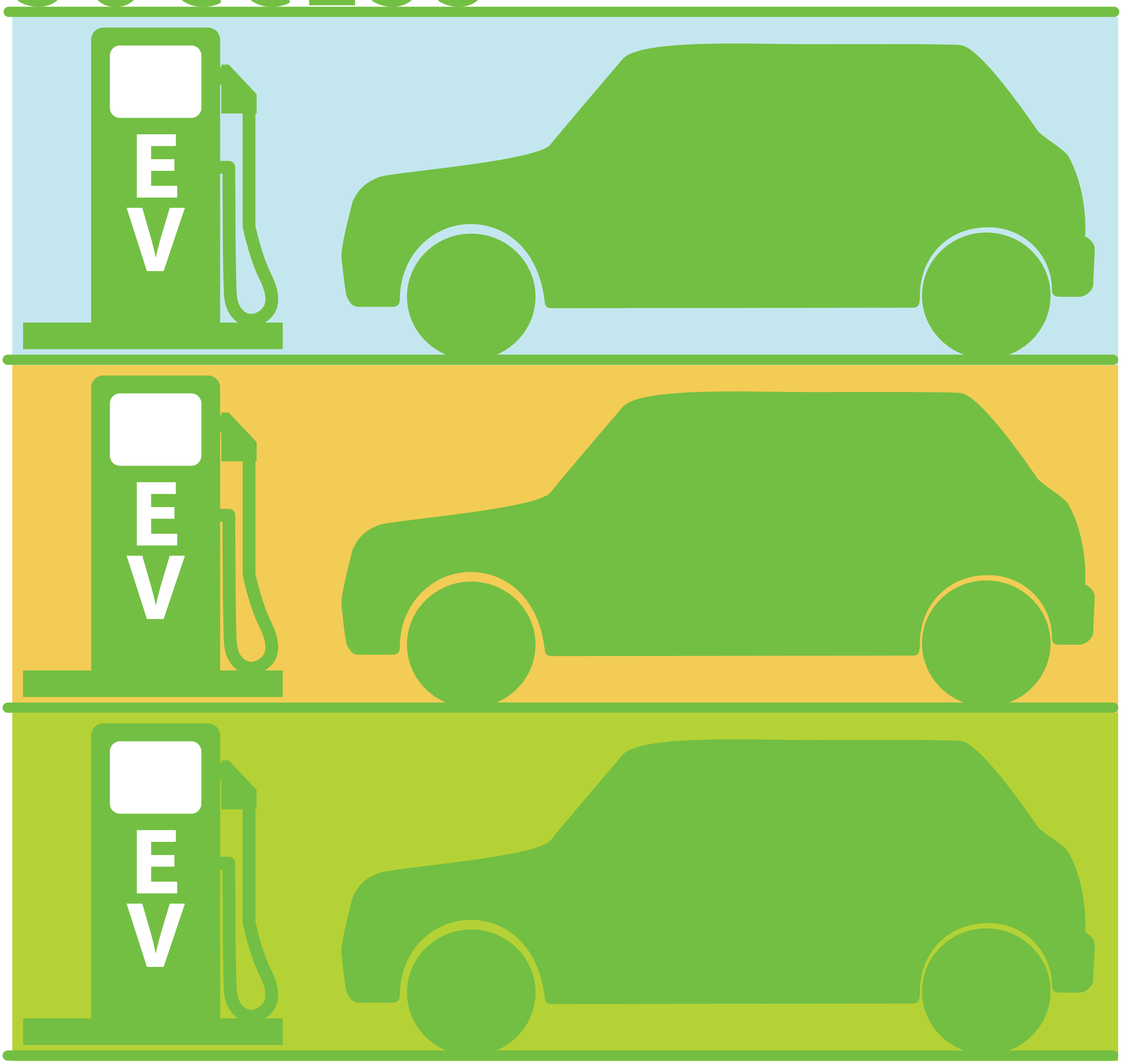
Vehicle Maintenance

It is expected that EVs will be less expensive to maintain than internal combustion engine vehicles. Maintenance is expected to mainly be performed by automakers, as is the current trend. However, like the certified contractors who are learning to maintain the charging stations, automakers are developing programs to train mechanics to maintain EVs as well.

Figure 21. What Should Organizations Charge to Break Even?



NEEDS & EXISTING RESOURCES FOR EV SUCCESS



Needs and Existing Resources for EV Success

In order for the wide adoption of EVs to occur in the Monterey Bay Area, there will need to be policies, incentives, training and possibly investment in companies producing EV related technologies. The following outlines the various resources, incentives, and needs.

Federal & State Incentives

Federal and state credits have been put in place to reduce the cost of purchasing EVs and charging equipment. A huge barrier to potential EV owners and the placement of charging stations is the cost. In 2011, a California resident purchasing a new EV was eligible for up to $7,500 in federal tax credits and up to $2,500 in state assistance. These combined made it more feasible for buyers of the Nissan Leaf ($34,000) and the Chevrolet Volt ($41,000) to consider an EV or PHEV as their next car to purchase.

For the most up to date list of State and Federal incentives, visit:

- http://www.pluginamerica.org/incentives
- http://www.afdc.energy.gov/afdc/laws/fed_summary
- http://www.afdc.energy.gov/afdc/laws/state?p=state_summary&state=CA&search_button=Go

Municipal Policies and Codes

The adoption and widespread use of EVs will initially be contingent upon local policies that encourage and easily permit the placement of EVSE equipment, and incentives for drivers (such as driving in the carpool lane, or priority parking). As stated in the *Pilot Project* section, there is a need for streamlined permitting processes. MBEVA has been working with the local building officials to streamline the residential permitting process. Next, they will focus on the commercial property permitting process, and then the public right-of-way permitting process. The goal of streamlining these processes is to have standards in place to minimize the chance of having to re-do a site plan or other portions of the application.

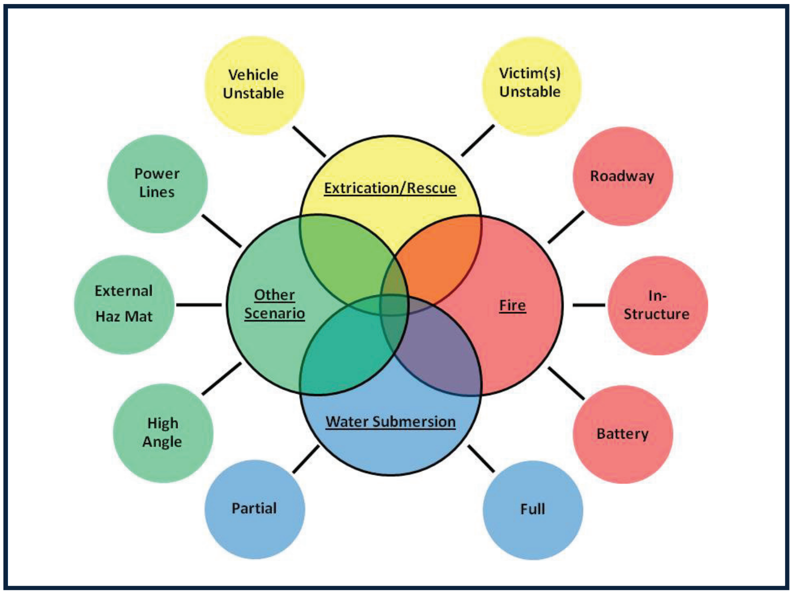
As more charging stations are installed collaboration with PG&E will be critical. New charging stations put an increased demand on the grid and therefore on local transformers. Coordinating with PG&E is the only way to ensure that the demand and grid infrastructure improvements can be managed is such as way that the chance of overloading the grid is minimized or eliminated.

Streamlined EV permitting and promotional policies in other cities are listed in Table 17. These policies may be used as guide for other cities in implementing policies to encourage EV adoption.

Table 17. Examples of Munipal Policies to Promote Electric Vehicles

City	Policy
San Francisco, CA	Preparing an Electric Vehicle-ready checklist for their website to help residents easily navigate the permitting process.
Raleigh, NC	Developed a clear step-by-step process and created an educational video, available online, to help residents understand the requirements for installing an electric vehicle charging station. Developing educational programs in cooperation with a local community college to train electrical contractors and inspectors. Advocates on behalf of electric owners to encourage major employers to provide electric vehicle charging stations.
Austin, TX	Home charging incentives to residents who buy or lease a plug-in electric vehicle.
Houston, TX ***Seattle, WA***	Created consumer demand overlay maps to illustrate where electric vehicle charging stations will be needed in the future.
Vancouver, Canada	Installed charging stations in City owned parking lots to encourage residents to become electric vehicle owners.
Philadelphia, PA	In partnership with New York City and Boston, Philadelphia hired an Electric Vehicle Policy Coordinator to examine the permitting processes for the City and suggest opportunities to make them more efficient. The City provides $500 alternative fuel rebates to residents who purchase electric vehicles.

Figure 22. Example of Response Concepts from the National Fire Protection Association.



Emergency Response Training

Since the technology of an EV is different from an internal-combustion engine, understanding of EV technology by emergency response teams is critical to prevent electric shock and other hazards. For example, when assessing a vehicle, the ignition can be off, but the motor can still be running. Training emergency response teams to know about these different technologies is essential as more vehicles are released into the market. Currently, the National Fire Protection Association is taking measures to help educate and train fire fighters and other response teams on EV technology. More information can be found at:

http://www.evsafetytraining.org

Battery Recycling

According to the Battery Council, 95% of all battery lead is recycled. For lead-acid batteries, this helps keep the cost low, and helps perpetuate environmentally friendly practices[41]. There are approximately fifteen battery recycling locations in North America. The capacity and locations of these recycling plants should expanded as mobility sources rely on batteries instead of combustible fuel. In the US, battery recycling and solid waste in general is regulated by the Resource Conservation and Recovery Act (RCRA).

Local Electric Vehicle Related Companies

Zero Motorcycles, Scotts Valley, CA

Started in Santa Cruz in 2006, Zero Motorcycles produces high performance electric motorcycles that utilize the patented Z-Force™ electric powertrain. Currently, there are five electric models specializing in dirt biking, street riding and dual sport categories. These are the ZERO DS™ (dual sport), ZERO S™ (street), ZERO XU™ (urban cross), ZERO MX™ (motocross), and the ZERO FX™ (trail). The electric motorcycles are also able to charge utilizing the standard 110V and 220V inputs that equate to Level 1 and Level 2 charging and have J1772 and CHAdeMO DC fast charge optional accessories. For more information visit:

http://www.zeromotorcycles.com/

Green Vehicles, Salinas, CA

While Green Vehicles closed its doors in the Summer of 2011, it is important to note its presence in the Monterey Bay Area, as this area does have the ability to attract green jobs. Started in 2008, the Salinas headquartered company built

41 (ETC), E. T., & Americas, E. V. (1995). Electric Vehicle Community Market Launch Manual: A Guide to Prepare Your Community for Electric Vehicles. U.S. Department of Energy, U.S. Department of Transportation.

Local Support Groups

Currently, in the Monterey Bay Area there are many resources for EV drivers, municipalities, private companies, and the public at large. Below are several resources that exist as of September 2011.

Monterey Bay Electric Vehicle Alliance (MBEVA)

Contacts: Sharon Sarris, slsarris@greenfuseenergy.com, Kristi Markey, MarkeyKA@co.monterey.ca.us

www.mbeva.org

The Monterey Bay Electric Vehicle Alliance (MBEVA) is a California grass-roots, public-private partnership comprised of diverse stakeholders in the tri-county region of Monterey, San Benito and Santa Cruz counties whose overall goal is to help the region prepare for the wide variety of electric vehicles coming to market in the next few years. MBEVA was formed in March 2009 at the Monterey College of Law in Seaside and since then has held regular general meetings hosted by the IBEW Local 234 in Castroville.

Currently, the MBEVA goals include:

- Increase funding for, and installation of, publicly-available EV charging stations
- Ensure local governments adopt supportive policies, including streamlined EV charging station permit processing and increased number of EVs in their fleets
- Increase public awareness about plug-in electric and hybrid electric vehicles
- Increase training of the local workforce for green jobs related to the EV industry, and attract electric vehicle businesses to the region.

It should also be noted that MBEVA has spearheaded most of the grants to bring EV charging stations to the Monterey Bay Area, including the initial grant writing for this report. The collaboration of MBEVA with both public and private entities has made it one of the leading EV community organizations in the country, and other regions are looking to MBEVAs as they prepare their own communities for EVs.

Electric Auto Association, Central Coast Chapter

Contact: Will Becket, will@becketts.ws

http://www.becketts.ws/eaa/

The Electric Auto Association (EAA) is a national non-profit organization,501(c)(3), formed in 1967 to promote the use of electrical vehicles as a viable transportation alternative that is efficient, economical and ecological.

Central Coast Clean Cities Coalition, San Luis Obispo, CA

Contact: Melissa Guise, mguise@co.slo.ca.us

http://www.c-5.org/

Greater Bay Area EV Corridor

contact: Richard Schorske, Ex. Director, EV Communities Alliance

richards@dsnetwork.org

http://www.energy.ca.gov/2010-ALT-1/documents/2010-10-19_workshop/presentations/Greater_Bay_Area_EV_Corridor_Project_Overview_2010-10_18.pdf

Plug-In America

http://www.pluginamerica.org/

Figure 23. Webpage for www.mbeva.org. This webpage was put together by Mike Zeller.

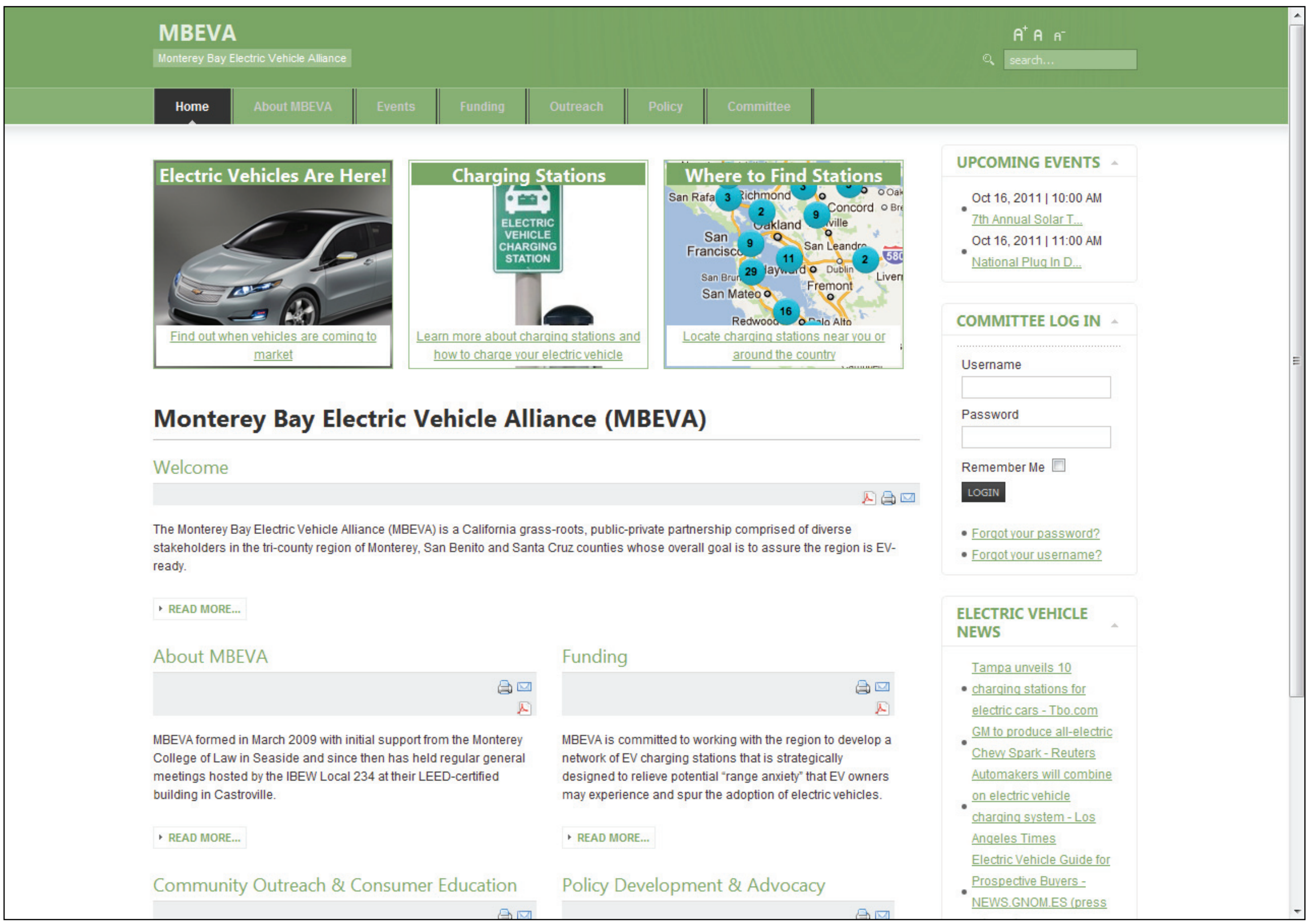
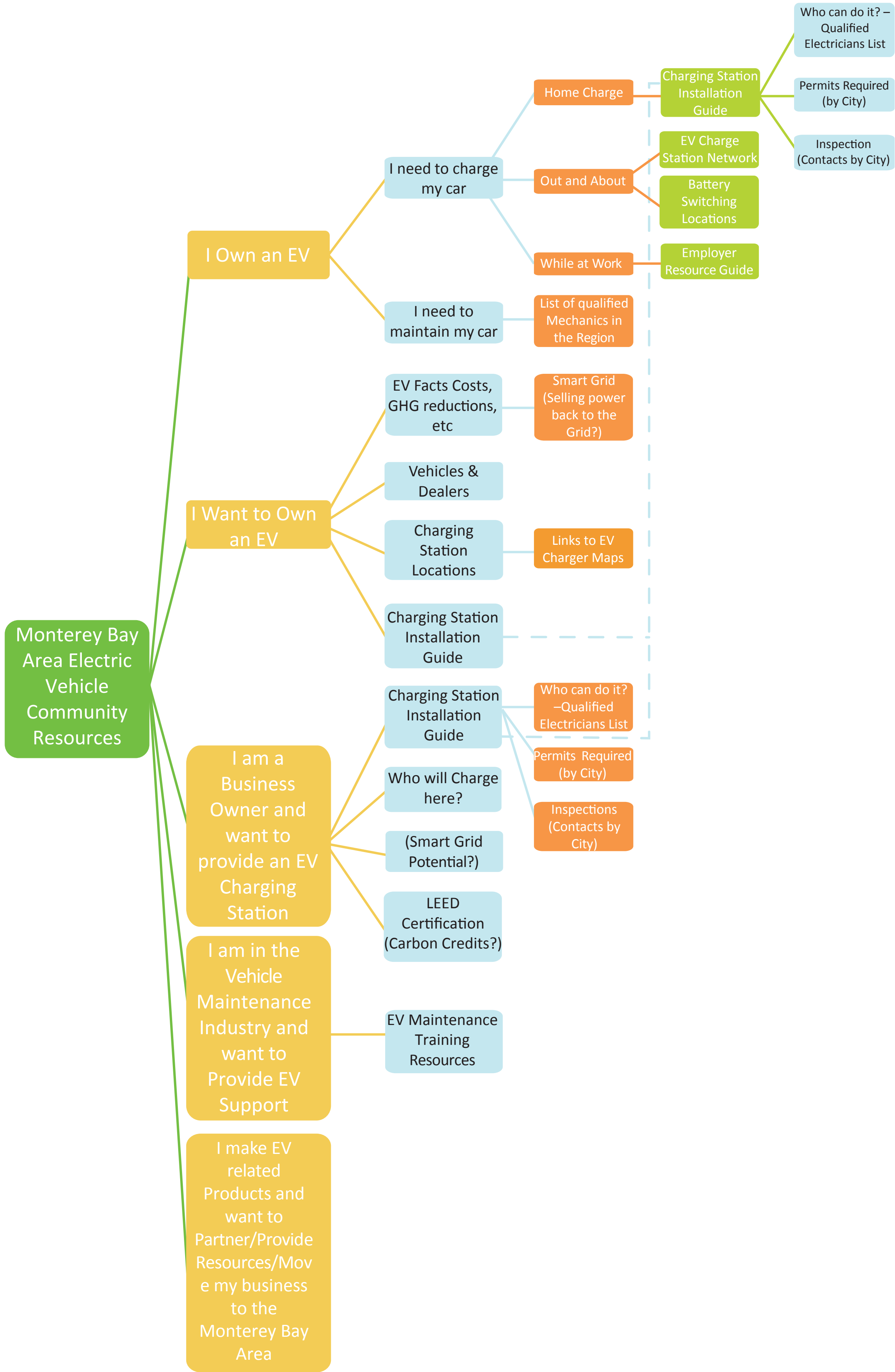
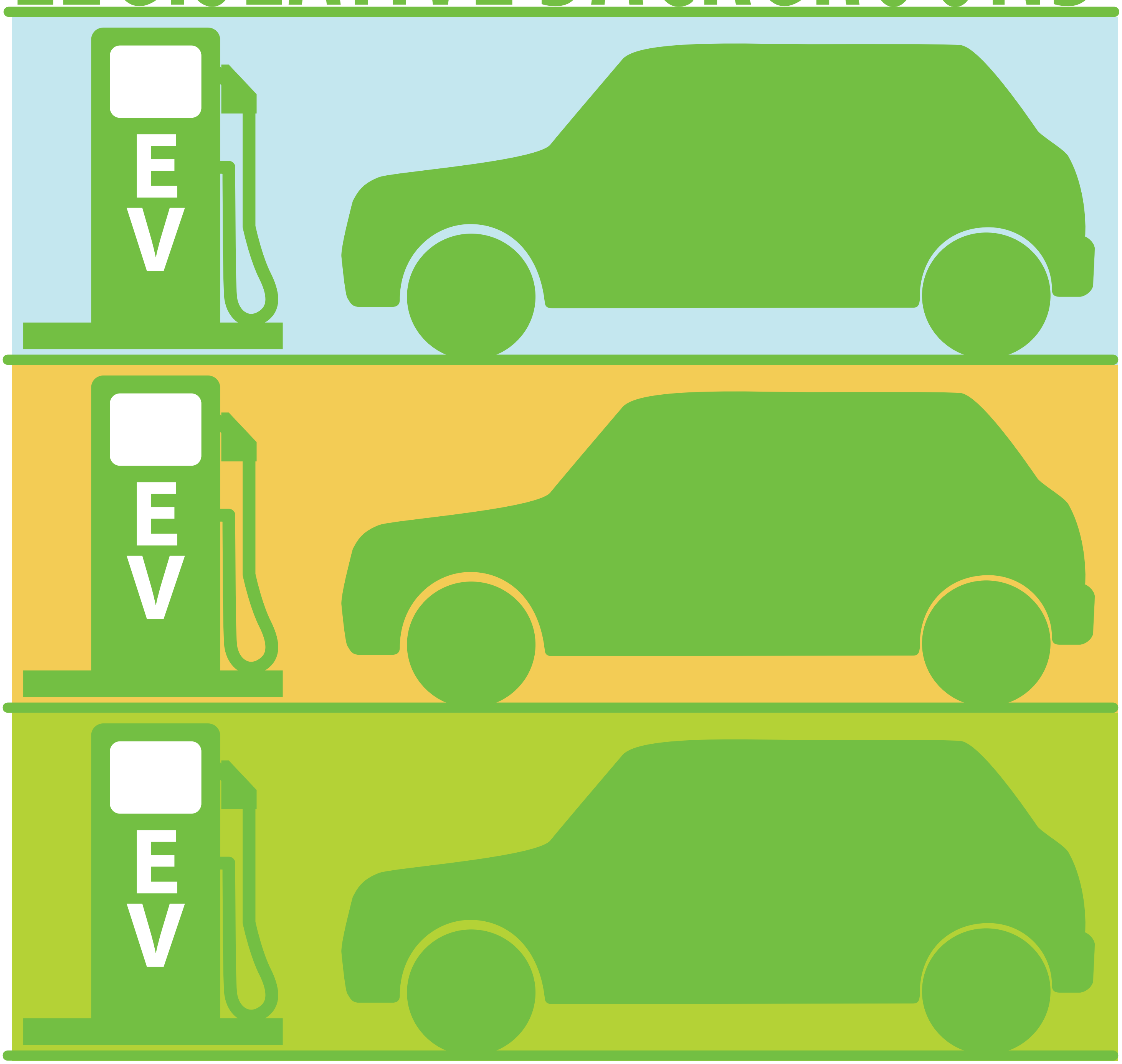


Figure 24. Potential Structure for a Community Outreach Website for EVs.



LEGISLATIVE BACKGROUND



Legislative Background

State Legislation

The *California Global Warming Solutions Act of 2006* (AB 32) requires the state to reduce emissions to 1990 levels by 2020, and 80% below 1990 levels by 2050[42]. In order to do this, the *California Climate Change Scoping Plan*[43], adopted in 2008, provides the overarching framework for achieving the goals set forth in 2006. This framework has six key elements, including the Zero Emissions Vehicle Program and Low Carbon Fuel Standards (LCFS), and expects that as much as 1/3 of the fleet in California by 2030 will need to be made up of battery-electric vehicles, plug-in hybrids and fuel cell vehicles to help meet the goals of AB 32.

Table 18. Key Elements to meet AB 32.

Expanding and strengthening existing energy efficiency programs as well as building and appliance standards.
Achieving a statewide renewable energy mix of 33 percent.
Developing a California cap-and-trade program that links with other Western Climate Initiative partner programs to create a regional market system.
Establishing targets for transportation-related greenhouse gas emissions for regions throughout California and pursuing policies and incentives to achieve those targets.**
Adopting and implementing measures pursuant to existing State laws and policies, including California's clean car standards, goods movement measures, and the Low Carbon Fuel Standard.**
Creating targeted fees, including a public goods charge on water use, fees on high global warming potential gases, and a fee to fund the administrative costs of the State's long-term commitment to AB 32 implementation.

**Pertains to the transportation sector.

Source: CARB 2008[44].

42 Executive Order S-3-05.

43 California Air Resources Board. (2008). *Climate Change Scoping Plan: A Framework for Change.* Sacramento: State of California.

44 California Air Resources Board. (2008). *Climate Change Scoping Plan: A Framework for Change.* Sacramento: State of California.

Table 19. The Climate Change Scoping Plan Recommended Mitigation Measures.

Recommended Reduction Measures	Reductions Counted Towards 2020 Target ($MMTCO_2E$)	
Estimated Reductions Resulting From the Combination of Cap-and-trade Program and Complementary Measures		146.7
California Light-Duty Vehicle Greenhouse Gas Standards • Implement Pavley standards • Develop Pavley II light-duty vehicle standards	31.7	
Energy Efficiency • Increase CHP generation by 30,000 GWh • Building/appliance efficiency, new programs, etc. • Solar Water Heating (AB 1470 goal)	26.3	
Renewables Portfolio Standard (33% by 2020)	21.3	
Low Carbon Fuel Standard	15	
Regional Transportation-Related GHG Targets	5	
Vehicle Efficiency Measures	4.5	
Goods Movement • Ship Electrification at Ports • System-Wide Efficiency Improvements	3.7	
Million Solar Roofs	2.1	
Medium/Heavy Duty Vehicles • Heavy-Duty Vehicle Greenhouse Gas Emission Reduction (Aerodynamic Efficiency) • Medium- and Heavy-Duty Vehicle Hybridization	1.4	
High Speed Rail	1.0	
Industrial Measures (for sources covered under cap-and-trade program) • Refinery Measures • Energy Efficiency & Co-Benefits Audits	0.3	
Additional Reductions Necessary to Achieve the Cap	34.4	
ESTIMATED REDUCTIONS FROM UNCAPPED SOURCES/SECTORS		***27.3***
High Global Warming Potential Gas Measures	20.2	
Sustainable Forests	5.0	
Industrial Measures (for sources not covered under cap and trade program) • Oil and Gas Extraction and Transmission	1.1	
Recycling and Waste (landfill methane capture)	1.0	
TOTAL REDUCTIONS COUNTED TOWARDS 2020 TARGET		***174***

Source: CARB 2008.

Electrification of the transportation sector is extremely important to reduce the emissions related to the transportation sector. The California Light-Duty Vehicle Greenhouse Gas Standards (commonly referred to as Pavley I and II), the Renewables Portfolio Standard, the Low Carbon Fuel Standard, and the Vehicle Efficiency Measures all contribute modifications of the mix of vehicles in the light duty car and truck fleet in California, and how they are powered. The remaining GHG emission reductions from the transportation sector will be met through SB 375, which seeks to reduce the overall VMT of each region by coordinating land use and transportation planning. The greenhouse gas savings achieved by EVs cannot be used to meet SB 375 goals as this component of the climate change legislation is concerned with VMT.

California Light-Duty Vehicle Greenhouse Gas Standards

The three following programs are being employed to address GHG emissions from passenger vehicles. Passenger vehicle GHG emissions account for approximately 30 percent of California's total emissions. This three-pronged strategy seeks to reduce GHG from vehicles, reduce the carbon content of the fuel the vehicles burn, and reduce the number of miles these vehicles travel.[45]

Pavley Bill I & II (California AB 1493)

The Pavley bill increases the fuel economy standards for new passenger vehicles sold in California to 37 miles per gallon (mpg) by 2016. By increasing the fuel efficiency standards for new vehicles, the overall fuel efficiency of the entire vehicle "fleet" will also be increased. This program is currently being adopted by other states in the US; however, they must also receive waivers from the Environmental Protection Agency (EPA) for implementation. In 2002, Pavley I was originally passed by the legislature, however, the regulations were not employed until 2009 after EPA granted California the authority to implement their own GHG emission reduction standards for new passenger cars, light trucks and SUVs.

Pavley I and II go above and beyond the US Corporate Average Fuel Economy standards (CAFE), and hence, an exemption from EPA was required. The latest CAFE standards require auto manufacturers to have cars exceed 27.5 mpg and light trucks exceed 20.7 mpg. These are still considered some of the lowest fleet average fuel economy standards amongst first world nations.

45 California Air Resources Board. (2008). *Climate Change Scoping Plan: A Framework for Change.* Sacramento: State of California.

The Energy Independence and Security Act of 2007 require auto makers to increase their fleet efficiency to 35 mpg by 2020, four years behind the Pavley standards. In preparation for meeting these standards, and avoiding paying penalties for not meeting CAFE standards, many auto makers are including hybrid or electric vehicles (EVs) in their fleet mix.

While not meeting CAFE standards has always required auto makers to pay a fee, Pavley will utilize a fee-bate program, combining rebates for low emitting vehicles and fees for high-emitting vehicles.

Zero Emissions Vehicle Program (ZEV)

The ZEV program requires the placement of hundreds of vehicles that produce zero emissions, which includes hydrogen fuel cell and battery electric vehicles and thousands of near-zero emission vehicles (plug-in hybrids, conventional hybrids) by 2012, and even more by 2015.

Planning for the infrastructure needs to facilitate the charging requirements for these vehicles is the essence of this plan. While it is recognized that the ZEV program will not supply all the EVs and PHEVs that will require charging infrastructure, this program will speed the adoption of ZEV vehicles.

Air Quality Improvement Program/Alternative and Renewable Fuel and Vehicle Technology Program (AB 118)

AB 118 authorizes CARB to administer the Air Quality Improvement Program, which supplies approximately $50 million per year in grants to fund clean vehicle and equipment projects, and the CEC to spend up to $120 million a year (from 2008 – 2015) to "develop, demonstrate and deploy innovative technologies to transform California's fuel and vehicle types." In 2010, the Monterey Bay Electric Vehicle Alliance (MBEVA) partnered with groups in the San Francisco Bay Area in an application for EV charging stations from this fund. In addition, Zero Motorcycles and Green Vehicles, two electric vehicle manufacturers in the Monterey Bay Area, also received funds as part of AB 118 programs.

Renewables Portfolio Standard (33% by 2020)

The CEC estimated in 2008 that approximately 12 percent of California's retail electric load was being met with renewable sources, including wind, solar, hydroelectric, geothermal, biomass, anaerobic digestion, and landfill gas. Investor owned utilities (IOUs) are obligated by SB 107 to increase their share of renewables in their electricity portfolios to 20 percent by 2010, and publicly owned utilities (POUs) are encouraged but not required to do the same. However, several POUs in the state have already adopted policies to achieve 20 percent or greater by 2010 or 2011.

Increasing the amount of renewable energy sources tied to the grid will be especially important for EVs – the type of electrical power they utilize is essentially the amount of GHGs produced per mile. Therefore, an EV that utilizes electricity derived from solar is essentially "cleaner" than an EV that uses electricity derived from burning coal, even though neither car produces any direct tailpipe emissions.

Low Carbon Fuel Standards (LCFS)

The Low Carbon Fuel Standards (LCFS) pushes fuel manufacturers to produce and market fuels that are less carbon intensive. Specifically, AB 32 calls for a 10 percent reduction in the carbon intensity of California's transportation fuels by 2020.

Regional Transportation-Related GHG Targets

SB 375, adopted in 2008, requires CARB to set regional transportation-related GHG targets to reduce emissions from passenger vehicles. Each of California's 18 metropolitan planning organizations (MPOs) have been given target greenhouse gas reductions for their region. AMBAG is the Monterey Bay Area MPO, and as such, the regional target is a 0 percent change in per capita GHG emissions by 2020, and a -5 percent per capita decrease by 2035.

Each MPO must demonstrate that they will be able to meet their target through modeling for the projects in their long range transportation plan. This will determine which transportation projects within the region are included in the long range transportation plan. Principally, the way to achieve the targets would be to reduce per capita vehicle miles traveled (VMT) by growing in a more sustainable manner. Please see AMBAG's *Envisioning the Monterey Bay Area: a Blueprint for Sustainable Growth and Smart Infrastructure* for more information about SB 375 and the related Sustainable Communities Strategy (SCS).

Vehicle Efficiency

This program seeks to reduce GHG emissions by ensuring that vehicles are operating at their most efficient levels, for example ensuring that tires are properly inflated, and reducing the need for air conditioning. These measures will also enable EVs to drive for a longer period of time before having to be recharged.

Figure 25.

Potential Charging Areas Based on Vehicle Activity Intensity

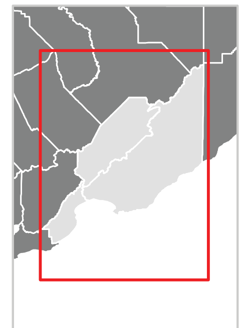
Date: June 2013
Project Name: Electric Vehicle Infrastructure Plan
Created By: Jason Adelaars, Intern

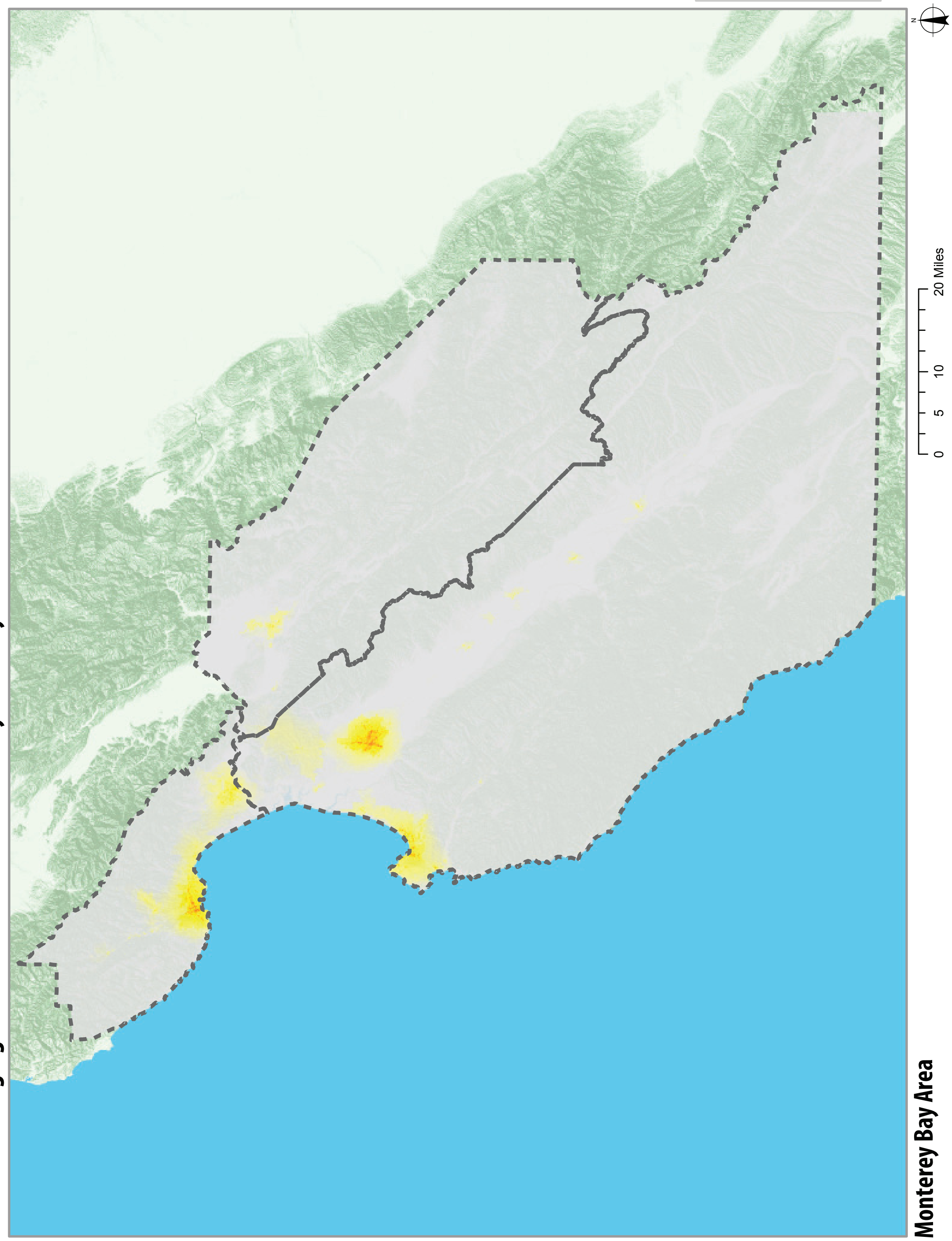
Data Sources:
EV Charger Maps;
AMBAG

Legend

Vehicle Activity Index
High
Low

County Boundaries





Monterey Bay Area

Figure 26.

Potential Charging Areas Based on Vehicle Activity Intensity

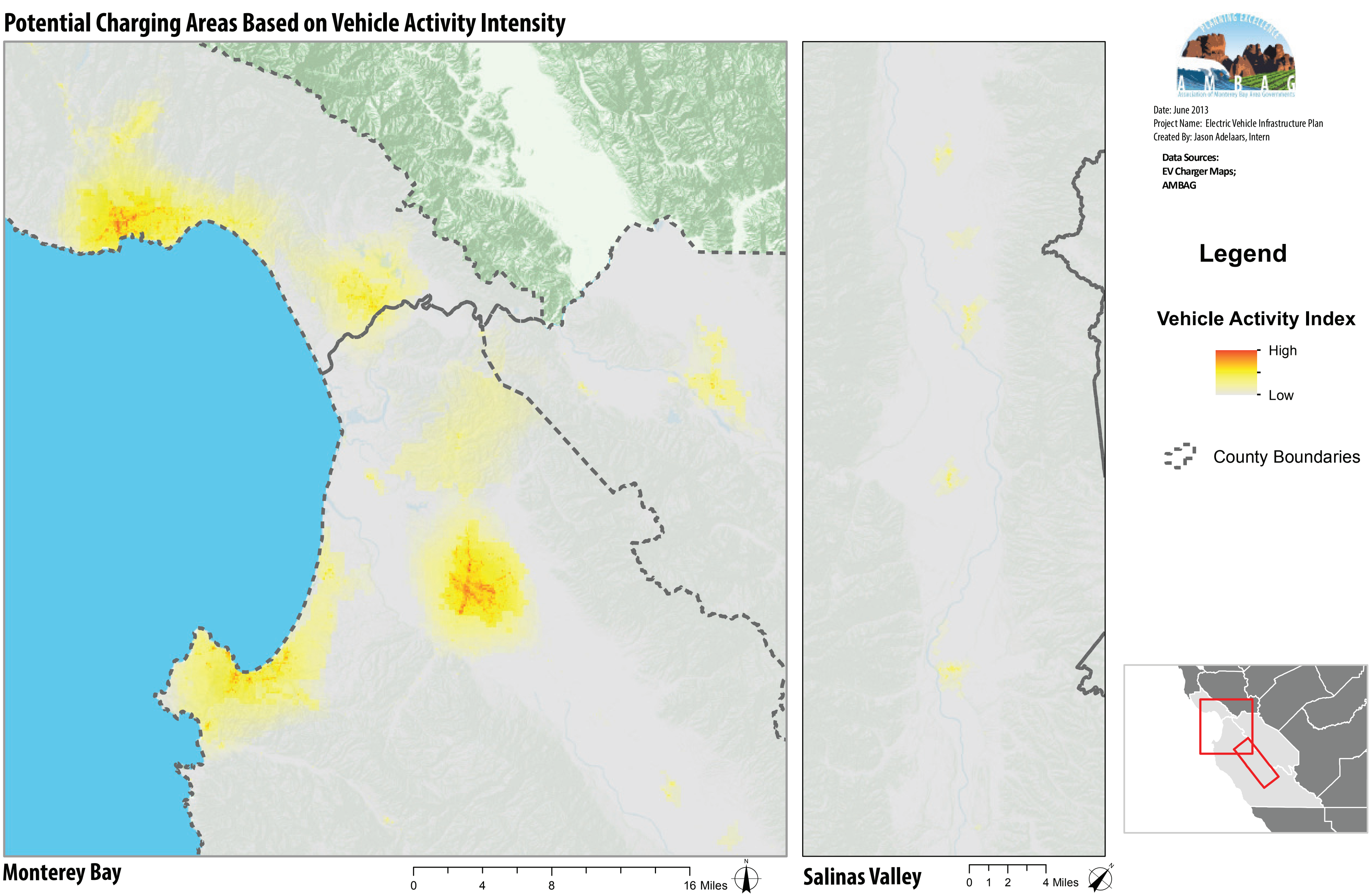


Figure 27.

Potential Charging Areas Based on Vehicle Activity Intensity

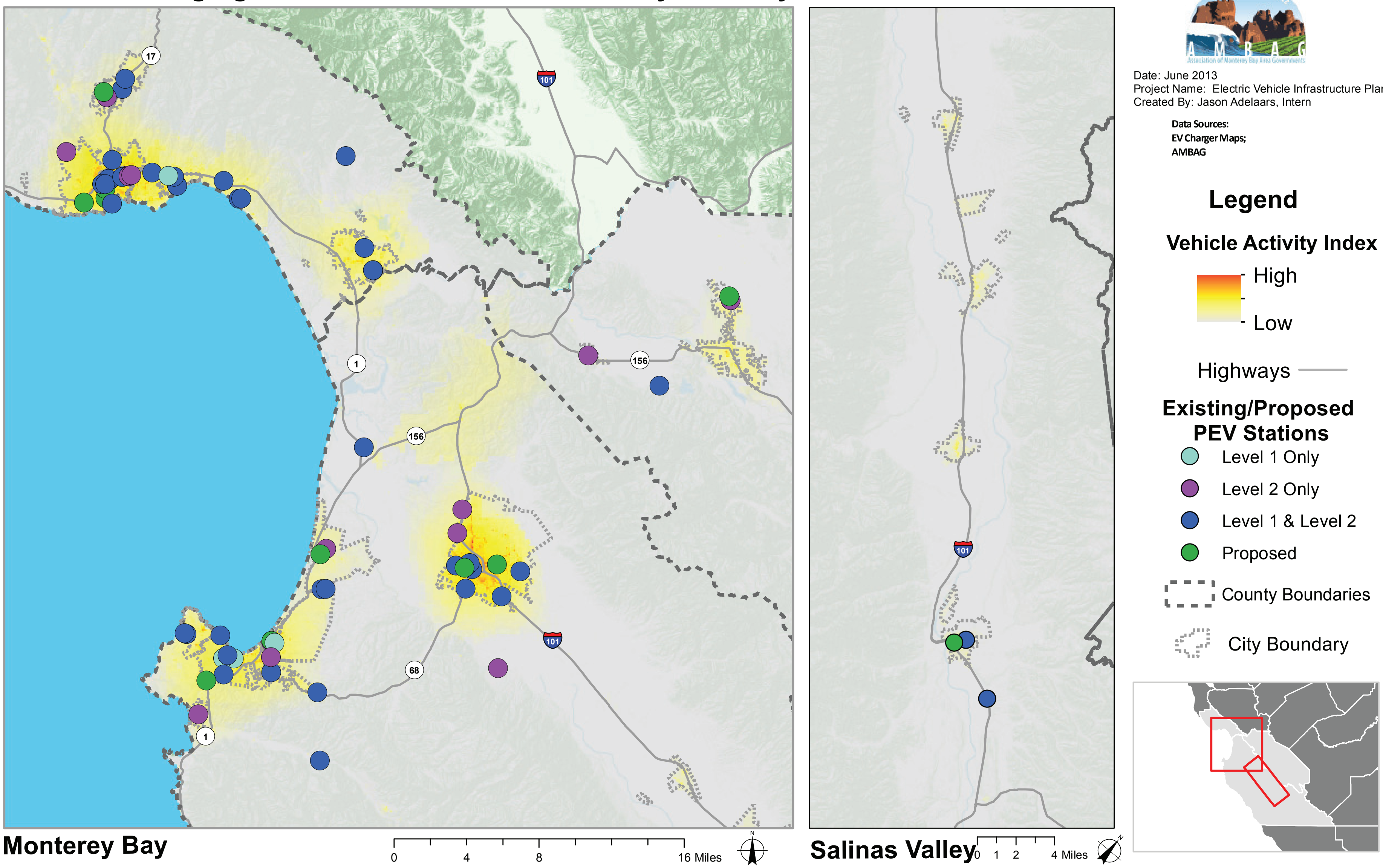


Figure 28.

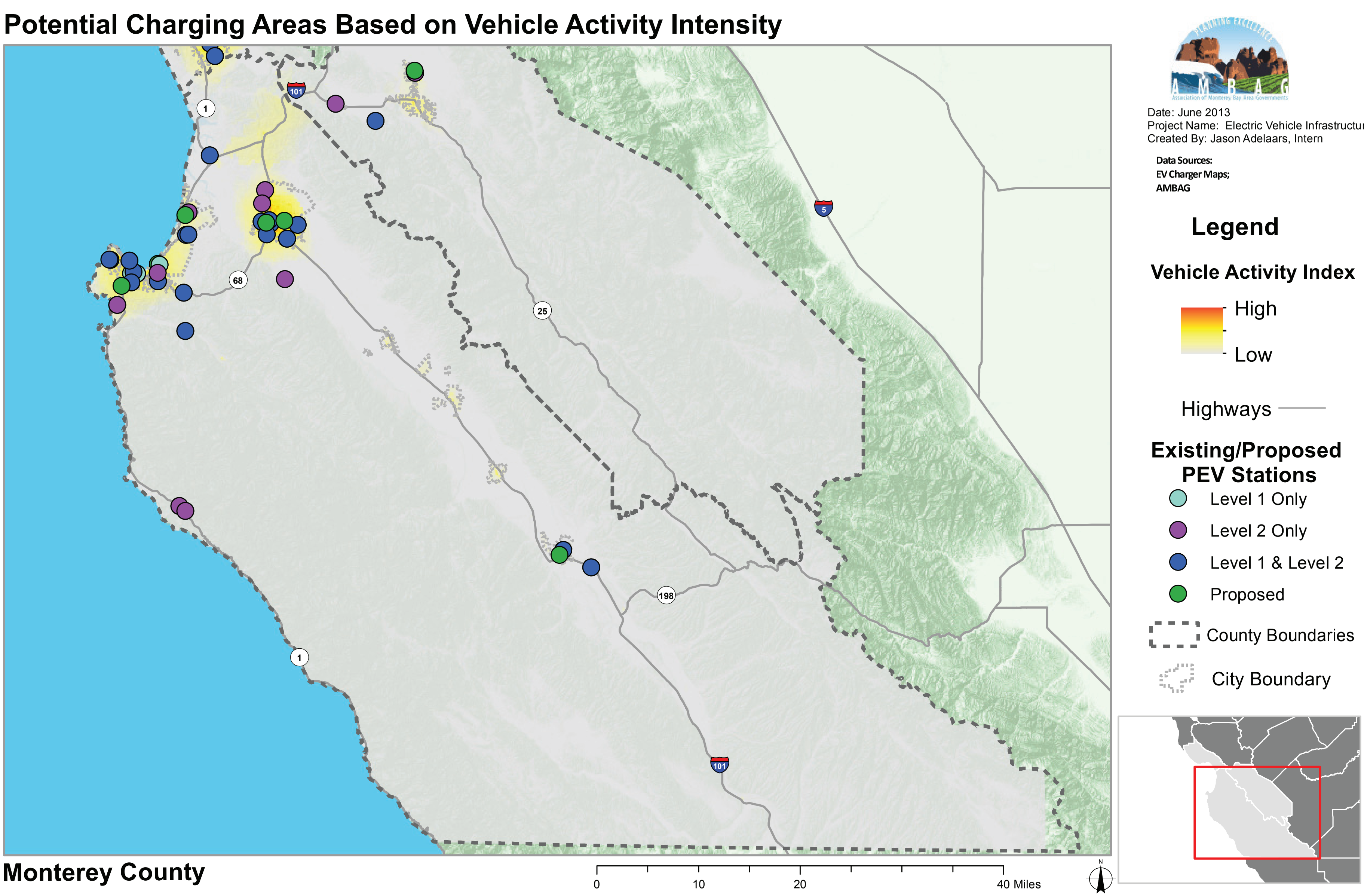
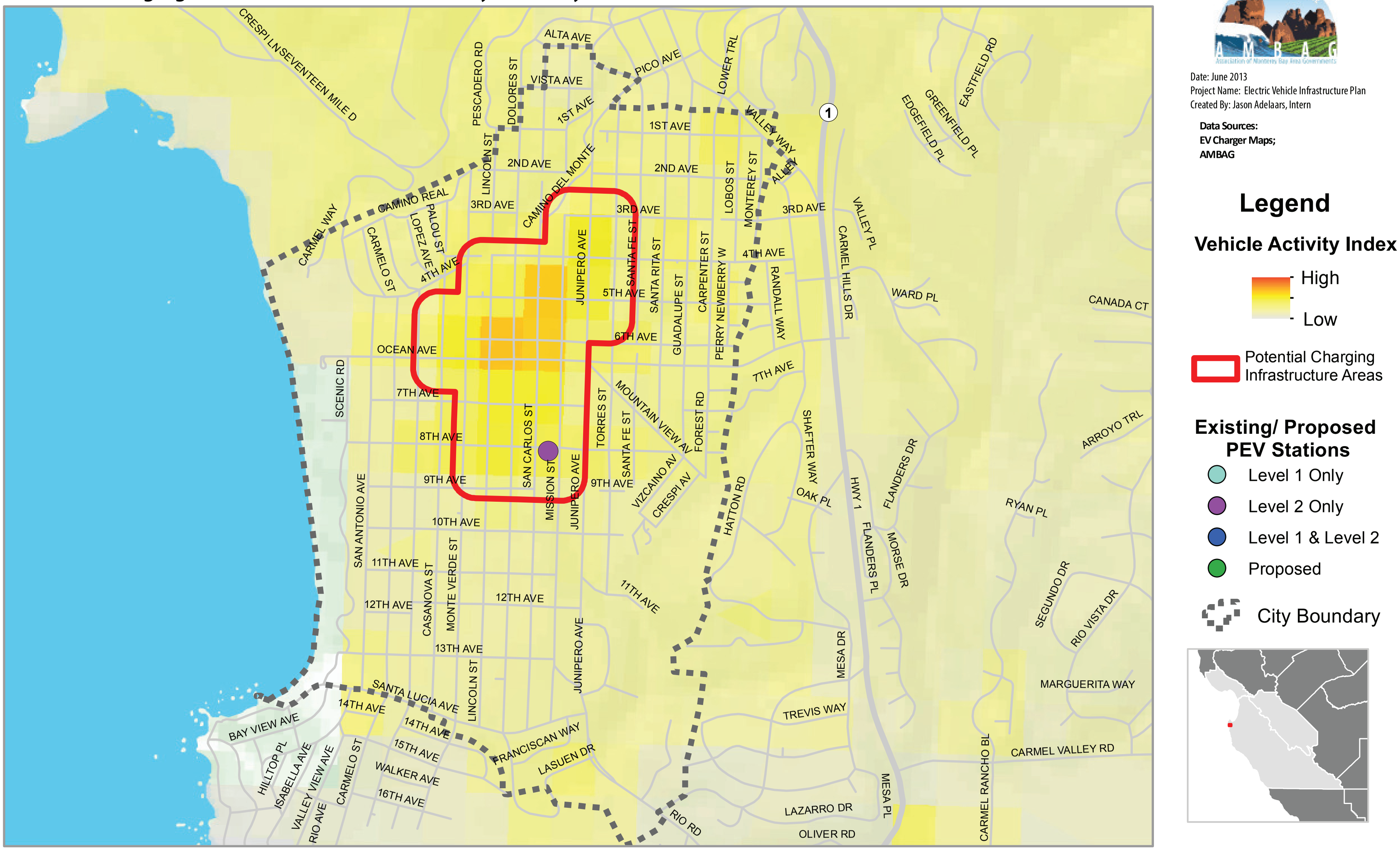

Potential Charging Areas Based on Vehicle Activity Intensity
Monterey County
AMBAG
Date: June 2013
Project Name: Electric Vehicle Infrastructure
Created By: Jason Adelaars, Intern
Data Sources:
EV Charger Maps;
AMBAG
Legend
Vehicle Activity Index
High
Low
Highways
Existing/Proposed PEV Stations
Level 1 Only
Level 2 Only
Level 1 & Level 2
Proposed
County Boundaries
City Boundary
0
10
20
40 Miles
N
1
101
68
25
5
198

Figure 29.

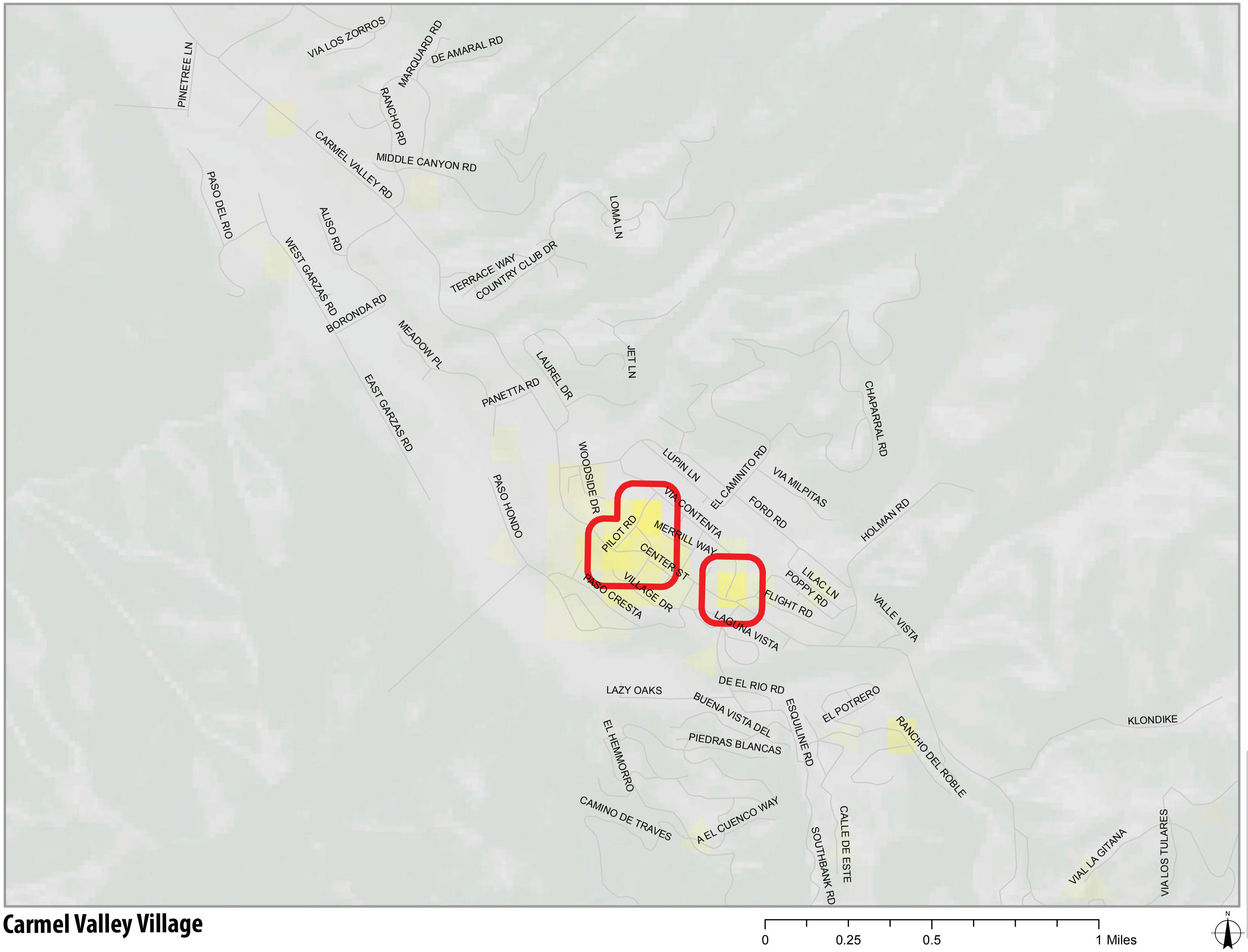
Potential Charging Areas Based on Vehicle Activity Intensity



City of Carmel-by-the-Sea

Figure 30.

Potential Charging Areas Based on Vehicle Activity Intensity



Carmel Valley Village

AMBAG
Association of Monterey Bay Area Governments
Planning Excellence

Date: June 2013
Project Name: Electric Vehicle Infrastructure Plan
Created By: Jason Adelaars, Intern

Data Sources:
EV Charger Maps;
AMBAG

Legend

Vehicle Activity Index

High

Low

Potential Charging Infrastructure Areas

Existing/Proposed PEV Stations

Level 1 Only

Level 2 Only

Level 1 & Level 2

Proposed

City Boundary

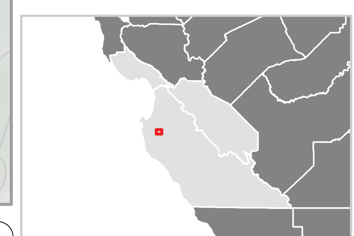
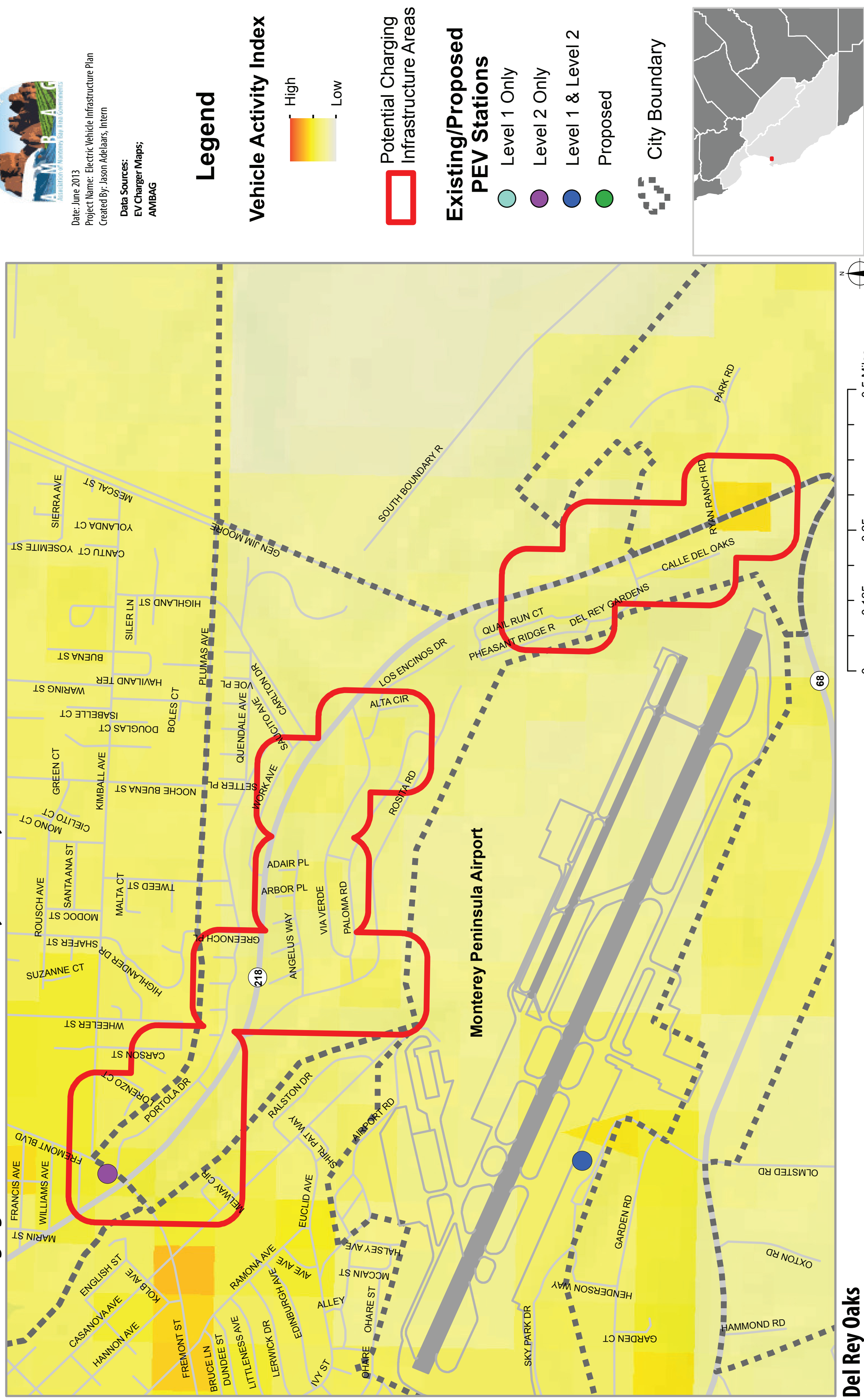


Figure 31.

Potential Charging Areas Based on Vehicle Activity Intensity



Del Rey Oaks

Figure 32.

Potential Charging Areas Based on Vehicle Activity Intensity

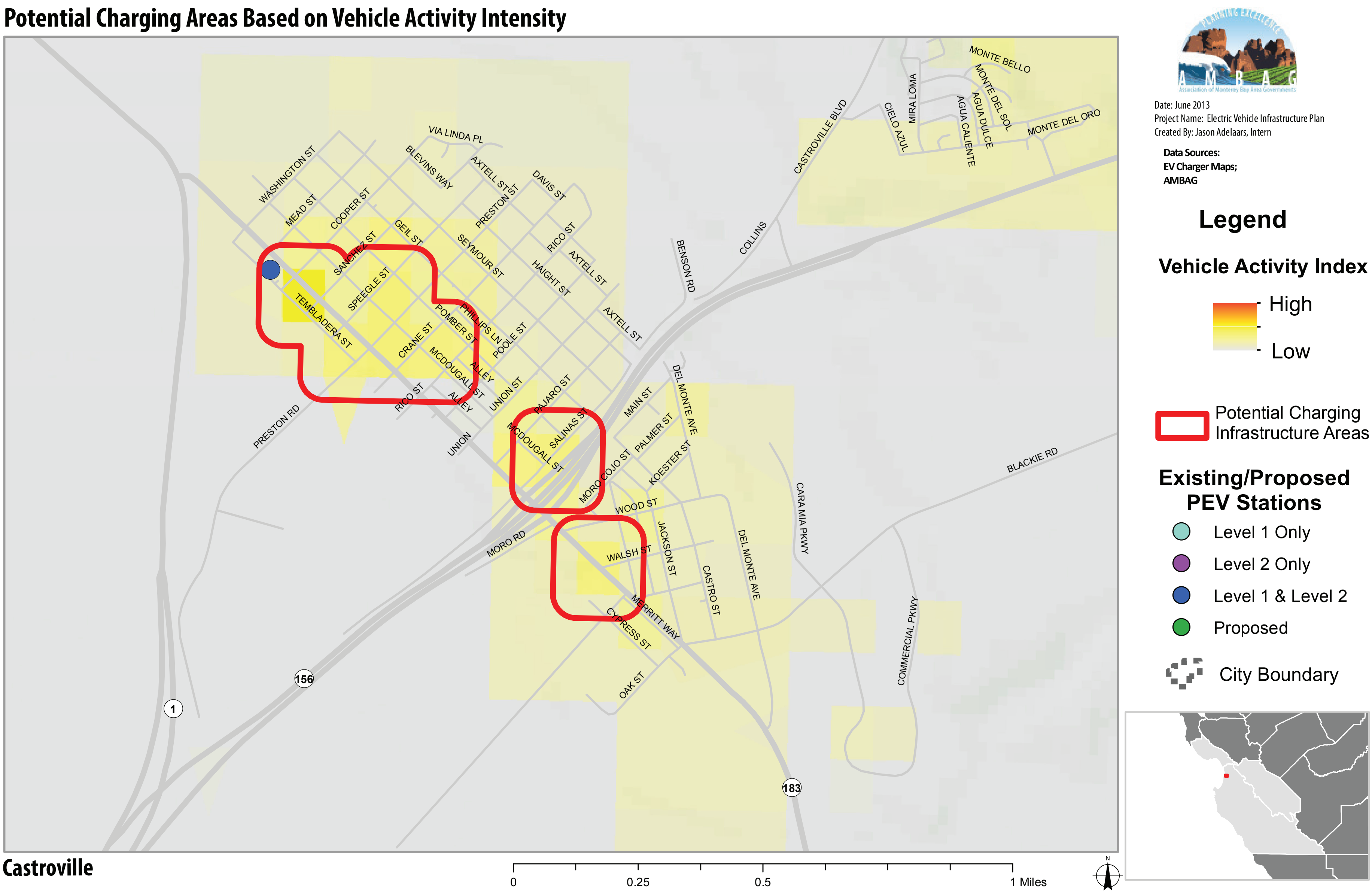
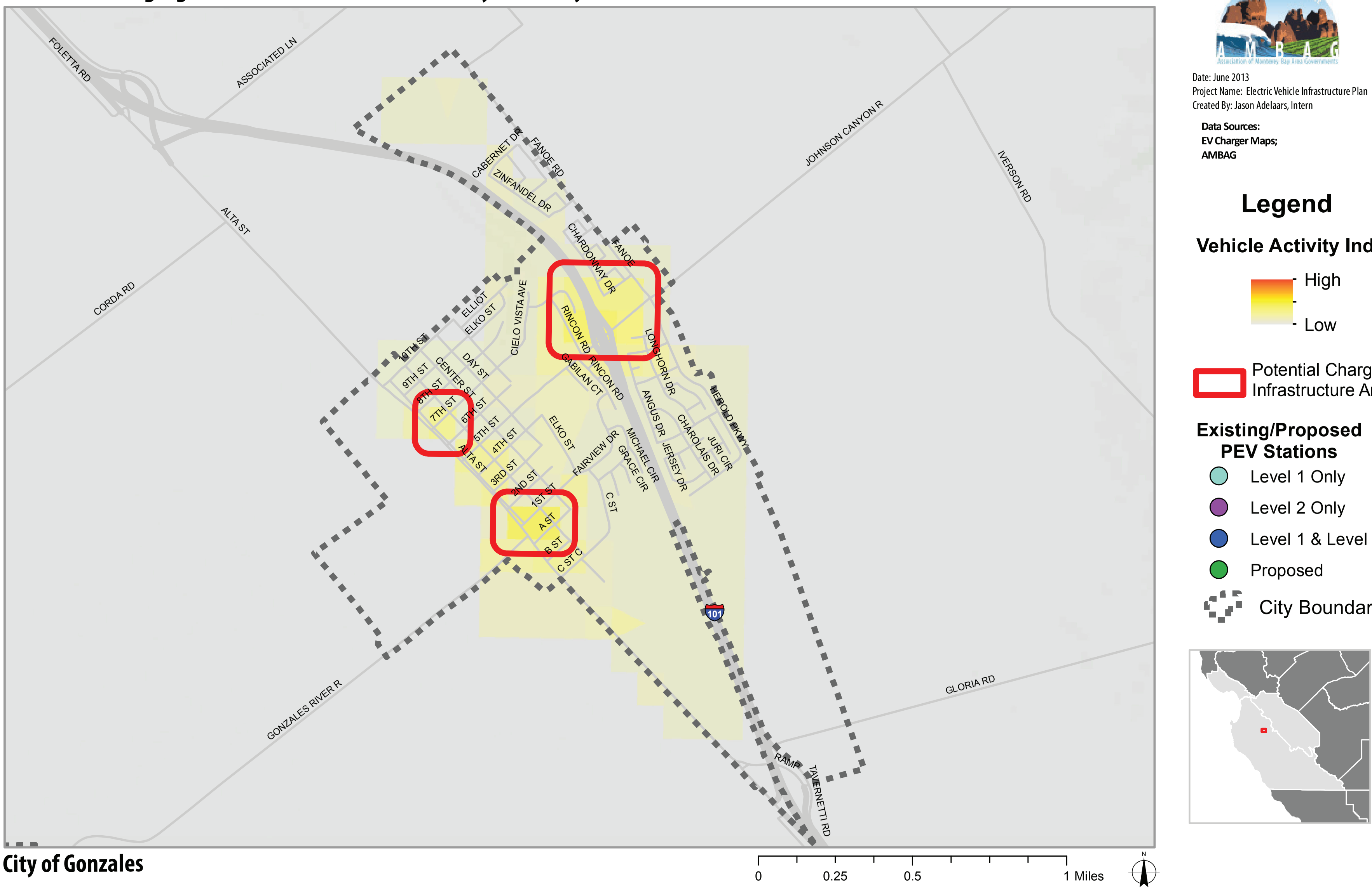


Figure 33.

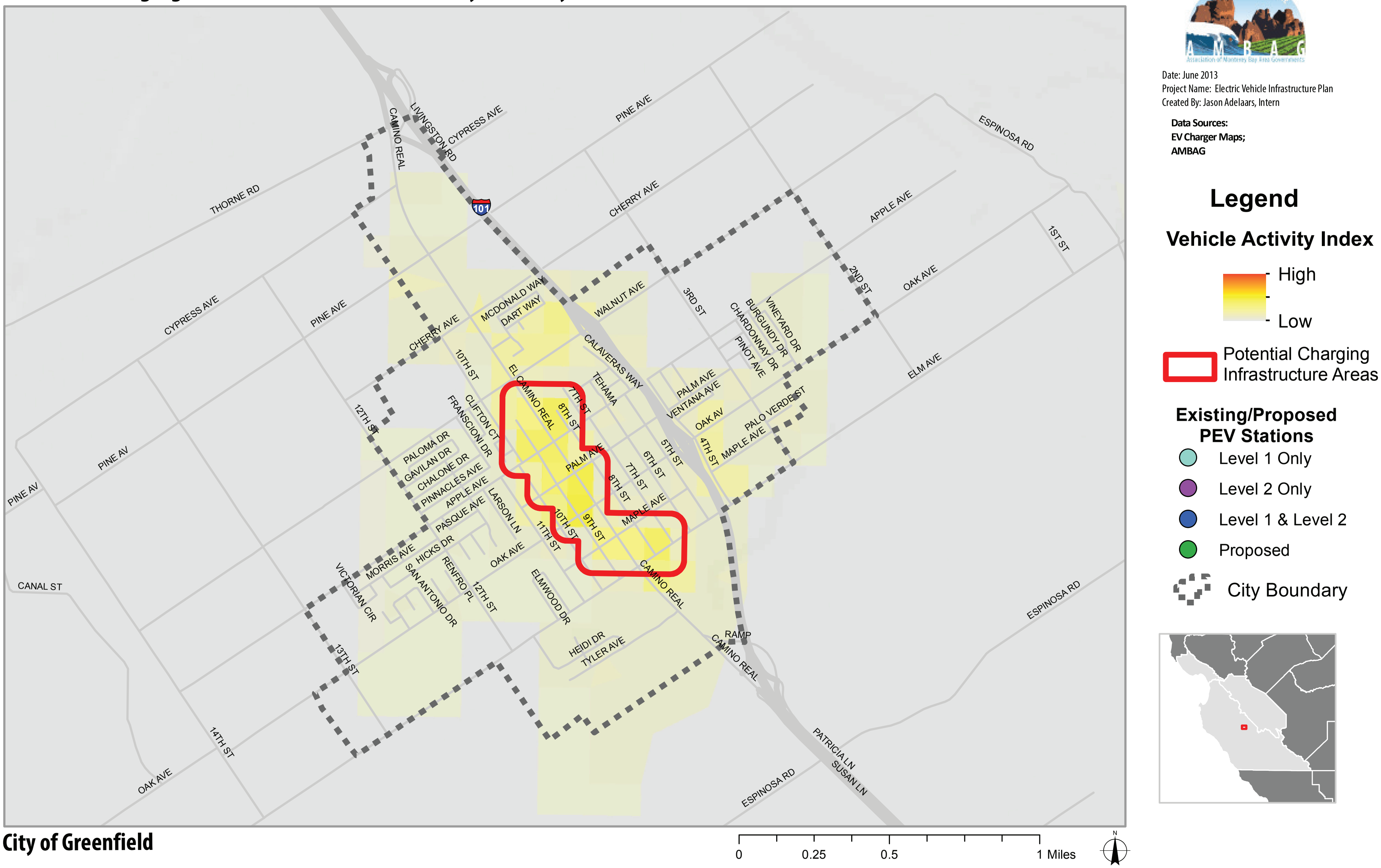
Potential Charging Areas Based on Vehicle Activity Intensity



City of Gonzales

Figure 34.

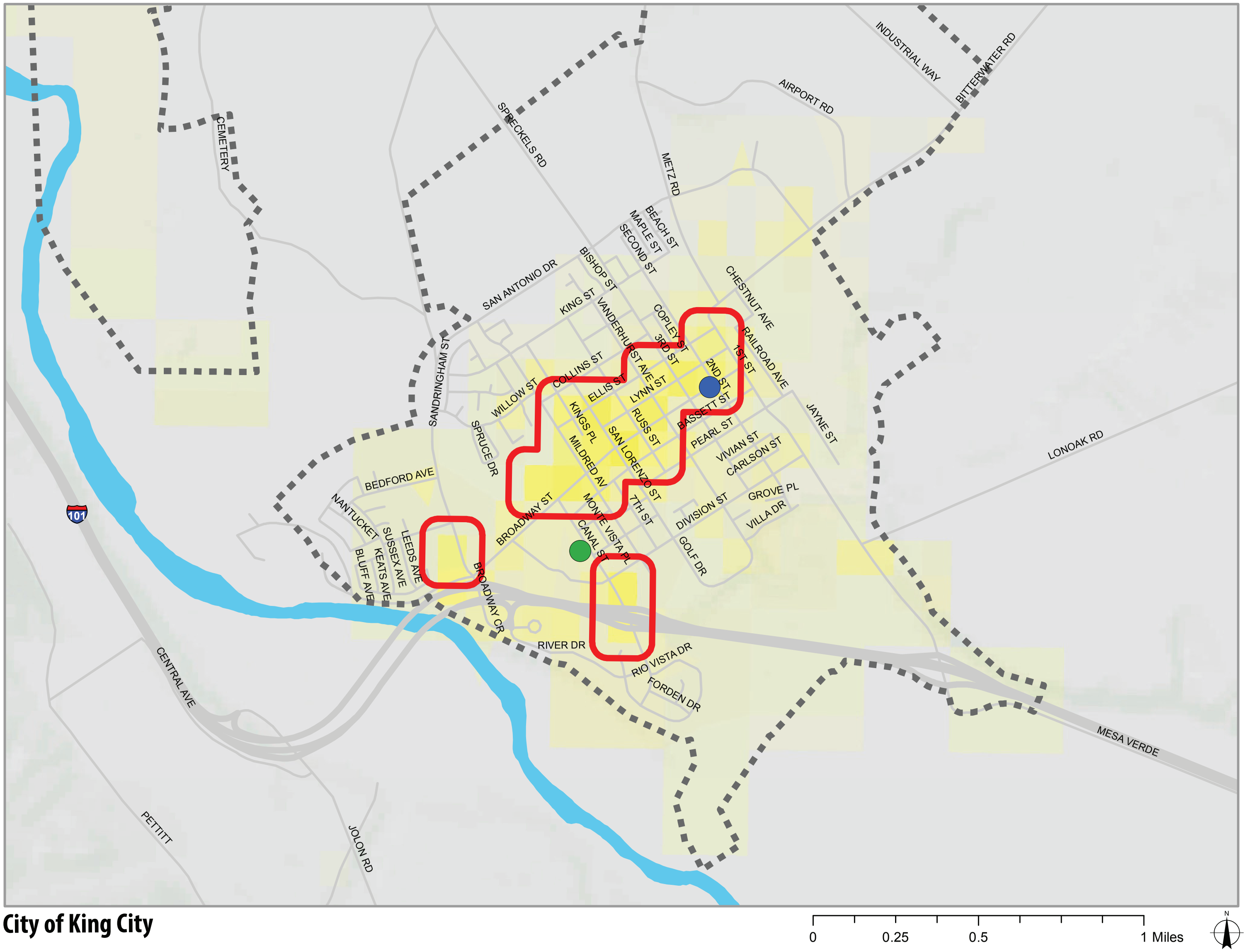
Potential Charging Areas Based on Vehicle Activity Intensity



City of Greenfield

Figure 35.

Potential Charging Areas Based on Vehicle Activity Intensity



City of King City

Date: June 2013
Project Name: Electric Vehicle Infrastructure Plan
Created By: Jason Adelaars, Intern

Data Sources:
EV Charger Maps;
AMBAG

Legend

Vehicle Activity Index
- High
- Low

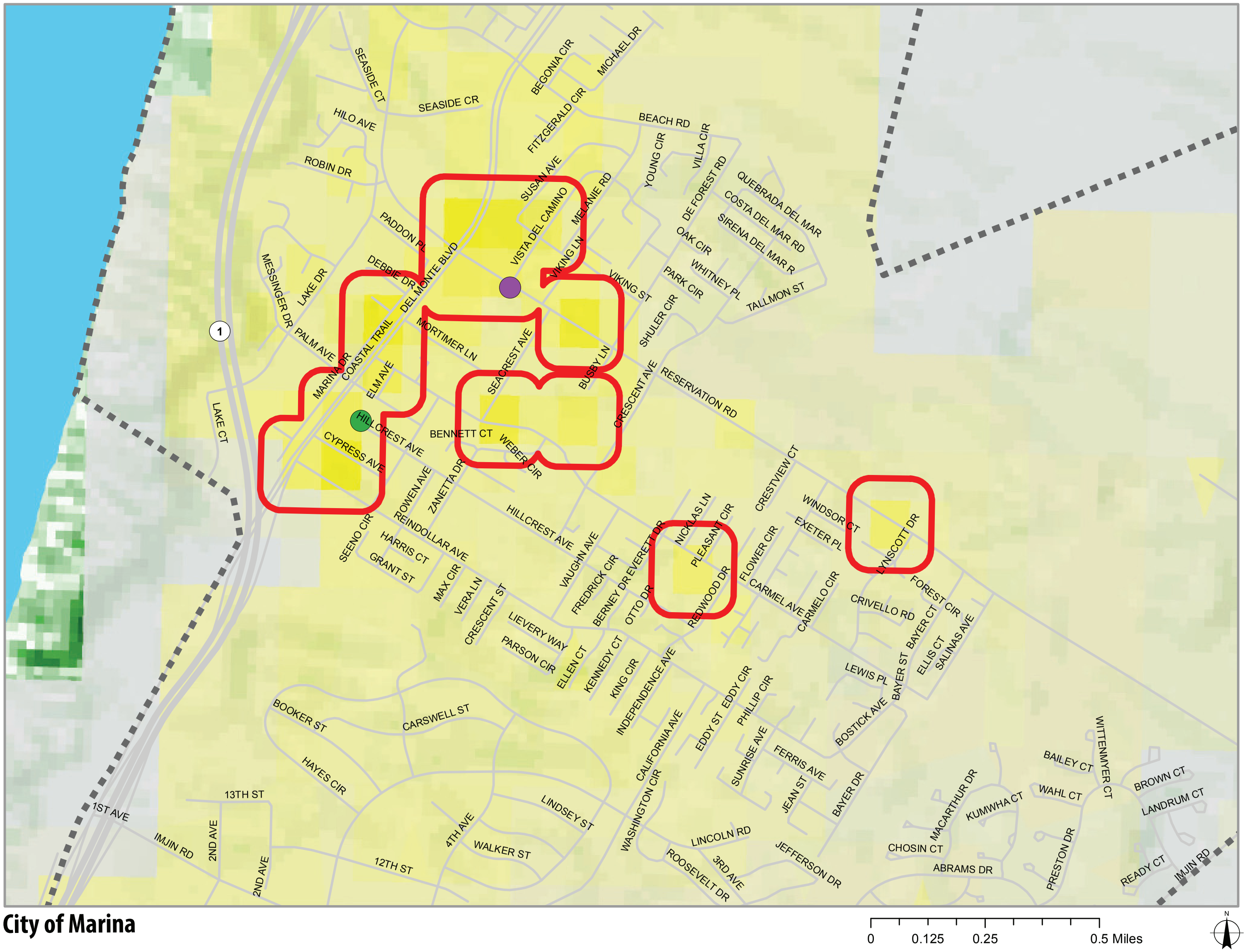
Potential Charging Infrastructure Areas

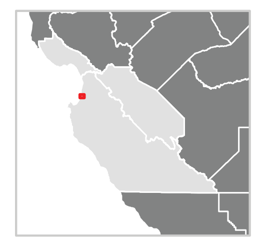
Existing/Proposed PEV Stations
- Level 1 Only
- Level 2 Only
- Level 1 & Level 2
- Proposed

City Boundary

Figure 36.

Potential Charging Areas Based on Vehicle Activity Intensity





Date: June 2013
Project Name: Electric Vehicle Infrastructure Plan
Created By: Jason Adelaars, Intern

Data Sources:
EV Charger Maps;
InfoUSA 2010 Employment Data;
AMBAG

Legend

Vehicle Activity Index

High

Low

Potential Charging Infrastructure Areas

Existing/Proposed PEV Stations

Level 1 Only

Level 2 Only

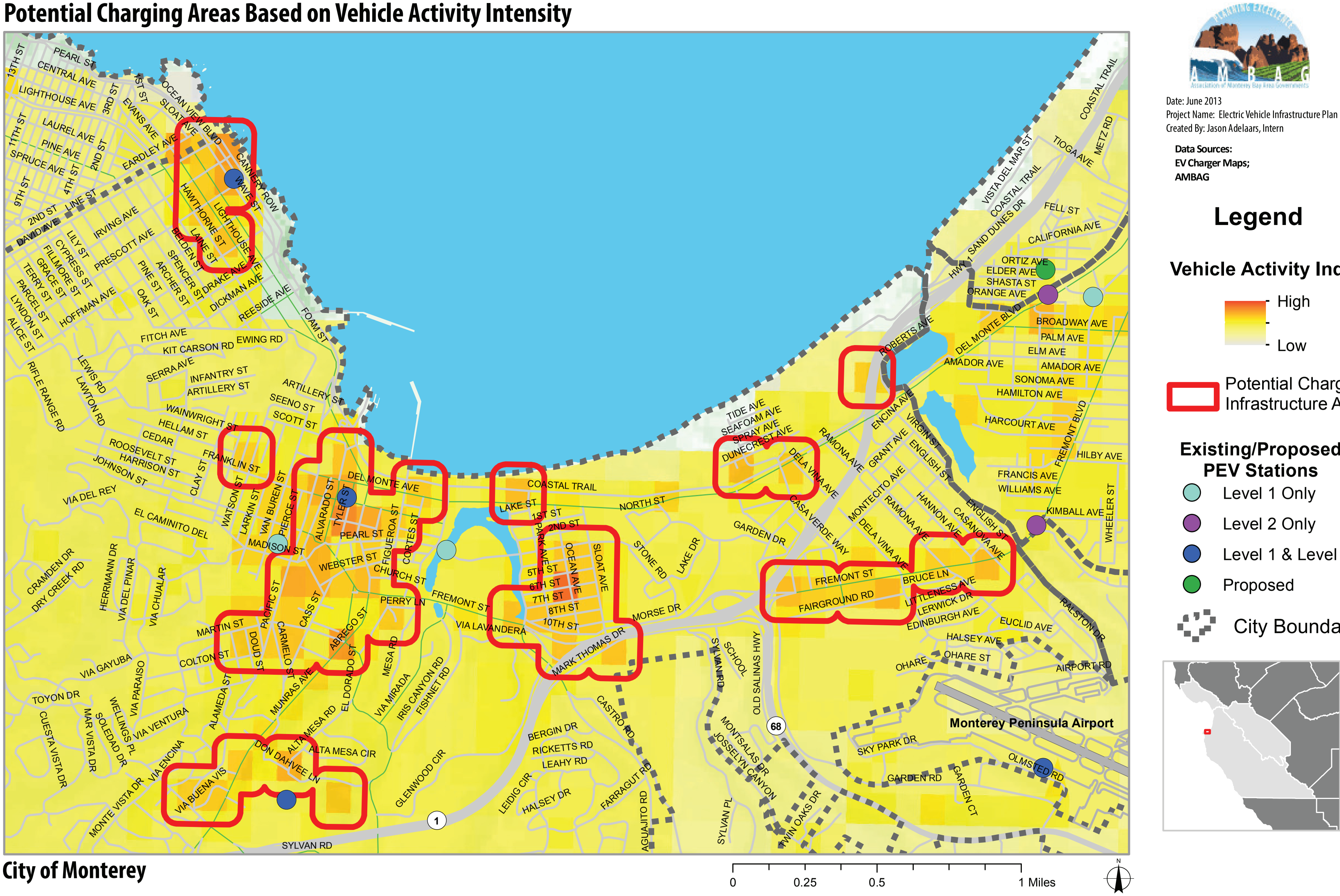
Level 1 & Level 2

Proposed

City Boundary

Figure 37.

Potential Charging Areas Based on Vehicle Activity Intensity



City of Monterey

Figure 38.

Potential Charging Areas Based on Vehicle Activity Intensity

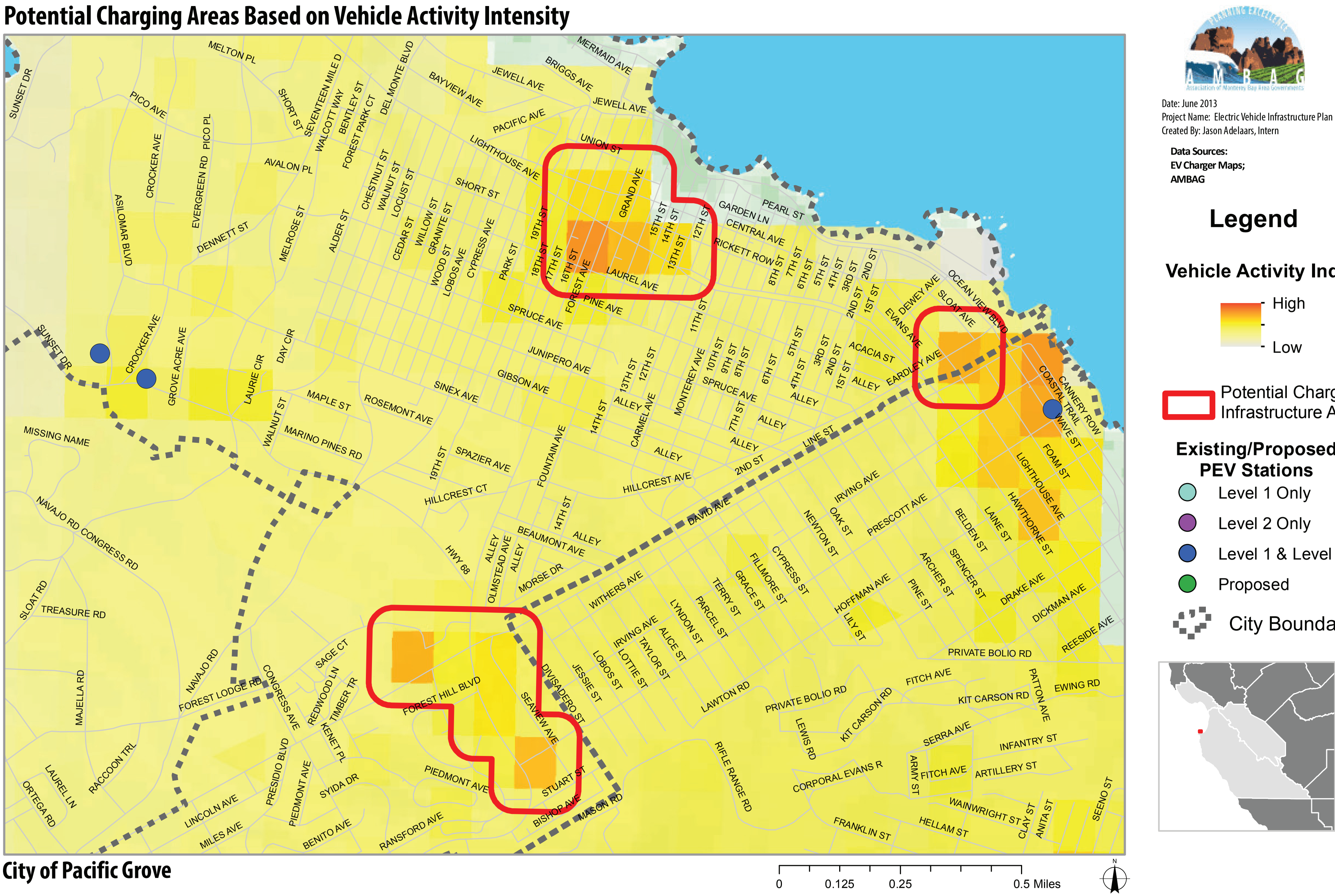
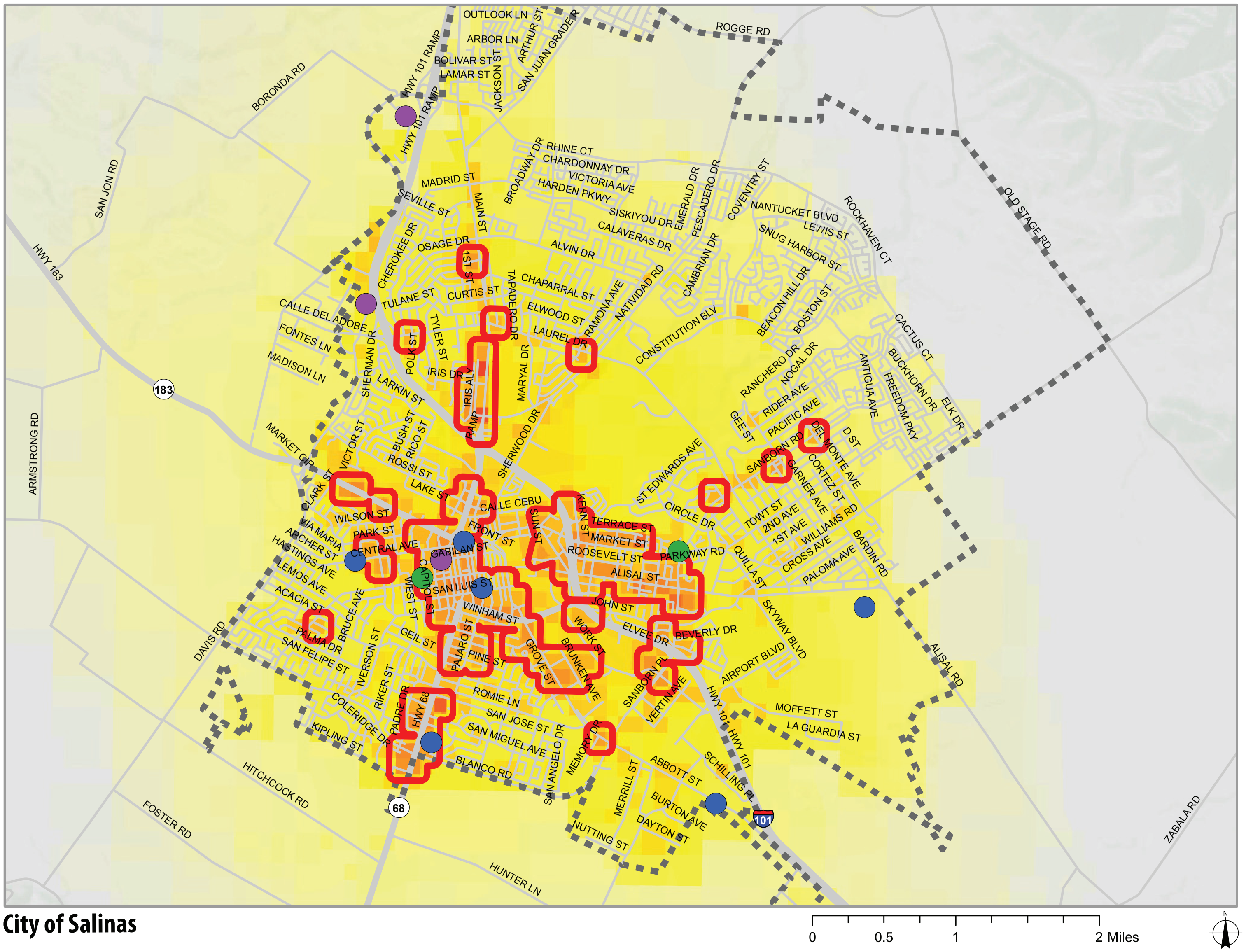


Figure 39.

Potential Charging Areas Based on Vehicle Activity Intensity



City of Salinas

Legend

Vehicle Activity Index

High

Low

Potential Charging Infrastructure Areas

Existing/Proposed PEV Stations

- Level 1 Only
- Level 2 Only
- Level 1 & Level 2
- Proposed

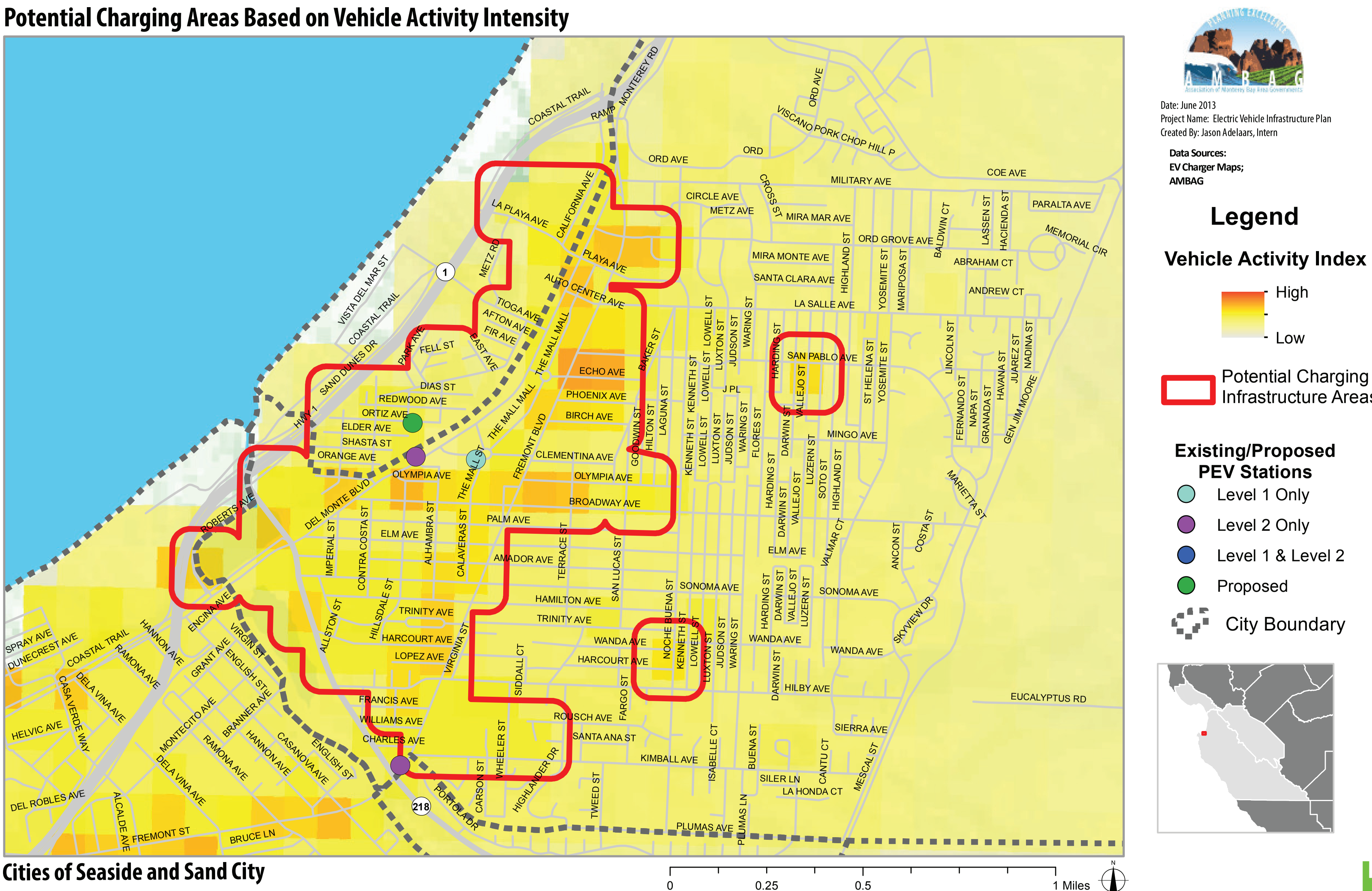
City Boundary

Date: June 2013
Project Name: Electric Vehicle Infrastructure Plan
Created By: Jason Adelaars, Intern

Data Sources:
EV Charger Maps;
AMBAG

Figure 40.

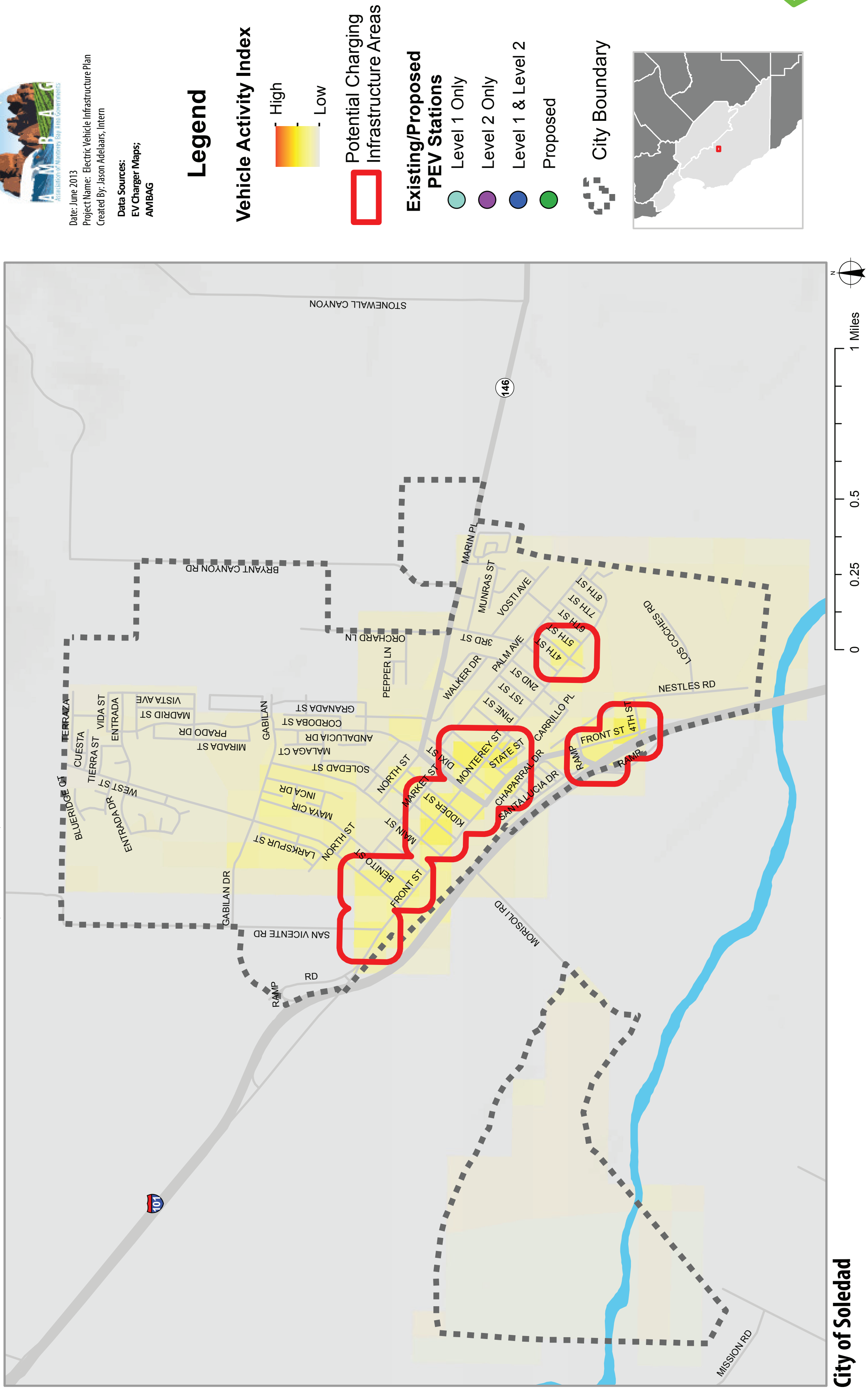
Potential Charging Areas Based on Vehicle Activity Intensity



Cities of Seaside and Sand City

Figure 41.

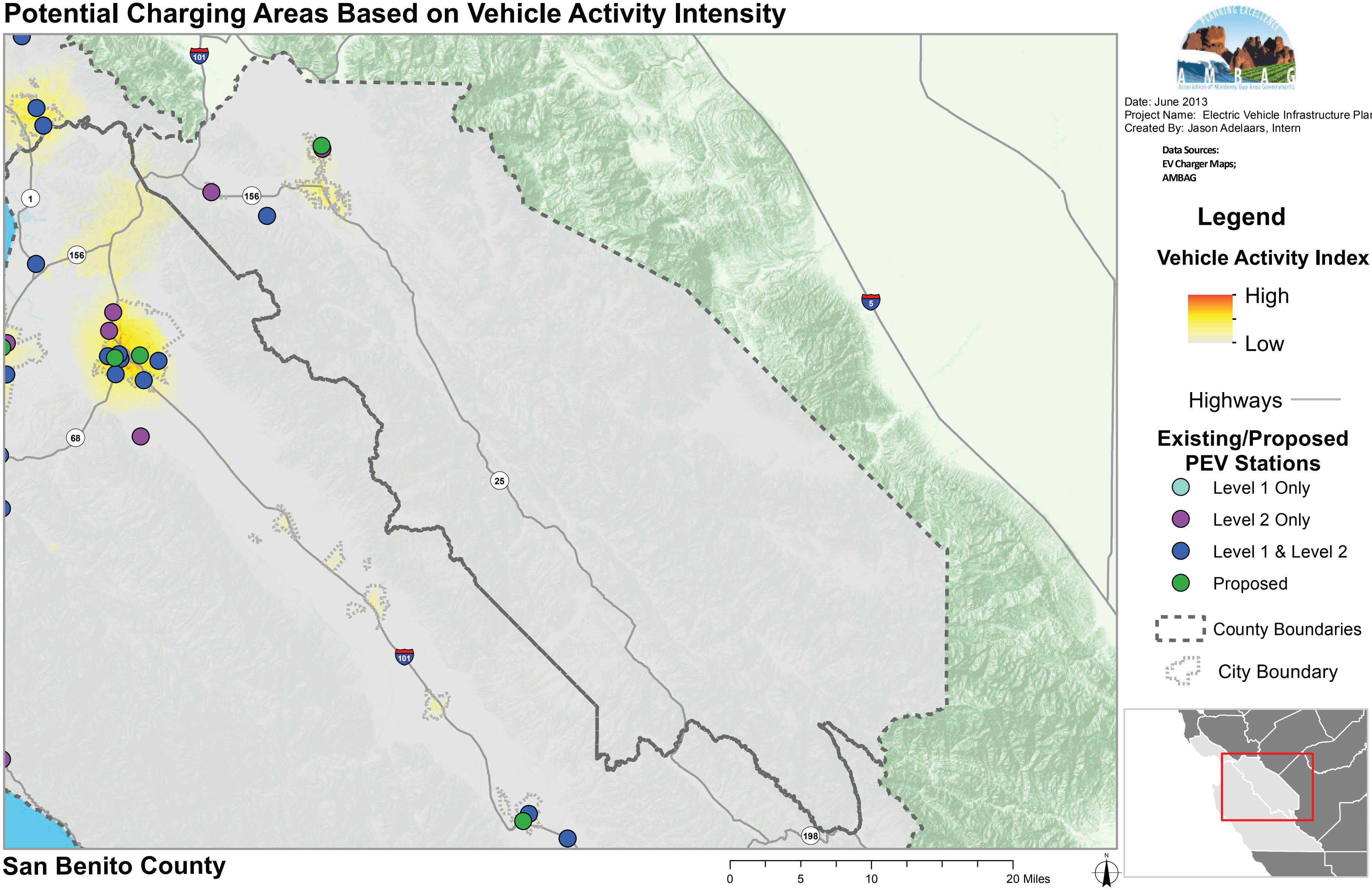
Potential Charging Areas Based on Vehicle Activity Intensity



City of Soledad

Figure 42.

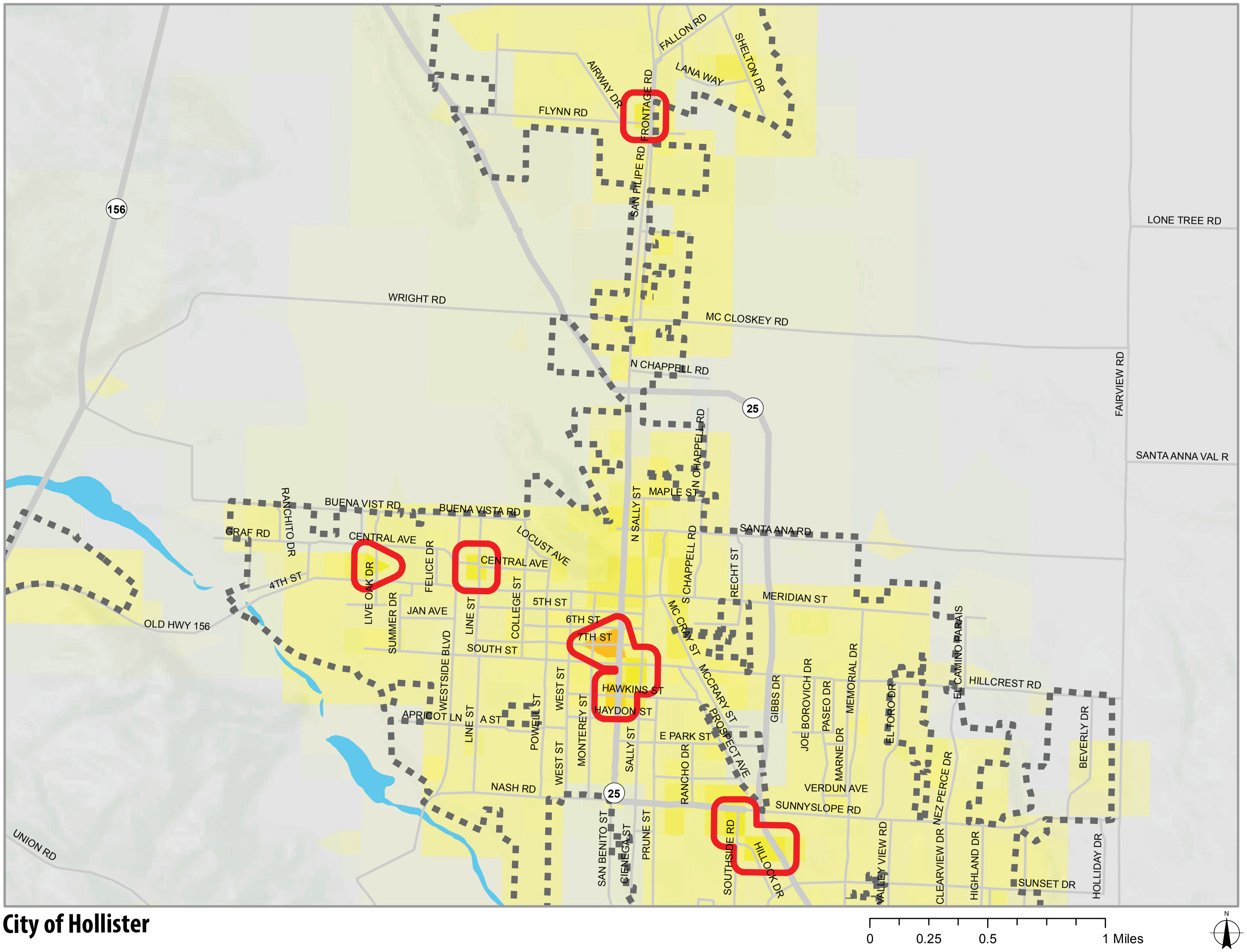
Potential Charging Areas Based on Vehicle Activity Intensity



San Benito County

Figure 43.

Potential Charging Areas Based on Vehicle Activity Intensity



City of Hollister

Date: June 2013
Project Name: Electric Vehicle Infrastructure Plan
Created By: Jason Adelaars, Intern

Data Sources:
EV Charger Maps;
AMBAG

Legend

Vehicle Activity Index
High
Low

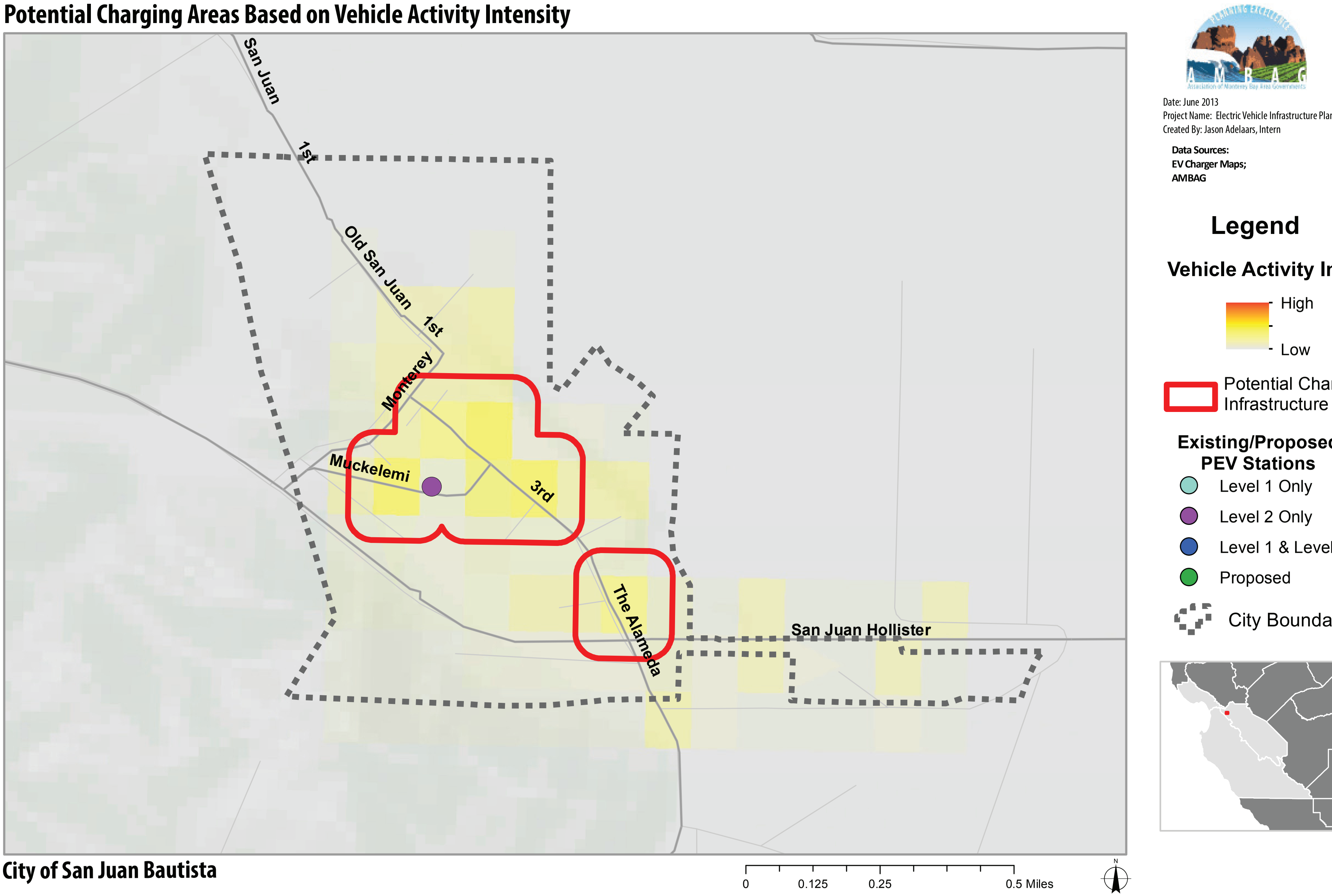
Potential Charging Infrastructure Areas

Existing/Proposed PEV Stations
Level 1 Only
Level 2 Only
Level 1 & Level 2
Proposed

City Boundary

Figure 44.

Potential Charging Areas Based on Vehicle Activity Intensity



City of San Juan Bautista

Figure 45.

Potential Charging Areas Based on Vehicle Activity Intensity

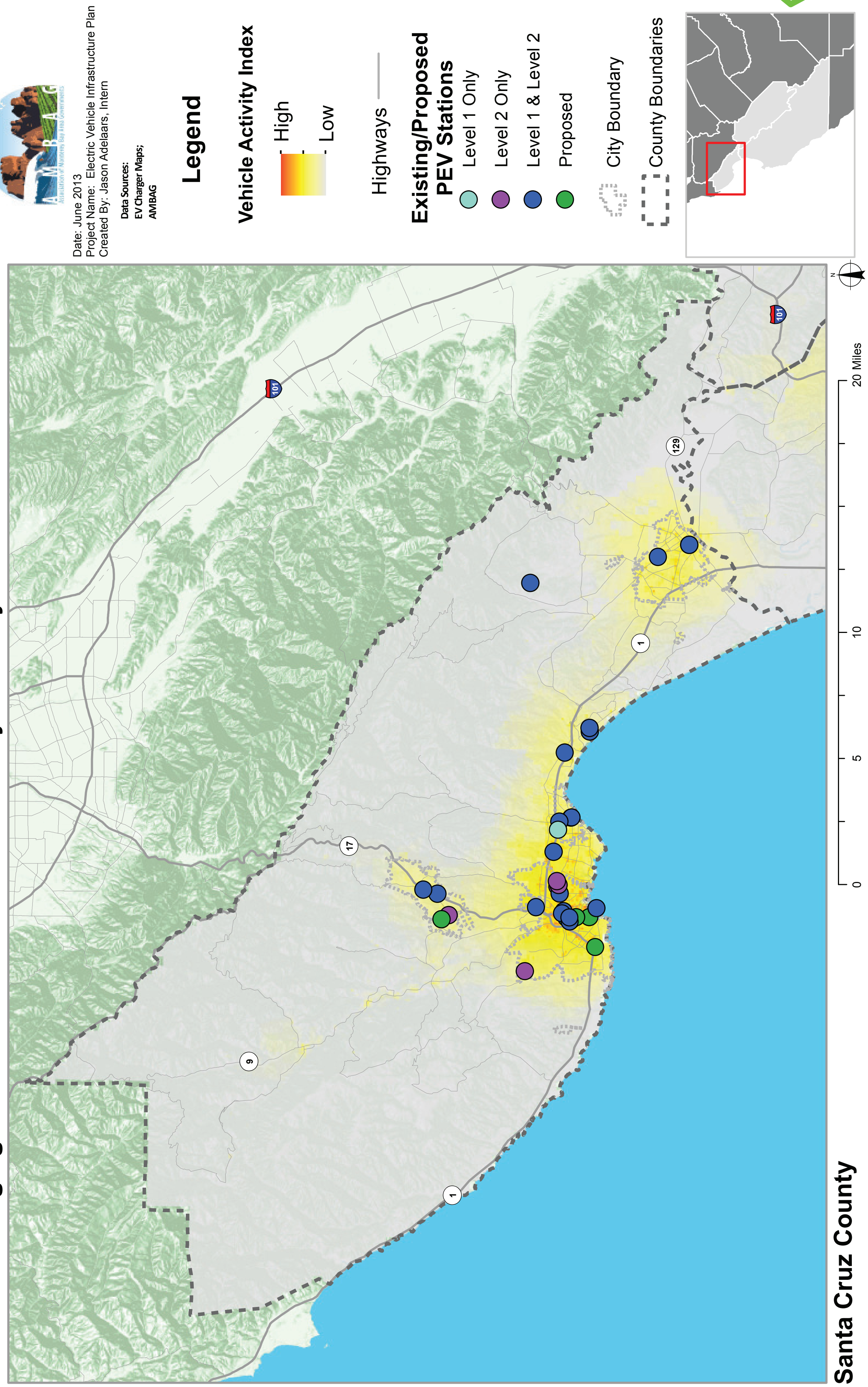


Figure 46.

Potential Charging Areas Based on Vehicle Activity Intensity

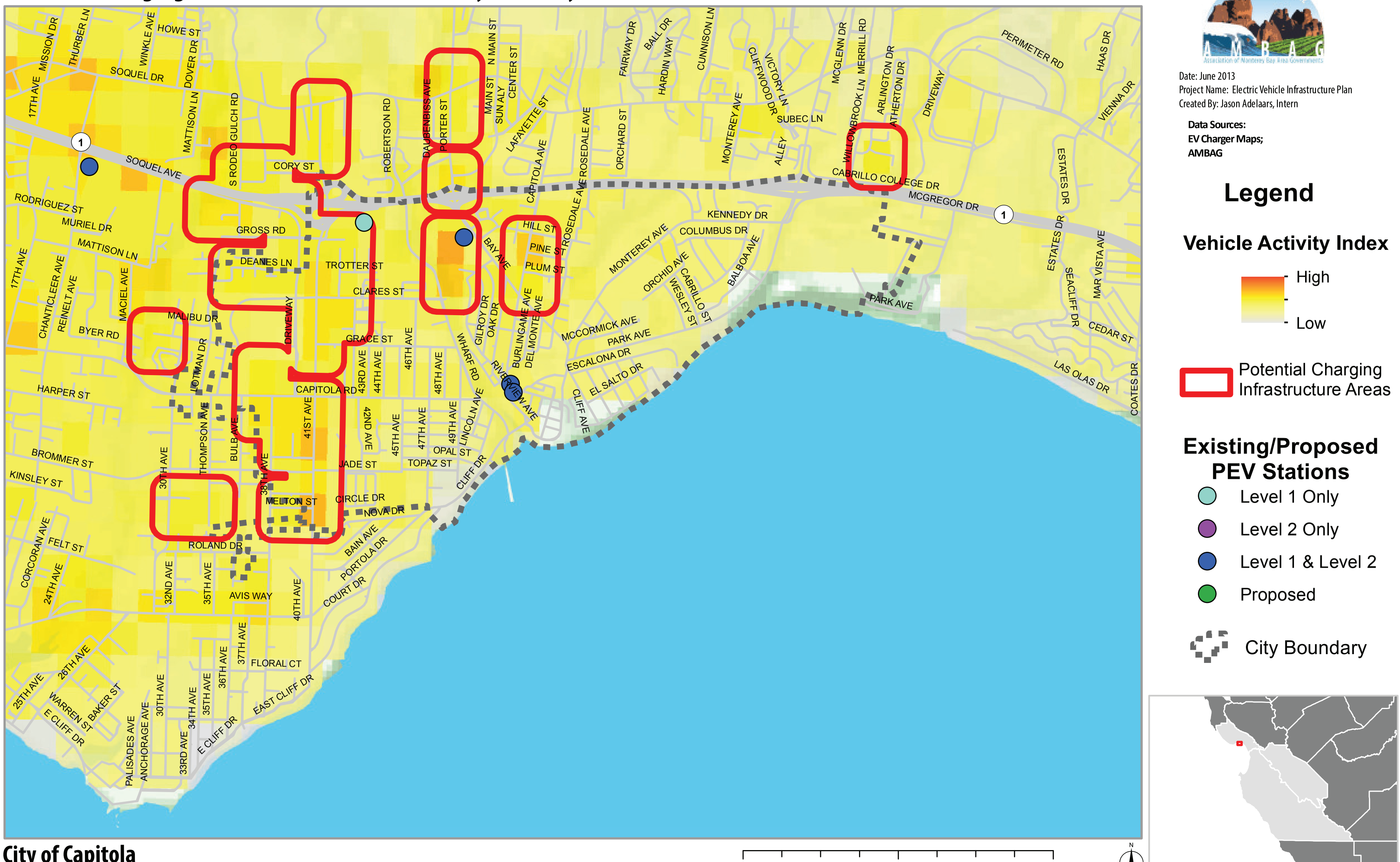
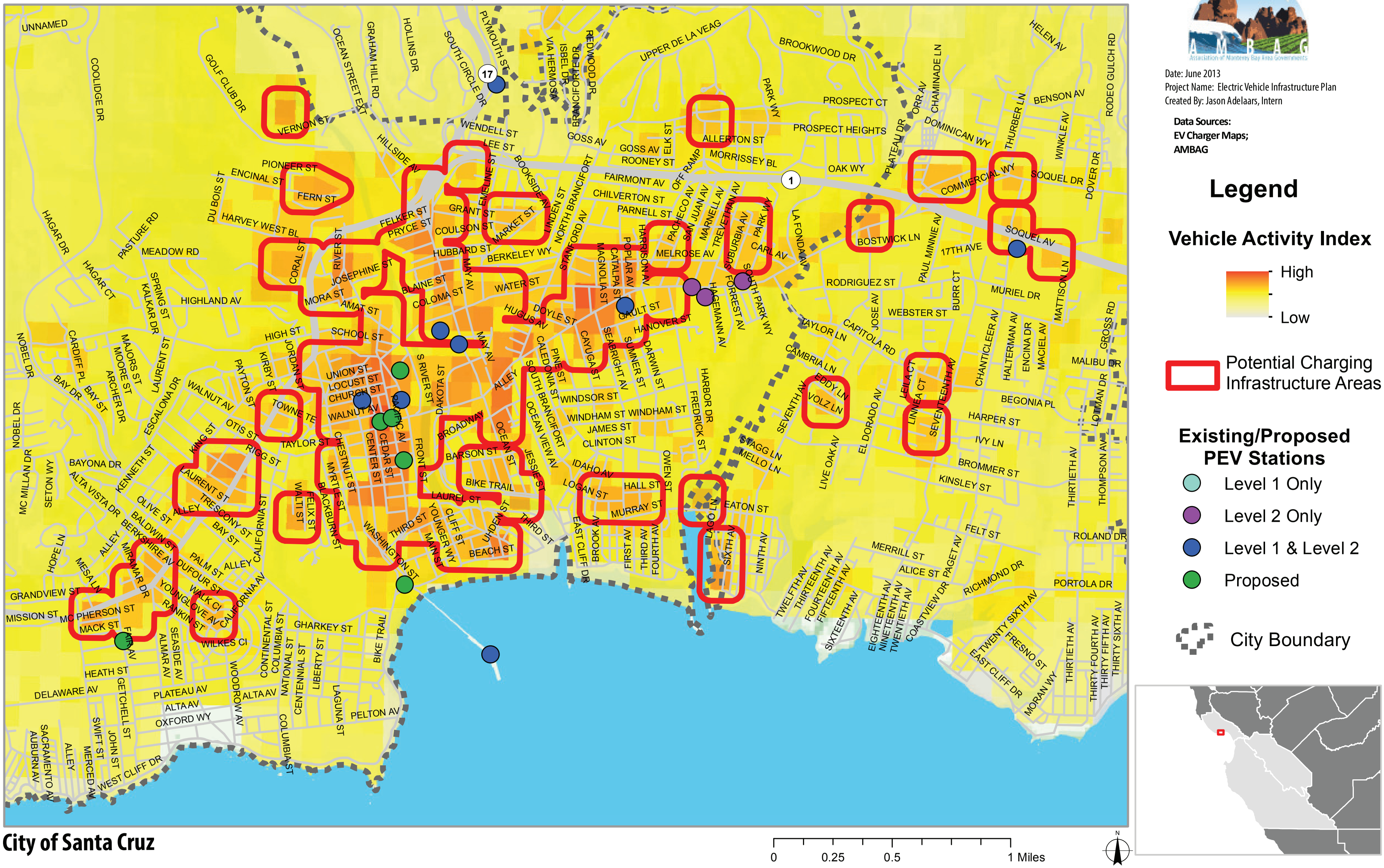


Figure 47.

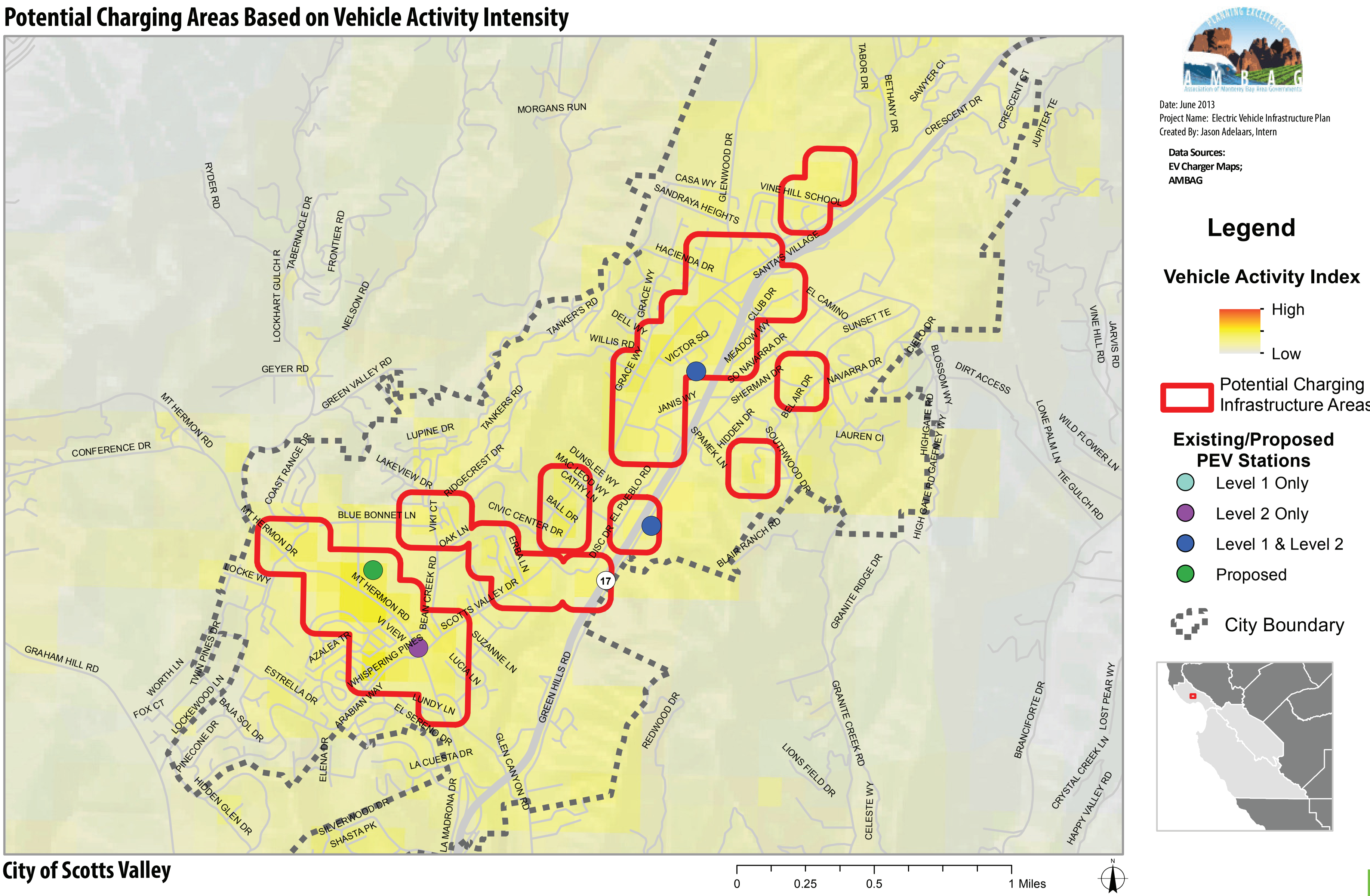
Potential Charging Areas Based on Vehicle Activity Intensity



City of Santa Cruz

Figure 48.

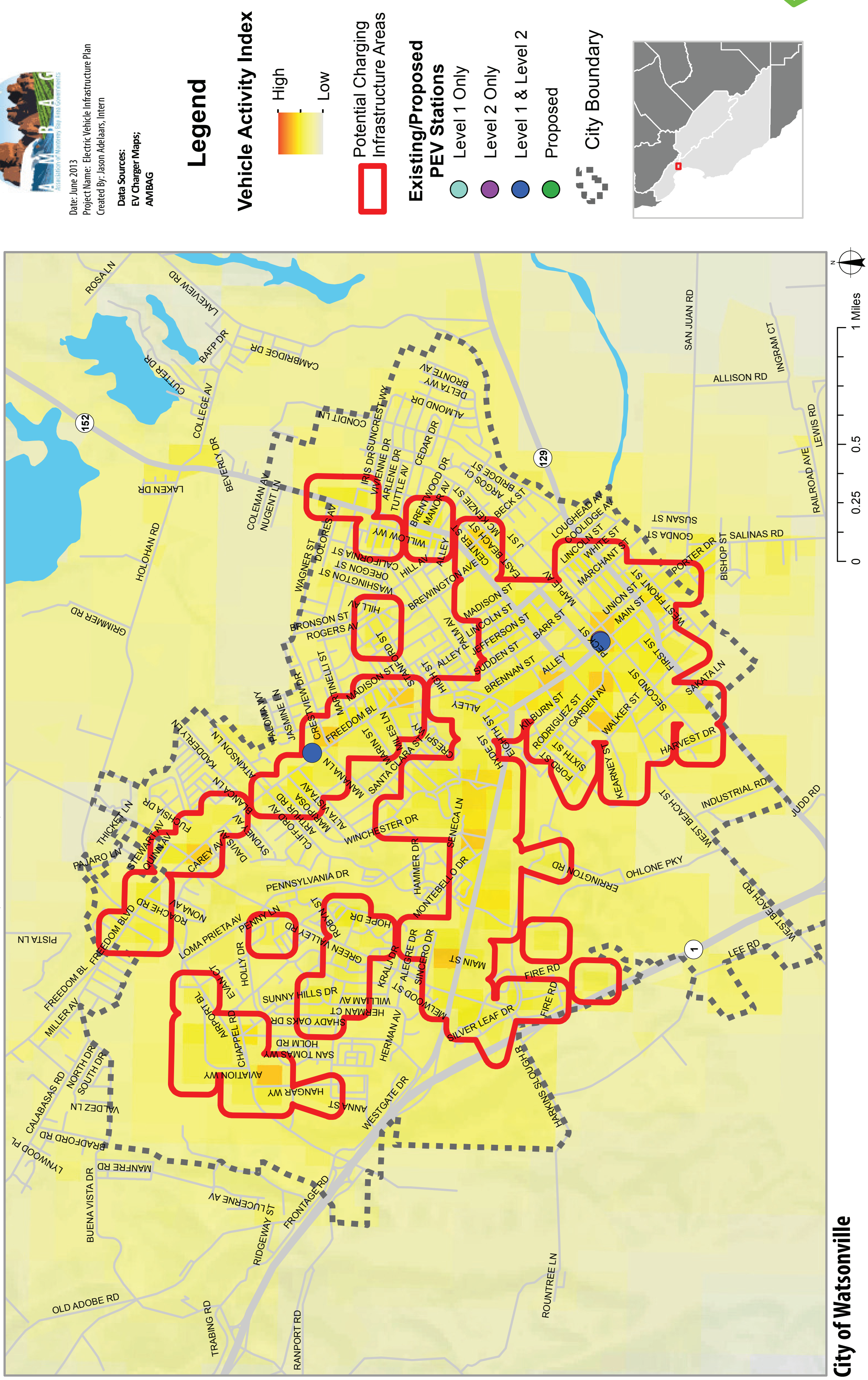
Potential Charging Areas Based on Vehicle Activity Intensity



City of Scotts Valley

Figure 49.

Potential Charging Areas Based on Vehicle Activity Intensity



City of Watsonville

Make	Model	Description
Aixam	Mega Van	
Aixam - NICE - Mega	City	
Aixiam-Mega group,France	Mega e-city	
American Electric, USA	Kurrent	
Aptera	2e	
Aptera, USA	Aptera 2e	
ATT R&D	Parade	
Audi	A1 e-tron	The A1 e-Tron is an OEM PHEV conversion of the 5 door, 4 passenger Audi A1. The A1 e-tron has an all-electric range of 31-62 mi (normal vs efficiency mode)...
Audi	e-tron	The e-tron is a 2 door, 2 passenger all electric sports car based on the R8. The e-tron's 42.4kW battery pack give it a range of 248 km. The eTron is powered by 4 hub motors. 1,000 car run with target intro 2012 BAIC C60
Audi	e-tron Spyder	The latest vehicle in Audi's e-tron family, the Spyder, is a two-door, two-seat sports coupe powered by a 221kW (300-hp) twin-turbo V6 TDI and two electric motors with a combined output of 64kW...
BAIC	BE701	The BE701 is a 4-door sedan, fully self-developed EV by Beijing Automotive Industry Holding Corporation (BAIC) under subsidiary Beijing New Energy Automotive...
BAIC	C60	A 4-door sedan available in China
Blade Electric Vehicles, Australia	Blade Electron	
BMW	ActiveE	The ActiveE is BMW's next vehicle in their EfficientDynamics lineup. It is an all electric BMW 1-series coupe powered by a 125kW electric motor (170hp) with 250Nm of torque...
BMW	i3	The i3 will be BMW's first production electric vehicle. It is a 3-door hatchback that is expected to be under 2,500 lbs, thanks to it's carbon fiber body and aluminum chassis...
BMW	i8	The i8 is a newly-designed 2-door 4 seater PHEV, with the same electric drive system as the BMW i3 powering the front wheels, and a 1.5 L, 3-cylinder engine driving the rear wheels...
BMW	MINI E	The MINI E is an OEM conversion of MINI 2-door hardtop to a 2-seat EV with AC150 drivetrain & battery from AC Propulsion. The MINI E has a 100mi range and...
BMW	MegaCity	2-door coupe

Target Release Date	Drive Train	Range (miles)	Top Speed (mph)	Battery Capacity (kWh)	Electric Motor Capacity (kW)
TBA		40	40		
Now Available		37	40		4KW
Now Available		37	40		
Now Available		40	35		
TBA					
Now Available		100	90		
TBA					
2011	PHEV	31	80		
2012	EV	154	124	42.4	230
TBA	PHEV	31	155		
TBA	EV	120	100		
2011	EV				
TBA		62	68		40
2011	EV	100	90		125
2013	EV	100	TBA		
TBA	PHEV	20	155		
Now Available	EV	100	95		
2013	EV	100	95	35	112

Appendix B. Electric Vehicle Matrix

Make	Model	Description	
BYD Auto	e6	The e6 is an all electric 5 passenger, 4 door crossover with a 330 km (205 mi) range and top speed of 100 mph. The e6 can accelerate from 0-60mph in 8 sec and can...	
BYD Auto	F3DM	The F3DM is BYD's first plug in hybrid with a 60 mi all electric range and 250 mi total range. The F3DM is powered by a 1L engine and two permanent magnet motors...	
Chery Automobile Co.	S18	Alternatively referred to as M1, the S18 by Chery is, 4-door, 5-seater compact with a 150km (93 mi) range and top speed of 120 kmh (75mph). The S18 is powered by a 336V 40kWh...	
Chevrolet	Volt	GM's EREV, extended range electric vehicle, with a 16kWh Li-ion battery from LG Chem, giving the Volt a 35 mi all electric range and 379 mi total range.	
Citroen	C1		
Citroen	C-Zero	4-door compact	
Citroën	C-ZERO	Rebadged Mitsubishi i-MiEV. 4-door hatchback, range 130 km "standard combined cycle", top speed 130 kph, 0-100 km/h 15 sec, 60-90 km/h 6 sec, 330V 16 kWh Li-ion battery...	
Citroën	Revolte	The Citroen Revolte is a compact 3-seater city car, said to be inspired by the famous 2CV. It will be powered by Li-ion batteries, an electric motor, and a small gas engine...	
Coda Automotive	CODA Sedan	The CODA is a 4-door, 5-passenger sedan. Range is 90-120 miles, top speed is 80mph...	
Commuter Cars	Tango T600	A unique 2 passenger car with inline seating and a range of 40-200 mi, depending on battery choice. The T600 will accelerate from 0-60 in just 4 sec...	
Detroit Electric	e63	Based on the Proton Persona, the e63 has a 4-speed transmission, will accelerate from 0-62 mph in under 8 sec, and contains a 25kWh Li-ion battery...	
Dodge	Circuit		
DOK-ING	XD	Smart-sized 3 seater with 30kWh of LiFePo4 batteries, 2 or 4 40kW (53HP) brushless AC motors, depeding on configuration, available in front, rear, or all-wheel drive, 0-62mph in...	
Duracar	Quicc DiVa	Lightweight, small van made from recycled plastic, LiFePo batteries, shareholder recently brought the company out of bankrupcy and are looking for more investors...	
Dynasty Electric Vehicle Limited, USA	IT Sedan		
Elbil	Norge Buddy		

Target Release Date	Drive Train	Range (miles)	Top Speed (mph)	Battery Capacity (kWh)	Electric Motor Capacity (kW)
2011	EV	205	100	48	75
2011	PHEV	60	TBA	17	
Now Available	EV	93	75		
Now Available	PHEV	35	100		16
TBA		60-70	60		
TBA	EV	130km	81	16	47
Now Available	EV	80	80		
TBA	EV	TBA	TBA		
2011	EV	100	80		
Now Available	EV	200	135		600
TBA	EV	112	112		
TBA					
TBA	EV	TBA	TBA		
TBA	EV	90	75		
Now Available	EV	30	25		
Now Available		60			13

Appendix B. Electric Vehicle Matrix

Make	Model	Description
Electric City Motors	Current	
Electric City Motors, USA	Current	
Electrrum Spyder		
Elettrica		
EV Drive	Puma	The Puma is an all-electric sports car, manufactured in South Africa
Fiat	e500	
Fisker	hybrid	
Fisker	Karma	A 4-door, 4-passenger luxury plug-in hybrid sports car with a 50 mi all electric range and 0-60 speed of less than six seconds. The Karma has an electric drivetrain by...
Fisker	Surf	The Fisker Surf will be the Karma's big brother. Fisker describes the Surf as "a crossover between a sport car and a station wagon".
Ford	C-Max Energi	The 2013 Ford C-Max Energi is a plug-in hybrid version of the Ford C-Max. The C-Max Energi can drive in all electric mode over 47 mph and is expected to have a range of over 500 miles...
Ford	Escape PHEV	Based on 5-seater Escape SUV, AER 40 mi, top speed 102 mph, Li-ion 10kWh battery pack, 6-8 hr recharge time on standard 120V/15A outlet, 120 mpg...
Ford	Focus Electric	The Focus Electric is based on Ford's next generation Focus body. The vehicle is powered by 23 kWh of Li-ion batteries with active liquid cooling.
Ford	Transit Connect	
GEM	e2	
GEM	e4	
GEM	e6	
GEM	eL	
GEM	eL XD	
GEM	eS	
GEM	Peapod	
GEM, USA	GEM e2	
GEM, USA	GEM e4	
GEM, USA	GEM e6	
Ginetta	G50 EV	Two seater sports car based off of gasoline G50, rear-wheel drive, brushless 300V DC motor...
Groupe Dassault	Cleanova	
Herpa Miniaturmodelle GmbH	Trabant nT	Two door modernization of the Trabant with EV range of 250km. Per Herpa website, Ronald Gerschewski, CEO of project partner company IndiKar said...

Target Release Date	Drive Train	Range (miles)	Top Speed (mph)	Battery Capacity (kWh)	Electric Motor Capacity (kW)
TBA		55	75		45
TBA		55	75		
TBA					
TBA		65	45		
Now Available	EV	60	75		
TBA		75	60		
TBA					
Now Available	PHEV	50	125		
2012	PHEV	TBA	TBA		
2012	PHEV	TBA	TBA		
2012	PHEV	40	102		
2011	EV	112	100		
Now Available		80	75		
TBA		35	25		
TBA		30	25		
TBA		30	25		
TBA		30	25		
TBA		40	25		
TBA		30	25		
TBA		30	25		
Now Available	EV	35	25		
Now Available	EV	30	25		
Now Available	EV	30	25		
TBA	EV	250	120		300V DC motor
TBA					
2012	EV	155	TBA		

Appendix B. Electric Vehicle Matrix

Make	Model	Description
Heuliez	Mia	
Heuliez	WILL	French coach builder in collaboration with Michelin & Orange, Opel Agila body, 4 Michelin in-hub wheel motors, has 2 trunks, three battery options for range of...
Honda	EV-N	
Honda	Fit EV	Honda's latest EV, the Fit EV is an all-electric OEM conversion of Honda's 5-passenger Fit. The Fit EV has an estimated range of 100 miles and is expected to be for sale in 2012.
Hyundai	Blue-Will	4-door hatchback, new body design, same wheelbase as Kia Ray, LG Chem Li-ion battery, 100kW electric motor, continuously variable transmission...
Hyundai	i10 EV	EV version of Hyundai's i10 5-door hatchback 5-seater city car, 0-60 mph 15 sec, 16 kWh LG Chem Li-ion polymer battery, recharge 240V less than 5 hr...
Kewet		
Kia	Pop	The Kia Pop is a uniquely-designed all electric vehicle that seats 3. The Pop's lithium polymer gel batteries and 50-kW electric motor will take it 100 miles per charge with a top speed of 87 miles per hour.
Kia	Ray	Uses same wheelbase as Hyundai Blue-Will, but designed to be more aerodynamic (Cd of 0.25), 1.4-liter 4-cyl engine and 78kW electric motor...
Kia	Venga EV	EV version of Kia's new Venga "tall wagon", 24kW oflithium polymer batteries stored under floorpan of vehicle, 80% recharge in 20 minutes with 50kW fast charger...
Lightning Car Company	GT	Hand built exotic car,0-60 mph < 4 sec, 30 Altair NanoSafe™ batteries, can recharge in 10 minutes, four in-hub 120kW wheel motors, body made from...
Lumeneo	SMERA	Ultra narrow tilting 4-wheel vehicle with two inline seats, 0-60 mph 8 sec, 10kWh Li-ion battery pack, two 15kW DC electric motors power rear wheels...
Luxgen	EV+	7-passenger minivan powered by 180kW (240hp) electric motor and AC Propulsion drivetrain, 0-62mph in 8.6sec, top speed of 145km/h, range: 350km...
Maranello	Maranello4	
Maranello, Italy	Maranello 4-cycle	
Mercedes	A-Class E-Cell	Daimler and Tesla have partnered to produce an all-electric A-Class. The vehicle will be manufactured at Daimler's Rastatt plant in Germany...

	Target Release Date	Drive Train	Range (miles)	Top Speed (mph)	Battery Capacity (kWh)	Electric Motor Capacity (kW)
	TBA					
	TBA	EV	249	TBA		
	TBA					
	2012	EV	100	90		
	2012	PHEV	38	TBA		100
	2011	EV	100	80		
	TBA					
	TBA	EV	100	87		
	TBA	PHEV	50	TBA		
	TBA	EV	112	87		
	2012	EV	188	130		
	Now Available	EV	90	80		
	2011	EV	200	90		
	Now Available		62	45km/h		4
	Now Available		62	28		
	2011	EV	124	93		

Appendix B. Electric Vehicle Matrix

Make	Model	Description
Mercedes	B-Class E-Cell PLUS	Plug in hybrid version of the B-Class E-Cell with an all electric range of 62 miles using an 18 kWh battery pack. A 67-hp 1.0L 3-cylinder engine gives the E-Cell Plus a total range of 373 miles.
Mercedes	BlueZero E-Cell	Electric-only version of the PHEV BlueZero E-Cell Plus, based on next generation B-class body style, 35 kWh battery pack. One of three in the BlueZero Family...
Mercedes	S500 Vision	Luxury sedan based on the popular S-class, 10kWh Li-ion battery, 44kW (60HP) electric motor with a 3.5L V6 petrol engine, and 73 mpg...
Mercedes	SLS E-Cell	Sports car with 4 hub motors with a combined output of 392kW and 880Nm of torque. Daimler claims the vehicle will accelerate from 0-62mph in four seconds...
Mercedes-Benz	Onece-in-a-Lifetime Electric Car	
Mila	EV	
Miles	Javlon XS500	
Miles Electric Vehicles, USA	Miles Z40s	
Mindset AG	Mindset	Ultra-lightweight hybrid vehicle with roof-mounted solar panels, gullwing doors, designed by former VW head of design Murat Günak, AER 100-200km based on driving style...
Mitsubishi	‘i’	The Mitsubishi ‘i’ is the North American model of the iMiEV electric car. The ‘i’ is powered by a 47kW AC synchronous motor and a 16-kWh Li-ion battery pack...
Mitsubishi	iMiEV Cargo	The iMiEV cargo is based on the all-electric iMiEV’s body and drivetrain. The back of the vehicle has been completely redesigned from the iMiEV to achieve of 60 cubic feet of storage space.
Mitsubishi	PX-MiEV	4-door, 4-seater, AER over 50km in “10-15 EV cruising” mode, Li-ion battery pack less than 16kWh, permanent magnet electric motors front & rear, 60 kW, 200 Nm...
MM NmG		
Mullen Motor Company	L1X-75 GT	
MyCar		
Myers Motors	Qui Motors	
Myers Motors, USA	NMG	
NevCar		
Nice	Mycar	
NICE and Fiat	Micro Vette	AKA Fiat e500; joint effort between Fiat and NICE, 4 seater, Li-ion polymer batteries, Chrysler will launch the vehicle in the US in 2012...

	Target Release Date	Drive Train	Range (miles)	Top Speed (mph)	Battery Capacity (kWh)	Electric Motor Capacity (kW)
	TBA	PHEV	62	93	18	
	TBA	EV	120	TBA	35	
	TBA	PHEV	19	TBA		
	2012	EV	130	155		
	TBA					
	TBA		150km			
	TBA					
	TBA		50	25		
	Now Available	PHEV	112	87		
	2012	EV	85	81		
	TBA	EV	TBA	TBA		
	2013	PHEV	31	TBA		
	TBA					
	TBA					
	TBA		40	40		
	TBA					
	TBA		30	75		
	TBA					
	Now Available		40	40		
	2012	EV	75	60		

Appendix B. Electric Vehicle Matrix

Make	Model	Description	
Nice, UK	Nice Mycar		
Nissan	Esflow	The Esflow is a concept sportcar of Nissan's new EV family. The Esflow uses technologies developed for the LEAF, with several enhancements, including two twin AC motors, one for each rear wheel of the vehicle.	
Nissan	LEAF	The Nissan LEAF was built from the ground up to be an EV. It is a 5-seater, 4-door hatchback based on Versa/Tida platform. The LEAF has an 80kW electric motor...	
Nissan	NUVU		
Nissan	Townpod	The Townpod is the newest member of Nissan's ZeroEmission family. It is an all electric vehicle, designed to be customized to meet the needs of almost any driver.	
Obvio!			
Opel	Ampera	The Opel/Vauxhall Ampera shares it's platform and E-Flex propulsion system with the Chevy Volt. Like the Volt, it has an all electric range of 56 km, a total range of 610 km, and can travel from 0-100 km/h about 9 sec.	
Optimal Energy	Joule	An all electric car from a South African startup. The Joule will accelerate from 0-100km/h (0-62mph) in under 16 seconds. The Joule's Li-ion battery pack will take 7 hours...	
Peugeot	HX1	The Peugeot HX1 is a plug-in hybrid MPV with a very low roof, resulting in a drag coefficient of only 0.28. The HX1 has four reverse-opening doors and will seat six.	
Peugeot	iOn	A rebadged Mitsubishi i-MiEV, the iOn is a 4-door hatchback, with a 130 km range (standard combined cycle) and a top speed of 130 kph...	
Pininfarina	Nido	2-door smart car-sized, 2-seater, 0-60mph in 6.7 seconds, platform designed to be easily converted into a 4 seater hatchback, small truck, light van...	
Pininfarina	EC		
Pininfarina-Bolloré	BlueCar	AKA B0, Pininfarina & Bolloré joint venture, 4-door hatchback, 5-seater, uses Li-ion batteries & ultracapacitors, recharge 8 hr, quick charge option available...	
Protoscar	Lampo 2	2 seater sports car, based on GM's Kappa platform, 0-62mph in about 5 seconds, powered by two electric motors offering 408 hp, 32kWh of LiIon batteries...	
Quiet Car	1		
Quiet Car	2		
R-Electric Car Co.			
Renault	DeZir	he Renault DeZir is an all-electric two-seat coupe that can accelerate from 0-60 in less than five seconds. 24kWh of Li-Ion batteries are vertically mounted behind the bench seat and provide the DeZir with a 100-mile range.	
Renault	Fluence Z.E.	Family sedan, standard recharge 4-8 hr, quick charge 20 min, "Quickdrop" battery exchange option, using a new body to be introduced in gasoline version in 2009, now taking reservations in EU...	
Renault	Kangoo ZE	The Kangoo ZE is an all-electric compact commercial van that seats two passengers. The Kangoo Z.E. has a curb weight of 1520kg and is powered by a 44kW (70hp) electric motor.	
Renault	Twizy		
Renault	Ze		
Renault	ZOE		

Target Release Date	Drive Train	Range (miles)	Top Speed (mph)	Battery Capacity (kWh)	Electric Motor Capacity (kW)
Now Available		40	40		
TBA	EV	150	TBA		
2011	EV	73	90		
TBA		125km	120km/h		
TBA	EV	TBA	TBA		
TBA					
2012	PHEV	35	100		
2014	EV	140	78		
TBA	PHEV	19	TBA		
Now Available	EV	80	80		
Now Available	EV	87	75		
TBA		153	80		
TBA	EV	155	81		
2011	EV	124	124		
TBA		60	70kph		
TBA		65	50		
TBA					
TBA	EV	100	TBA		
2011	EV	100	80		
2011	EV	100	80		70kW electric motor, 226 Nm of torque
2011		60	47		
TBA					
2012	EV	100	85		

Appendix B. Electric Vehicle Matrix

Make	Model	Description
Renault	Zoe ZE	Compact coupe, standard recharge 4-8 hr, quick charge 20 min, "Quickdrop" battery exchange option, 70kW electric motor...
Reva	G-Wiz	
REVA	NXG	Named for "NeXt Generation", two-seater with a targa roof, designed by Dilip Chhabria, top speed of 130 km/hr, range of 200 km, reserves a % of battery capacity...
REVA	NXR	Named for "NeXt Reva", four-seat, three-door hatchback family car suitable for urban driving. NXR Intercity top speed 104 kmph, range 160 km, Li-ion battery...
Reva Electric Car Company, India	Reva G-Wiz i	
Reva Electric Car Company, India	Reva G-Wiz Li-ion	
Rinspeed	UC	A small two seater that uses joystick steering, top speed at 120km/h, 0-50km/h (31mph) in 4.1 sec, range of 105km (65mi) at 75km/h (47mph), 30kW electric motor...
Rolls Royce	102EX	Based off of the gasoline-powered Phantom, the 102 EX is an all-electric experimental vehicle, designed to evaluate the ultra-luxury electric vehicle market.
Rolls Royce	Electric Phantom	
Saab	9-3 ePower	The ePower is an OEM conversion of the Saab 9-3 SportsCombi wagon. It is powered by 35.5kWh of LiIon batteries and a 135kW (184hp) electric motor, that will bring the car from 0-60mph in 8.5 seconds.
SABA	Carbon Zero	2 door, 2 seater, convertible roadster, 0-60 in 5 sec, 120-140 mi per charge, price not officially announced, will be "affordable"...
SAIC	Roewe 750	4-door sedan, top speed 150 kmph, range 200 km, Li-ion battery, recharge 6-8 hr from Shanghai Automotive Industry Corporation...
Scion	eBox	
SEAT	IBE	SEAT has redesigned the IBE from the original version that debuted at the 2010 Geneva Auto Show. The new IBE is a two-door four-seater sports coupe with 102 horsepower.
Smart	ED	An OEM conversion of the Smart Fortwo. Smart began life as Swatch car in 1998, and was first converted into EV form in 2006. The Smart ED will have 16.5kWh of Li-ion batteries...
Smart	EV	
Smith Electric Vehicles	Edison	Available in as chassis cab, panel van or 15 seater minibus. Uses 40kWh Li-ion Iron Phosphate (LiFePO4) battery, 90kW induction motor, payload up to 3960lbs
Stevens	Zecab	
Stevens	ZeCar	
Stevens	Zevan	
Stevens Vehicles, Wales	Stevens ZEcar	
Subaru	R1e	2-seater with Li-ion batteries capable of 15 min quick charging to 80% SOC, displayed at the 2008 New York Auto Show, it has been in various test programs in Japan...

Target Release Date	Drive Train	Range (miles)	Top Speed (mph)	Battery Capacity (kWh)	Electric Motor Capacity (kW)
2012	EV	62	TBA		70kW electric motor
Now Available		40-48	50		13
2013	EV	124	81		
2012	EV	100	65		
Now Available		48	51		
Now Available		75	51		
2011	EV	65	74		
TBA	EV	120	100		
TBA					
TBA	EV	125	93	35.5	135
TBA	EV	120-140	TBA		
2012	EV	124	93		
TBA					
TBA	EV	81	100		
Now Available	EV	90	70		
TBA		71	70		
Now Available	PHEV	100	50		
TBA					
TBA		110	56		
TBA					
TBA		100	56		
TBA	EV	50	65		

Appendix B. Electric Vehicle Matrix

Make	Model	Description	
Subaru	Stella EV	OEM conversion of mini-car Stella, 4-door, 9.2 kWh lithium-ion battery, recharge 5 hr 240V or 120V, quick-charge to 80% SOC 15 min, 47 kW motor, 125 lb-ft torque...	
Suzuki	Swift PHEV	Popular Swift 4-door hatchback 4-seater model, AER 20km, 2.66kWh 260V Li-ion battery pack, 50kW electric motor, 40kW 660cc engine, front wheel drive...	
Tata Motora	Indica EV		
Tata Motors	Indica Vista EV	4-seater, range 200 km, 0-60 kmph < 10 sec, polymer Li-ion batteries, joint venture between TMETC (Tata) and Miljobil Greland...	
Tazzari	Zero		
Tesla	from BRABUS		
Tesla Motors	Model S	The Model S is a new ground-up 4-door, 7-seat sedan built by California EV startup Tesla Motors. It's range will be based on battery options of 150 mi, 230 mi, and 300...	
Tesla Motors	Roadster	The Roadster is Tesla Motors' first vehicle. It is a high performance 2-seater sports car, capable of accelerating from 0-60 mph 3.7 sec (sport version).The roadster...	
Tesla Motors, California	Tesla Roadster		
The Electric Car Corporation, UK	Citroen C1 ev'ie		
Think	A306		
THINK	City	Two seater City car with 180km range (based on MES DEA Zebra battery, US model will use EnerDel LiFEPO4 batteries). Body is ABS recycled plastic, steel...	
THINK	Ox	An all electric 5-seat, 4-door hatchback, 0-60 mph about 8.5 seconds, Li-ion batteries, recharge to 80% SOC < 1 hr, solar panels in roof power the onboard electronics...	
Think	Nordic AS		
Think, Norway	Think City		
Toyota	2nd Gen. RAV4 EV	The second generation Toyota RAV4 EV is the result of the Toyota and Tesla Motors collaboration. Based on the popular RAV4 compact SUV and powered by a Tesla electric powertrain...	
Toyota	FT-EV	Name from "Future Toyota Electric Vehicle", 2-seater, based on iQ body, will have it's own body style, will get its own body style to create a stand-alone model...	
Toyota	FT-EV II	Named "Future Toyota Electric Vehicle II", second generation of the unreleased FT-EV 2-door micro car, range 90km (56mi), top speed 100kmph...	
Toyota	Plug-in Prius	OEM PHEV conversion based on 3rd generation Prius using Li-ion batteries. All electric range of around 13 miles, while below 100 km/h (62 mph)...	
Velozzi	SOLO	Crossover PHEV, genset powered by a microturbine that can run on a variety of fuels, powered by LiIon batteries and supercapacitors, 100mpg, 0-60mph in 6sec...	
Venturi	Volage		
Venturi, France	Venturi Fetish		
Verde Autos, Ireland	Verde VC-2		
Verde Autos, Ireland	Verde VC-4		
Verde Autos, Ireland	Verde VC-6		

Target Release Date	Drive Train	Range (miles)	Top Speed (mph)	Battery Capacity (kWh)	Electric Motor Capacity (kW)
TBA	EV	50	62		
TBA	PHEV	12	TBA		
Now Available		200km			
TBA	EV	99	71		
Now Available		88	56		
TBA					
2012	EV	300	120		
Now Available	EV	245	125		185
Now Available		220	125		
Now Available		75	60		
Now Available					27
Now Available	EV	111	60		
TBA	EV	155	TBA		
TBA					
Now Available		124	62		
2012	EV	100	TBA		
TBA	EV	93	70		
TBA	EV	56	62		
2012	PHEV	13	112		
2012	PHEV	TBA	130		
TBA			62		
Now Available		155	100		
TBA		50	25		
TBA		50	25		
TBA		37	25		

Appendix B. Electric Vehicle Matrix

Make	Model	Description	
Volkswagen	E-Up!		
Volkswagen	Golf Blue e-motion	The Golf Blue e-motion will be an OEM conversion of the seventh-generation Volkswagen Golf. It will be powered by a 85 kW (114 hp) electric motor...	
Volkswagen	TwinDRIVE	Golf type 6 using VW twinDRIVE® no transmission, 1-liter turbocharged gasoline engine, runs on electric only to 30 mph, then switches to gas engine...	
Volkswagen	Up Blue e-motion	OEM conversion of the Volkswagen Up!, a 2-door mini car that seats 3 adults + 1 child. 130km range, 0-60 mph in 11 sec with 60 kW electric motor...	
Volvo	C30 EV	OEM conversion of two-door, four-seater C30 with 82kW motor and 24 kWh battery pack (22.7 kWh useable), yielding a range of 150 km (approx 94 mi)...	
Volvo	V60 Plug-in Hybrid	The V60 Plug-in Hybird is one of the first ever plug-in diesel hybrids. It will have 3 drive modes: Pure, Hybrid, and Power, offering varying efficiencies and speeds.	
Volvo	V70 PHEV	Unspecified future model, shown as a Volvo V70 PHEV concept car, AER 50 km (31 mi), Li-ion battery, recharge about 5 hr from 240V wall socket, diesel engine...	
Von Mynheer Automotive	CHICO	The CHICO is a summer fun electric vehicle. It is powered by two twin AC motors, which give the CHICO 44kW of power and bring the vehicle from 0 to 60 mph in 12 seconds. The CHICO has a 2+2 seating configuration and allows the rear seats to be folded down for extra cargo space.	
Wheego	Whip LiFe	Two-passenger Smart-sized vehicle with 45kW brushless AC motor, top speed 65mph, 28kW LiFe battery pack, 10 hour charge time at 240VAC...	
XP Vehicles			
Zap	Alias		
ZAP, USA	ZAP Xebra		
ZENN Motor Company, Canada	ZENN		
Zytek			

Target Release Date	Drive Train	Range (miles)	Top Speed (mph)	Battery Capacity (kWh)	Electric Motor Capacity (kW)
TBA		130km			60 kW electric motor, 210 Nm of torque (80-hp and 155 ft-lbs of torque)
2013	EV	93	85		
TBA	PHEV	TBA	TBA		
2013	EV	81	TBA		
2011	EV	94	81	24	82
2012	PHEV	32	TBA		
2012	PHEV	31	TBA		
2011	EV	100	67		
Now Available	EV	100	65		
TBA					
TBA					
Now Available	EV	25	40		
Now Available		50	25		
TBA					

Bibliography

Andrews, C. J. (2008). Energy Conversion Goes Local. Journal of the American Planning Association , 74 (2), 231-254.

Association of Monterey Bay Area Governments. (2010, July). Municipal Facility locations shapefile. Marina, CA: AMBAG.

Association of Monterey Bay Area Governments. (2005). Regional Travel Demand Model files.

Boschert, Sherry. (2006). *Plug-in-Hybrids: The Cars that will recharge America*. Canada: New Society Publishers.

Boyce, Bill, S. M. (2009). Electric Vehicle Infrastructure: Market History and Observations. *September 23, 2009 EV Charging Public Meeting.* Sacramento: California Air Resources Board.

California Air Resources Board. (2008). *Climate Change Scoping Plan: A Framework for Change.* Sacramento: State of California .

California Energy Commission. (2010). 2010-2011 Investment Plan for the Alternative and Renewable Fuel and Vehicle Technology Program. California Energy Commission.

California Energy Commission. (2011). 2011-2012 Investment Plan for the Alternative and Renewable Fuel and Vehicle Technology Program.

California Plug-In Electric Vehicle Collaborative. (2010). Taking Charge: Establishing California Leadership in the Plug-In Electric Vehicle Marketplace. Institute of Transportation Studies at the University of California, Davis. Plug-in Hybrid & Electric Vehicle Research Center.

Chavis, C., Kanairo, K., Samartino, A. L., Sathaye, N., Sidhu, I., Kaminsky, P., et al. (2009, September 18). Strategies for Electric Vehicle Deployment in the San Francisco Bay Area. *Center for Entrepreneurship & Technology Technical Brief* . Berkeley, CA: University of California, Berkeley.

Cheng, I., Desai, D., Koudigkelis, K., de Vasconcellos, P., Kaminsky, P., Sidhu, I., et al. (2008, November 21). Electric Vehicle Charging Infrastructure Rollout Strategy. *Global Venture Lab Technical Brief* . Berkeley, CA: U.C. Berkeley.

County of Sonoma. (2011). Electric Vehicle Charging Station Program and Installation Guidelines. General Services Department. County of Sonoma.

Curtin, R., Shrago, Y., & Mikkelsen, J. (2009). Plug-in Hybrid Electric Vehicles. Ann Arbor , MI: Pacific Northwest National Laboratory; University of Michigan Transportation Research Institute.

Davis, S. C., Diegel, S. W., & Boundy, R. G. (2010). Transportation Energy Data Book: Edition 29. U.S. Department of Energy, Center for Transportation Analysis Energy and Transportation Science Division. Oak Ridge: Oak Ridge National Laboratory.

ECOtality North America. (2001). Blink: Pedestal Charging System Owner's Manual. Phoenix, AZ.

Electric Transportation Engineering Corporation (eTec). (April 2010). *Electric Vehicle Charging Infrastructure Deployment Guidelines for the Oregon I-5 Metro Areas of Portland, Salem, Corvalis and Eugene.* Phoenix: U.S. Department of Energy under Award Number DE-EE0002194.

Electrification Coalition. (2009). *Electrification Roadmap: Revolutionizing Transportation and Achieving Energy Security.* Washington, DC: Electrification Coalition.

Electrification Coalition. (2010). Fleet Electrification Roadmap: Revolutionizing Transportation and Archieving Energy Security.

(ETC), E. T., & Americas, E. V. (1995). Electric Vehicle Community Market Launch Manual: A Guide to Prepare Your Community for Electric Vehicles. U.S. Department of Energy, U.S. Department of Transportation.

EV Charger News. (2009, October 21). *EVChargerMaps*. Retrieved July 8, 2010, from EV Charger News: http://www.evchargermaps.com/?Address=Anaheim&Want=SPI%20LPI%20AVC%20OC&Zoom=9

infoUSA, Inc., ESRI. (2009, 5 15). ArcGIS 9.3.1 Business Analyst . Readlands , CA, USA: ESRI.

Mayor of London. (2009). An Electric Vehicle Delivery Plan for London.

Mightycomm. (2011). Green Vehicle Market Analysis. Los Gatos.

Morrow, K., Karner, D., & Francfort, J. (2008). Plug-in Hybrid Electric Vehicle Charging Infrastructure Review. U.S. Department of Energy Vehicle Technologies Program - Advanced Vehicle Testing Activity.

Puget Sound Regional Council . (2010). Electric Vehicle Infrastructure: Regional Station Siting Analysis.

Puget Sound Regional Council; State of Washington Department of Commerce;. (2010). Electric Vehicle Infrastructure: A Guide for Local Governments in Washington State. Seattle.

PMC. (2010). *Final Supplemental Environmental Impact Report: 2010 Monterey Bay Area Metropolitan Transportation Plan.* Association of Monterey Bay Area Governments. Monterey, CA: PMC.

U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy. (2010). Fuel Economy Guide: Model year 2010.

U.S. Environmental Protection Agency. (1997, April). National Vehicle and Fuel Emissions Laboratory Emissions Models.

Waters, P. M. (2011). Opportunities and Challenges for Plug-in Electric Vehicles.

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