

# SITE DESIGN FOR ELECTRIC VEHICLE CHARGING STATIONS



Prepared by:

**Sustainable Transportation Strategies**

July 2012

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VERSION 1.0

JULY 2012

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## 1 INTRODUCTION

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Sustainable Transportation Strategies prepared this report to highlight best practices for designing electric vehicle (EV) charging stations – those parking spaces where EV supply equipment will be used to charge vehicles. Now that communities are ramping up with installations of EV supply equipment, designers are encountering a host of design issues that are generating creative solutions – and mistakes.

***Now that communities are ramping up with installations of EV supply equipment, designers are encountering a host of design issues that are generating creative solutions – and mistakes.***

This report is intended to be used by persons who are responsible for safe and convenient design of EV charging stations. Many topics covered by this report are beyond the professional responsibility of electrical contractors. The report should be used alongside other resources, including those that cover electrical design standards for installation of EV supply equipment.

*Site Design for Electric Vehicle Charging Stations* addresses the kind of equipment available and how parking facility design offers

both opportunities and challenges for charging station installations. Several design scenarios are illustrated.

## 2 WHAT KIND OF EV SUPPLY EQUIPMENT IS AVAILABLE?

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In the near term, EVs will use the following three categories of EV supply equipment classified according to power levels and circuit requirements:

- AC Level 1, up to 120-volt single-phase circuit with either 15-ampere (amp) or 20-amp configuration.
- AC Level 2, 208-volt to 240-volt single-phase circuit with an 80-amp maximum, but often using 40-amp rated circuits.
- DC fast charger, converts AC power levels rated at 208 volts to 480 volts (3-phase) to DC power to deliver up to 50 kilowatts at the EV's battery voltage.



**Level 1 EV supply equipment**



**Level 2 EV supply equipment**



**DC fast charger**

Both Level 1 and Level 2 EV supply equipment are sometimes called EV chargers – but technically speaking, they are not. Their main purpose is to deliver power to a vehicle’s charging module, or charger. Electric cars all have charging modules on board that convert the EV supply equipment’s AC power to DC and deliver it to the battery according to manufacturer-specified rates (typically expressed as kilowatts). In contrast, a DC fast charger bypasses a vehicle’s on-board charger to directly deliver power to the vehicle’s battery.



**Neighborhood EV at Level 1 EV charging station**

Level 1 EV supply equipment can recharge the battery of a standard electric car within 4 to 6 hours if it is driven less than 30 miles per day. For Level 1 charging, vehicles plug into a typical electrical outlet (NEMA 5-15R or 20R) using a portable cable set supplied by the vehicle manufacturer. Most new electric cars are equipped with a Level 1 cable outfitted with a J1772 connector that plugs into the vehicle. This is the same connector used for Level 2 charging. Since 120-volt circuits are so ubiquitous,

Level 1 EV supply equipment is the easiest and least expensive type to install.

Level 1 charging is less useful for completely recharging large battery packs found in trucks and many electric cars. Fully depleted, a 24-kilowatt-hour battery could require

15 to 20 hours to charge using Level 1 EV supply equipment.<sup>1</sup> Level 2 EV supply equipment can fully recharge the same battery in less than 4 hours.<sup>2</sup>

Level 2 EV supply equipment operates on circuits with a capacity similar to those that run appliances, such as electric ovens and clothes dryers. Some Level 2 equipment used at commercial sites runs on circuits rated at up to 80 amps. Level 2 EV supply equipment and DC fast chargers have the charging cable and connector permanently affixed.



**J1772 connector**

Various designs of Level 2 EV supply equipment can attach to ground surfaces, walls, posts, poles, and ceilings.



**Level 2 EV charging cable retracts**

The majority of EV supply equipment being sold can charge one vehicle at a time but models are available that can connect with two to four vehicles at once. In some cases, single units have connectors for both Level 1 and Level 2 charging.

Most Level 2 EV supply equipment installed in the past few years utilizes simple cable storage where the cable is manually wound around a holder attached at the bottom or side of the unit. Some styles include cable management systems where the cable retracts back to the unit at a height where the cable can be suspended rather than lying on the ground during operation. Pedestal units that suspend the cable during use are necessarily taller than those that do not.

<sup>1</sup> Electric Transportation Engineering Corporation. (2010, April). Electric Vehicle Charging Infrastructure Deployment Guidelines for the Oregon I-5 Metro Areas of Portland, Salem, Corvallis and Eugene.

<sup>2</sup> This assumes the battery is connected to a charging module using a 6.5-kilowatt rate.



**Level 2 EV charging cable automatically lowers from ceiling**  
(photo courtesy of EVSE Ltd.)

Overhead systems drop the cable down level with the vehicle's charging inlet when triggered by local or remote control.

DC fast chargers will be important to drivers who need to quickly recharge their depleted batteries. Using DC fast chargers, most vehicles will recharge up to 80 percent of capacity in 30 minutes or less.

DC fast charging is just beginning to become available to consumers in the U.S., and it appears that two charging standards will be in use.

Two companies offer fast charging

inlets as an option on their vehicles imported to the United States: Nissan and Mitsubishi. Both use the Japanese CHAdeMO connector. The Society of Automotive Engineers is expected to adopt a different standard in 2012, a modification of the J1772 connector that will support DC charging as well as Level 1 and Level 2 AC. Three major U.S. automobile manufacturers and five manufacturers from Europe plan to use this "J1772 combo connector" starting in 2013.<sup>3</sup>



**CHAdeMO connector (below) and J1772 connector (above)**

Several brands of EV supply equipment offer advanced electrical metering that tracks power usage as well as communication network connections to transmit power usage and other data. Networked EV supply equipment can perform a number of services. Drivers are able to remotely check on the status of networked equipment, determine where units are available, and make reservations. Networked EV supply equipment with meters can support "smart grid" applications. As an example, utilities can send signals that reduce EV charging when grid loads are high or initiate charging when electricity costs are low. Better control of electrical flow by location and time is likely to make smart grid applications profitable for both utilities and consumers.

<sup>3</sup> Ponticel, Patrick. (2012, May). "J1772 'combo connector' shown at the 2012 Electric Vehicle Symposium." Prepared for SAE International. Found at: [www.ev.sae.org](http://www.ev.sae.org).

### 3 DESIGN NEEDS FOR OPERATING EV SUPPLY EQUIPMENT

EV charging introduces equipment and a new set of activities into parking facilities. Safe and convenient operation of the EV supply equipment requires sufficient space. Designing EV charging stations also requires consideration of the parking facility design and the patterns of how it is being used. Adequate functioning of the parking area itself should not be compromised by poor EV charging station design.

Most public charging station installations are of Level 2 EV supply equipment. People who operate Level 2 EV supply equipment will normally plug in at places where they

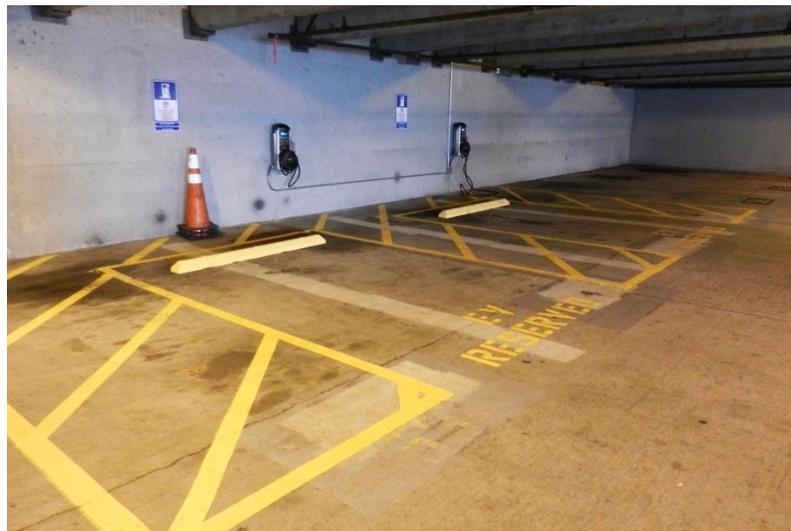
***A person needs room to stand in front of the EV supply equipment and operate it – about a 3-foot by 3-foot space.***

have scheduled activities. During charging, the vehicles will be unattended for several hours or overnight.

Level 1 charging, which requires more time, follows this same pattern of parking and leaving the vehicle. Use of DC fast chargers will differ. This high-powered equipment is designed for commercial and other public settings.

Because people will plug into DC fast chargers for only about 10 minutes to 30 minutes, most will either wait at their vehicle or walk a short distance to nearby services and shopping.

Charging station designers usually site EV supply equipment near the front of the vehicle so that the cable can reach charging inlets where they are located at the front and sides of vehicles. For these types of installations, a person needs room to stand in front of the EV supply equipment and operate it – about a 3-foot by 3-foot space. Public parking design generally does not include room for activities at the front of the vehicle. Retrofitting existing spaces with EV supply equipment requires finding parking stalls that are already long or have space in front that can be adapted for EV charging.



**Striped pavement designates space to operate EV supply equipment**

Persons with disabilities need additional room to maneuver while charging a vehicle<sup>4</sup>. A person in a wheelchair needs maneuvering room including space at or near the EV supply equipment to turn around.

Space is also needed to the sides of the vehicle to maneuver the charging cable. Unfortunately, cables placed on the ground do not always lie flat. Level 2 cables are about 3/4 inches in diameter with a typical length of 18 feet to 20 feet (allowable up to 25 feet).

The portable Level 1 cables are smaller in diameter and more manageable. Designing additional space alongside the vehicles creates better conditions for using the cables and also helps pedestrians avoid tripping.



**Cables can create tripping hazard**



**Suspending cable assists with handling**

exposure to weather and eliminate having cables lie on the ground. This equipment eliminates the tripping hazard and the cables do not become buried in accumulations of snow and ice.

DC Fast charger cables using the CHAdeMO connector measure over 1 inch diameter, and in combination with the connector, are heavy. Consequently, several DC fast charger manufacturers are designing their equipment so that cables remain suspended and require little lifting.

Some EV supply equipment uses a combination of suspension and retraction of the cable to reduce



**Suspended, retractable cable prevents the cable from being buried in snow or ice (photo courtesy of EVSE Ltd.)**

<sup>4</sup> Mayfield, David. (2012, February). EV Charging for Persons with Disabilities. Found at: <http://www.sustainabletransportationstrategies.com>

## 4 PARKING FACILITY DESIGN

Municipally owned public parking often serves entire neighborhoods. This differs from parking that serves specific destinations like retail entrances, where property owners orient customers towards specific entrances. Routes from parking at multi-unit dwellings are designed in both manners and can be either diffuse or focused to specific building entrances. Where parking is focused towards specific destinations, parking near the destination entrance is the most frequented and popular. Charging station designers need to consider whether to avoid or use the most frequented parking spaces.



**Trenching long distances to install electrical conduit raises costs**

EV charging joins a number of activities that regularly occur in parking facilities other than just parking and walking. Parking facility designers have to address service, delivery, and transit vehicles mixing with other traffic in public parking areas. Parking fee collection can include entry payments or kiosks. Retail outlets require planning for shopping carts or other means for transferring goods. Parking lot maintenance activities include debris and snow removal.

Surface parking, which is very common in the United States, extends over a considerable area of developed sites. Designers orient surface parking to serve the one or more destinations by making it as convenient as possible to park and walk. Major layout elements include the parking stalls, traffic entrances and aisles, sidewalks, and landscaping.

Surface parking is typically paved with asphalt concrete, although brick, paving blocks, gravel, and other materials are encountered. Trenching through and then repairing pavement during electrical conduit

installation can amount to a significant portion of total installation costs. Some hardscape surfaces cannot be repaired without a substantial change in the design of the facility. Disturbing these surfaces should be avoided where aesthetic considerations are important. Installations also should be avoided in areas subject to flooding.

## 4.1 PARKING SPACES



Angled, 90-degree, and parallel parking

The wider and/or longer parking spaces in a parking facility are usually best for installing EV charging stations. Extra space is needed to accommodate the new equipment and

its operation. Finding adequate space plus factors such as power availability, ADA accessibility, and convenience helps identify potential EV charging sites.<sup>5</sup> As with all publicly available parking facilities, the first EV charging station should be ADA-accessible and similarly located as the site's designated accessible parking: near a building entrance with an accessible pathway. Obstacles such as curbs will affect the ability to reach operable parts of the EV supply equipment from a wheel chair. To make the site suitable

for persons with disabilities, the ground surface should be firm, level (with a slope no more than 2 percent in any direction) and smooth (obstacles less than ¼ inch).<sup>6</sup>

***The wider and/or longer parking spaces in a parking facility are usually best for installing EV charging stations.***

<sup>5</sup> Mayfield, David. (2012, April). Siting EV Charging Stations. Found at: <http://www.sustainabletransportationstrategies.com>

<sup>6</sup> Mayfield, David. (2012, February). EV Charging for Persons with Disabilities. Found at: <http://www.sustainabletransportationstrategies.com>

Parking lot designers orient parking spaces either perpendicular, angled, or parallel to traffic flow. Of these, installations are easiest where the parking is perpendicular or angled. Many parking lot designers use perpendicular parking because of its spatial efficiency. Parking layouts with 60-degree and 70-degree angles are also common and effective choices used by designers. Parking stalls typically range from a "standard" 9-foot by 18-foot space to compact sizes that are 8 feet by 12 feet. Newer facilities usually include areas for bicycles and in some cases, parking stalls for motorcycles.

Some parking lot designers shorten parking stall length when it is assumed that the vehicle can overhang the curb. Where charging stations are added to this type of parking stall design, wheel stops or bollards may need to be added to prevent damage to the EV supply equipment – or existing wheel stops may need to be moved back. When moving back wheel stops, adequate parking aisle width will need to be preserved.



**Moving wheel stops back can prevent vehicles from damaging EV supply equipment**



**Pedestal-mounted EV supply equipment well-located at angle parking**

Angled parking often creates triangular unused spaces suitable for operating EV supply equipment. In many cases, the curb can be used as the barrier to protect the equipment and no bollards or wheel stops are necessary. Where parking is designed at angles less than 60 degrees, the EV supply equipment may need to be moved to the center of the parking space so that the cable can reach the back side panel of a vehicle.

Parallel parking presents the greatest challenge to safe EV charging station design. EV manufacturers have not standardized which side of the vehicle has the recharging inlet. With parallel parking, the J1772 connector and inlet can be exposed to traffic. Parking space and street width are important considerations because of moving vehicles.



**Parking protected by painted stripes**



**Bike lane buffers EV charging from traffic**

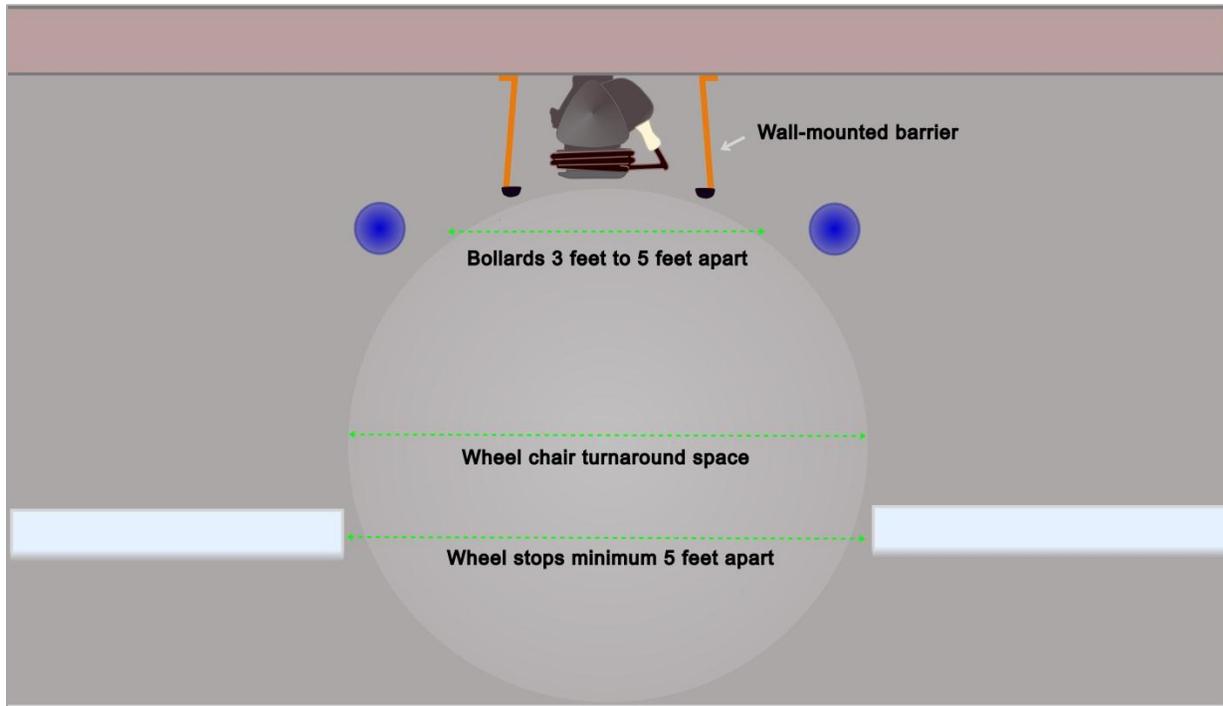
Bike lanes can buffer on-street charging stations from traffic lanes. However, a cable lying on the ground can contribute risk to passing bicycles and pedestrians. EV supply equipment with cable management is recommended to reduce risk in this situation.

On-street EV charging can be safely conducted where the parking is inset into a curbed area. In this example, additional pavement striping helps separate the vehicle from the traveled way.

Parking facilities use barriers such as curbs, wheel stops, railing, wall-mounted barriers, and bollards to protect property and equipment. These barriers also help define the separation between parking and other uses such as landscaping and pedestrian spaces.

Wheel stops are widely used barriers, especially along parking lot perimeters. Some EV charging stations introduce wheel stops to a parking facility to protect the EV supply equipment. They are economical to install but have disadvantages such as being a potential tripping hazard and adding to maintenance cost by making sweeping or snow removal more difficult.

During charging station installation, existing wheel stops may need to be removed or replaced by shorter wheel stops to create adequate access for persons using wheel chairs or walkers.



**Barriers can be designed to provide turnaround space for wheel chairs**

Parking facility designers minimize potential tripping hazards of all types both to protect the public but also to reduce liability claims. Compared to wheel stops, bollards create very little tripping hazard. However, they are comparatively more costly to install. Where bollards are used at charging stations, they should be placed a minimum of 3 feet apart – but less than 5 feet apart to block vehicles.

The City of Bellevue, Washington has installed wall-mounted barriers at a number of charging stations to provide an effective way to protect EV supply equipment without adding barriers at the floor level.<sup>7</sup>



**Wall-mounted barriers offer an alternative to wheel stops and bollards**

<sup>7</sup> Luetzgen, Kim. (2012, June). Personal Communication. City of Bellevue Facilities Operations Specialist.

## 4.2 LANDSCAPING

The location and type of landscaping helps define pedestrian movements, and thus influences charging station siting and design. Shrubby landscaping to the front or side of a parking stall can orient pedestrian travel towards the rear of the vehicle. Conversely, lawns can attract activity.

Landscaping adjacent to surface parking offers places to install EV supply equipment without disrupting adjacent sidewalks and pavement. However an assessment should be conducted to select a site where roots vital to mature trees and bushes will not be damaged.



**EV supply equipment can reach two parking stalls (Photo courtesy of Capital District Transportation Committee)**

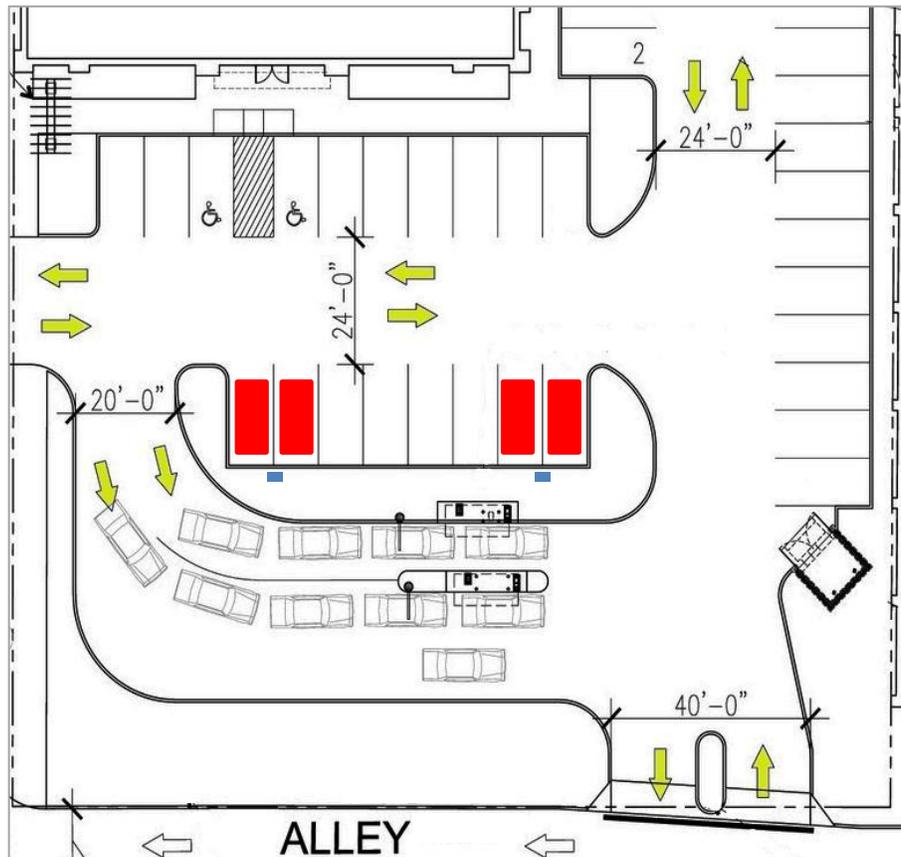
Where perpendicular parking stalls face into landscaping, some local development and zoning codes allow the first 2-3 feet beyond a continuous curb to be considered part of the parking space. In these cases, the appropriate setback for EV supply equipment needs to be modified. Bollards or wheel stops may be needed to protect the EV supply equipment from encroaching vehicles.



**EV supply equipment placed in landscaping at Durham NC's south regional library (Photo courtesy of Robert Shuler, North Carolina Department of Insurance).**

### 4.3 PARKING AISLES

Once vehicles enter a parking facility, they circulate using parking aisles. To fit an EV charging station into existing parking, designers seek sites that avoid unsafe encroachments into parking aisles.



**Charging stations for parking marked in red would preserve parking aisle width and not interfere with pedestrian circulation**

Local code typically specifies acceptable widths for design of parking aisles. They are sized to create a safe space for drivers to safely back out of the stalls and provide adequate distance behind parked vehicles to reduce conflicts with traveling vehicles.

Parking aisles also serve as informal pathways for pedestrians and for loading and unloading activities. For this reason, factors such as site distance and aisle width need to be checked as part of designing EV charging stations.

Standard design widths for parking aisles are greatest where the parking angle is 90 degrees and traffic flows in both directions. Parking aisle width is narrowest for parking at acute angles (30 degrees, for example) where traffic is flowing in only one direction.

## 4.4 PEDESTRIAN FACILITIES

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The best facility designs separate pedestrian activities from traffic to minimize conflict points and increase safety. Existing sidewalks, paths, and informal walking routes should be identified for protection prior to designing a charging station.

Some charging station installations site EV supply equipment and signs on an existing sidewalk. This can only be safely accomplished if the sidewalk is wide enough to accommodate the equipment and safe pedestrian clearance. The equipment, the attached cables, and the signs all need to be placed so that they are not unsafe obstacles or tripping hazards. Designs should never have cables cross designated walkways. Consideration should be given to tripping hazards for pedestrians moving from adjacent parking to the sidewalk.

Adequate sidewalk width should be maintained for passing pedestrians and wheel chairs. Federal guidelines specify that a minimum clear width for a wheelchair is 36 inches, pinching down where necessary to 32 inches for distances of less than 24 inches. Applicable building codes address sidewalk width standards that can be stricter than this federal rule.

Creating an ADA-accessible charging station requires identification of the shortest accessible route from EV charging to the destination. The identified route should try to take advantage of each site's design strengths and improve or avoid design flaws.



**The best parking facility designs separate pedestrian routes from traffic**

## 4.5 PARKING STRUCTURES

Parking structures stack parking in a compact footprint that often reduces the average distance from parking to a destination.

Parking structures not only protect EV charging stations from weather, but also create opportunities for cost-effective installations. Charging stations can be located near an electrical room, an existing electrical panel, or elevators where existing power and available conduits may be located. Installation of new conduit is most efficiently done by surface mounting onto walls, beams or ceilings. Wall-mounted charging stations with surface-mounted conduit tend to be the most cost-effective.

Ceilings offer some installation advantages. Ceiling beam-mounted conduit can avoid vehicular damage by being mounted near the wall. Ceiling-mounted EV supply equipment, as shown in Section 2, avoids tripping hazards that could be caused by cables lying on the floor.



**Ceiling-mounted conduit located near wall**

Parking structures typically have floors composed of reinforced concrete. Installation costs rise when new conduit requires boring through structural elements. Parking structures with structural steel embedded within the concrete can be evaluated by using ground penetrating radar to reveal locations of conduit, rebar, and post-tension cable.



**Existing ADA-compliant parking near elevators**

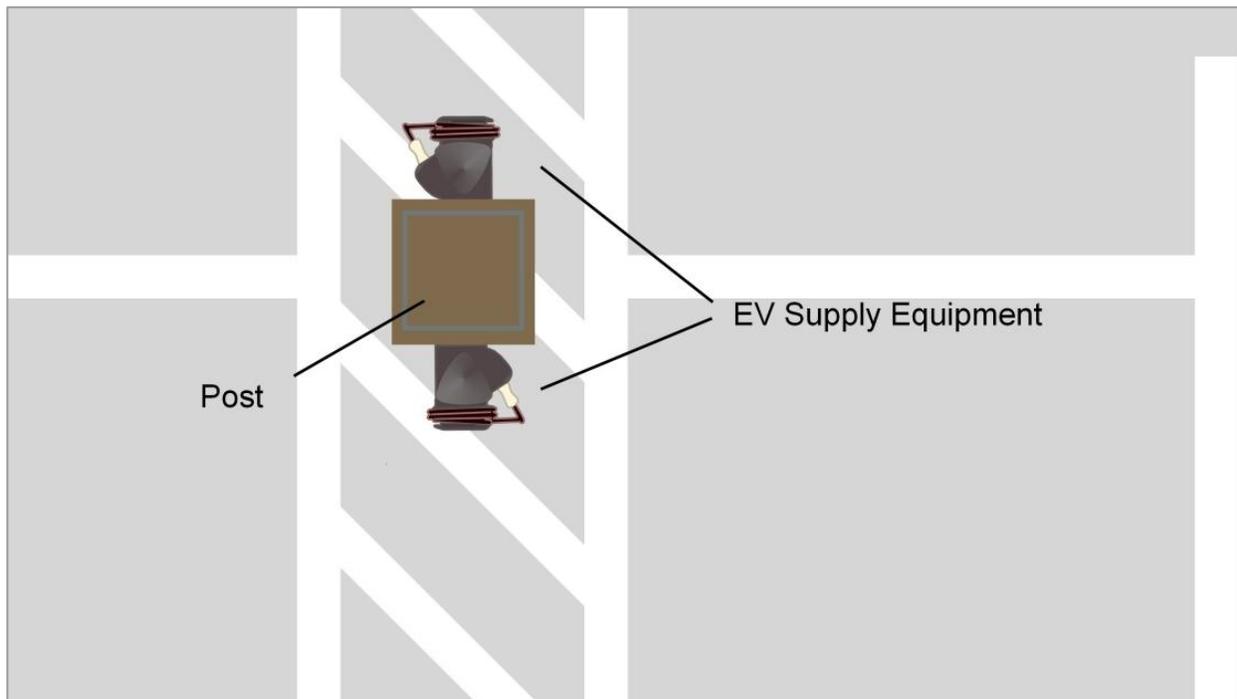
Parking in basements creates the greatest difficulty for reliable communications for networked EV supply equipment because the surrounding structure blocks wireless signals.

Parking structures commonly have parking stalls on sloping ramps. If the charging station is intended to be accessible for persons with disabilities, it should avoid sloping areas and be installed at level parking spaces (less than 2 percent slope in all directions). Existing ADA-accessible parking is usually located in such spaces adjacent to elevators.

Posts and poles can provide good opportunities for mounting a charging station. Posts and poles often have buffer space or barriers that would also protect EV supply equipment attached to, or adjacent to them. The EV supply equipment should be oriented so that the post protects the equipment from adjacent parking. In some cases, there is no need for additional protection such as bollards or wheel stops.



**This installation inset between posts includes no wheel stops or bollards**



**EV supply equipment oriented so that buffer between parking stalls protects both the post and the equipment**

Functional needs of parking areas change over time. Parking structures older than the 1970s were created for larger vehicles and many now have underutilized areas within the facility where EV charging stations can be sited without interfering with other activities.



**Former drive-up ATM converted to EV charging**



**Charging station added to hotel entrance**  
(Photo courtesy of Capital District Transportation Committee)

Structures that are not built as parking infrastructure can also be adapted for EV charging – places such as the covered entrance of a building or a free-standing solar canopy.



**Solar canopy with EV supply equipment**

## 4.6 ELECTRIC AND CELLULAR INFRASTRUCTURE

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### ELECTRIC INFRASTRUCTURE

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**From left to right: (1) pole-mounted transformers; (2) surface-mounted transformer and electrical panels; (3) circuit breakers in electrical panel**

Electric infrastructure at a parking facility may consist of:

- Utility-owned electric distribution cables located underground in conduit or overhead on utility poles.
- Utility-owned and privately-owned transformers. Transformers are typically located at ground level or on utility poles.
- Utility-owned electrical meters.
- Electrical panels and electric cables that distribute electricity across the site.

Choices for connecting to electric power include opening a new service with the utility (including a new meter) or using an existing meter with a new or existing electrical panel. If a new electrical panel is not already being planned as part of the EV charging station installation, existing infrastructure will need an electrical load study to determine if it has adequate capacity for the EV supply equipment. A professional licensed electrician working with the local utility can evaluate the service load and adequacy of existing infrastructure to support the EV charging station installation. Upgrades could require a new electrical panel or transformer.

Installation of an EV charging station typically requires a dedicated cable in conduit from an electrical panel to the EV supply equipment. Level 1 and Level 2 EV supply equipment installations are most cost-effective if the service load evaluation supports using an existing electrical panel and the charging station can be located nearby.

## COMMUNICATIONS

Parking facilities vary in terms of available communications. Many of the functions that EV supply equipment perform depend upon communications between the equipment and a network service. The three methods for communication relevant to EV charging stations are Wi-Fi, cellular, and Ethernet.



**Cellular modem for group of EV charging stations**

Most EV supply equipment are designed with a number of potential communication pathways since the equipment is be used in a variety of settings. Residential installations of Level 2 EV supply equipment can connect to the internet using Wi-Fi or a personal area network protocol that communicates with an existing home area network.

Public and commercial EV supply equipment can connect to an internet provider through a local area network; however, most of commercial charging stations use cellular technology to become networked. A cellular wireless modem can establish connections with many charging stations using either Wi-Fi or a personal area network technology and then route the data to a network

service. Groups of EV supply equipment installed at the site can use mesh communication technologies to better ensure correct data transmission to the modem. With mesh, EV supply equipment located in the same area receive and re-transmit data among the group. Units farthest from the main cellular modem need only to transmit their data to other nodes that can communicate with the modem. As an example, the ChargePoint<sup>8</sup> network technology uses mesh technology to group up to 25 EV supply equipment with a single modem.<sup>9</sup>

Adequacy of signal strength can be readily checked in parking structures and in underground garages where effective transmission can be difficult. If impenetrable



**Directional antenna sends data from remote parking location**

<sup>8</sup> ChargePoint is a national EV charging network that offers a variety of services.

<sup>9</sup> DiNucci, Mike. (2012, April). Personal Communication. Coulomb Technologies.

surfaces interfere with the wireless signals, signal repeaters or amplifiers can be installed to extend the radio frequency signal. Ethernet cable might be necessary to extend the signal to a location with strong, reliable signal quality.

It may be desirable to communicate to a network from a remote outdoor location. Additional hardware such as a directional antenna and a repeater usually can improve reliability of data transfer in these situations.

Steps can be taken to minimize the need for signal repeaters, including:

- Test signal strength at several alternative charging station sites.
- Locate equipment where physical barriers such as concrete walls will not block wireless service.
- Avoid locations near other electrical equipment known to interfere with signals, such as electric motors and fluorescent lights, and
- Install away from other wireless devices emitting the same signal frequency.

## LIGHTING

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Almost all parking facilities are designed with lighting. For safety, a minimum luminance of 0.2 foot-candles is recommended.<sup>10,11</sup> Locations where charging stations will be installed should be checked for night-time illumination levels between parked cars especially if the style of EV supply equipment being used has cables that extend along the ground between the EV supply equipment and the charging port on the vehicle. Dim lights and cables along the ground could create a tripping hazard.

Adequate lighting may also reduce vandalism of the EV supply equipment and theft of small EVs such as electric-assisted bicycles.



**Area lighting for parking safety**

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<sup>10</sup> 1 foot-candle is the luminance cast on a 1-foot square surface by 1 lumen (originally defined as the light of one common candle).

<sup>11</sup> Batinsey, John. (2006). Outdoor Lighting Ordinance Guide. Found at [http://www.nj.gov/dep/opsc/docs/Sample\\_Lighting\\_Ordinance.PDF](http://www.nj.gov/dep/opsc/docs/Sample_Lighting_Ordinance.PDF)



Lighting installed above EV charging station

Codes and standards of most local jurisdictions describe illumination requirements and restrictions on public and private property. Some business practices and ordinances require dimming of area lighting after close of business. This should be a factor in designing charging stations planned for 24-hour public access.

Some EV supply equipment includes lighting. Adding supplementary lighting could be as expensive as installing the EV charging station.

EV supply equipment that utilizes vacuum florescent display screens offer readable messaging under almost any lighting condition, including bright sunlight. However, some charging station screen types cannot easily be read in direct sunlight and should be shaded or sited such that they are facing away from direct sunlight.

## 4.7 SIGNAGE

To help the public, signs need to be well located, recognizable, and readable. Federal and local standards seek clarity and uniformity in use of words, symbols and colors. Almost all signs follow the rule of "one concept per sign."

### Uniform Sign Colors

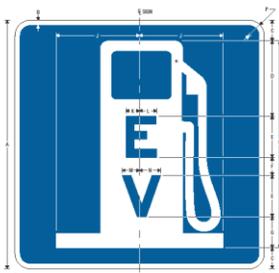
- Red:** *Stop or Prohibition*
- Green:** *Guidance, Permissive Activities*
- Blue:** *Services, Information*
- Black/White:** *Regulatory*



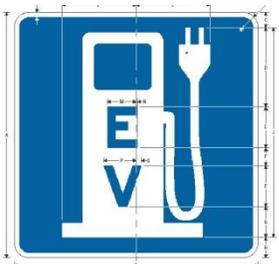
"One concept per sign" installation

Federal Regulations specify the Manual on Uniform Traffic Control Devices (MUTCD)<sup>12</sup> as the national standard for signage used to inform people using public right-of-way and private roads open to public travel. MUTCD includes standards on lettering height, the size of the sign, and mounting heights based upon distance from the viewer and assumed traveling speed. These regulations are not required in parking areas including parking aisles. A number of EV-related signs in use are not consistent with MUTCD signage standards including color-coded messaging.

The MUTCD has a standard sign for identifying EV charging stations. In 2011, the Federal Highways Administration agreed to an interim alternate to that standard and will grant jurisdictions approval to use it upon written request. A state may request approval to use the alternate symbol for all jurisdictions in that state.<sup>13</sup>



**MUTCD standard EV charging station symbol**



**MUTCD alternate symbol**



**Way finding sign at freeway off-ramp**

Way finding signs that direct drivers to EV charging stations are best placed where they are easily seen but will not cause safety issues by blocking an important view or creating a hazardous barrier.

Signage at a charging station helps identify parking stalls associated with EV charging and inform persons about the rules associated with parking there. Signs inform drivers on topics such as identification of EV charging stations, parking restrictions, and

<sup>12</sup> FHWA. (2009). Manual on Uniform Traffic Control Devices for Streets and Highways 2009 Edition.

<sup>13</sup> Lindley, Jeffrey A. (2011, April). MUTCD – Interim Approval for Optional Use of an Alternative Electric Vehicle Charging General Service Symbol Sign. FHWA Memorandum to Federal Lands Highway Division Engineers and Division Administrators.

enforcement, such as towing. To avoid confusion, each parking stall should have signage. Local regulations often determine sign placement and other standards.

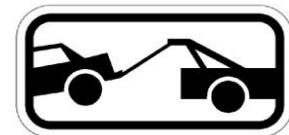


Signs from left to right: (1) Identifies EV charging station; (2) EV permit required; (3) restricts parking space to EVs only (middle and right photos courtesy of Greater Long Island Clean Cities Coalition)



EV charging station marked with paint

While MUTCD sign standards are not required in parking facilities, the use of these readily recognizable symbols is recommended.



MUTCD standard for tow-away signage

Some designers of EV charging stations add to signage by painting the entire charging station space a separate color in order to distinguish it from regular parking.

An important factor with designing sign installations is to not place the sign in the path of pedestrians or ADA-accessible aisles where it could create a hazardous barrier. At pedestrian pathways in the street right-of-way, the MUTCD requires a vertical clearance of at least 7 feet to the bottom of a sign.



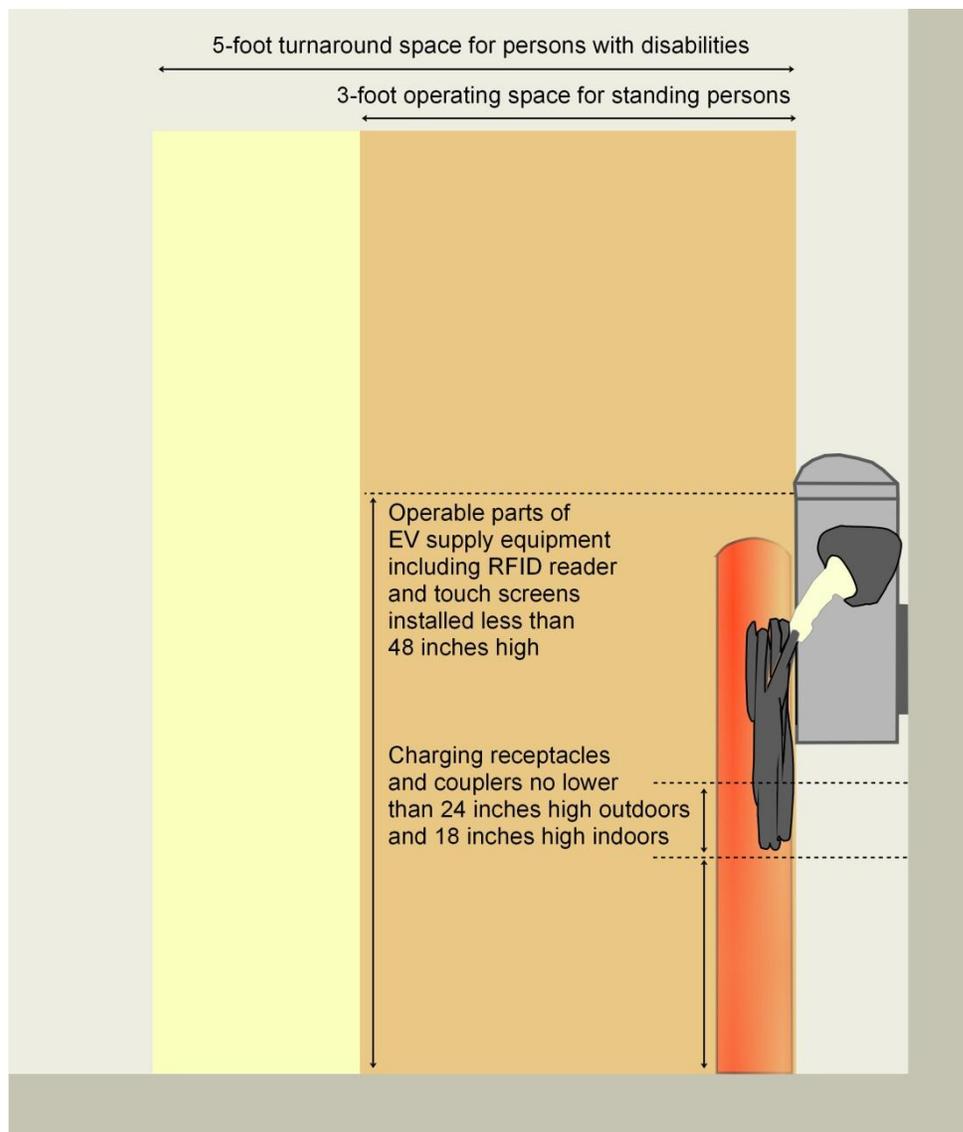
**Directional sign in parking garage (Photo courtesy of Greater Long Island Clean Cities Coalition)**

## 5 EV CHARGING STATION DESIGNS

The following section builds upon best practices from installations across the U.S. to provide sample layouts of EV charging stations. These designs, which use national standards, are available to be adapted to local specifications. Layouts that are accessible for persons with disabilities will be noted.

### 5.1 CHARGING STATION PROFILE

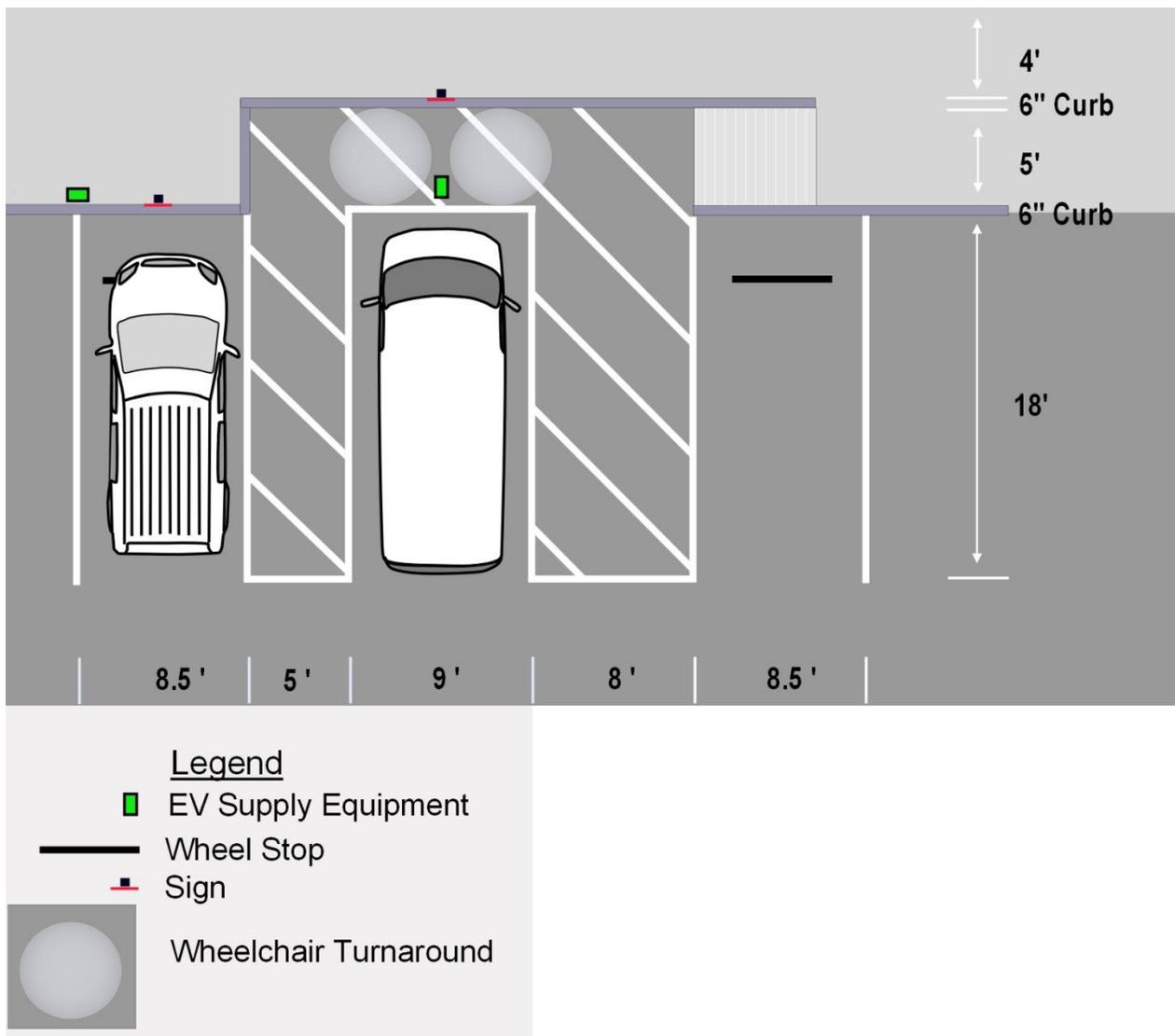
The side view of a charging station depicted below features wall-mounted EV supply equipment. Measurements are derived from federal ADA standards and the National Electric Code Article 625.



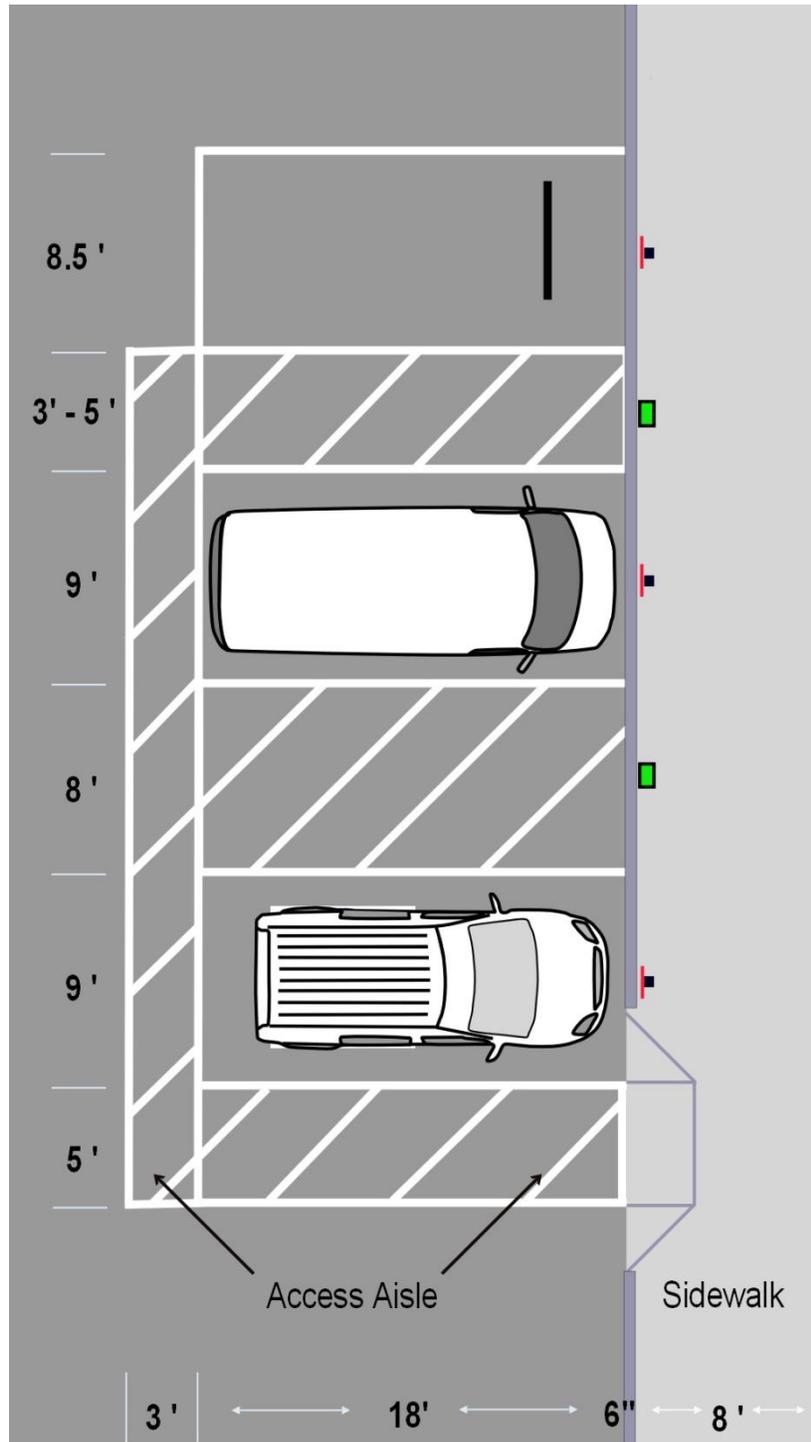
## 5.2 CHARGING STATION LAYOUTS

This design shows two charging stations. The charging station on the right is ADA-van accessible. The charging station left of the van space is not fully ADA-accessible.

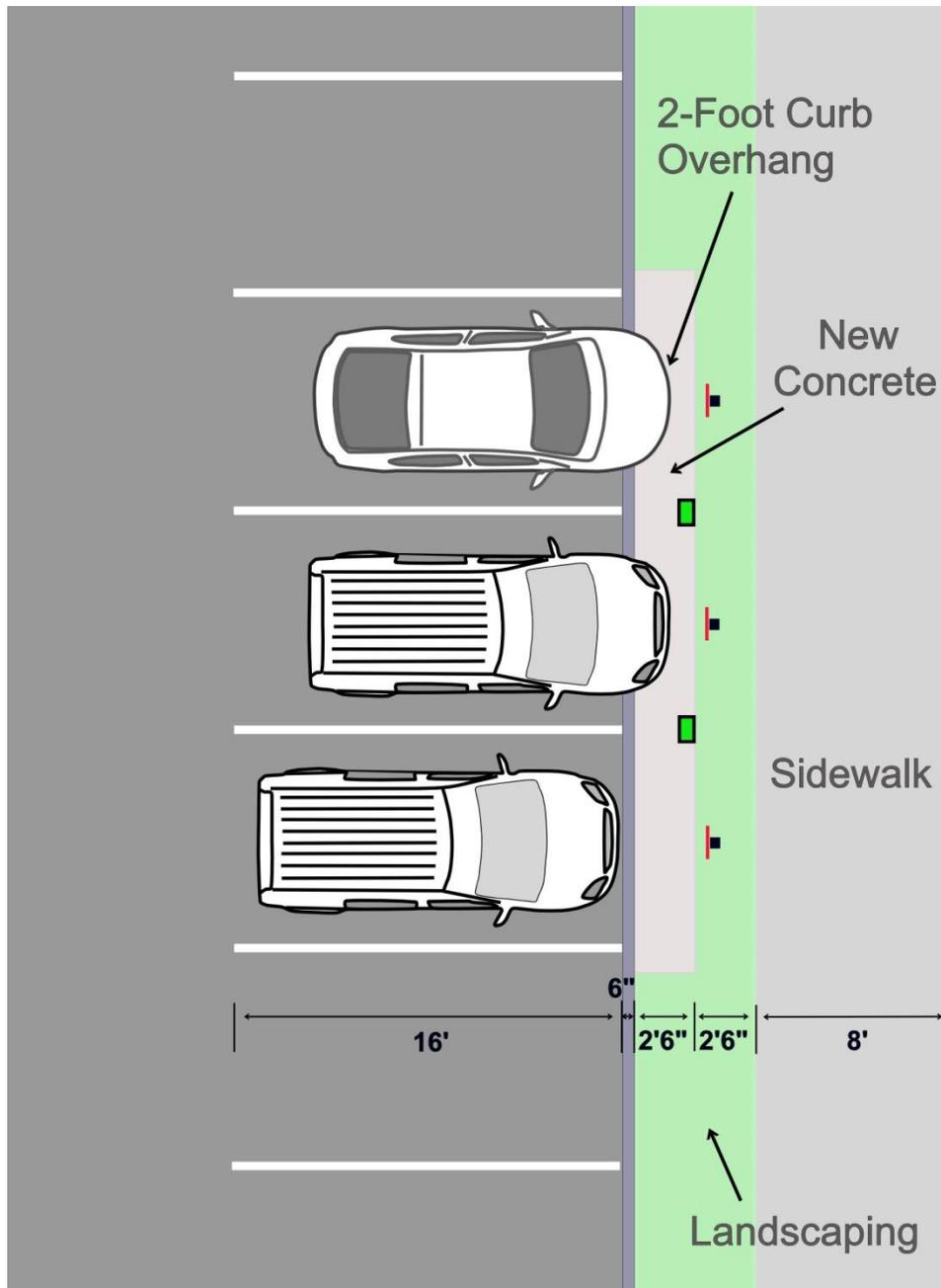
The van-accessible charging station has wheelchair access to the front and sides of the vehicle. An accessible ramp leads to the sidewalk. The EV supply equipment is oriented sideways in front of the parking stall to facilitate use by a person in a wheelchair. Circular turnaround space for a wheelchair is indicated on both sides of the EV supply equipment.



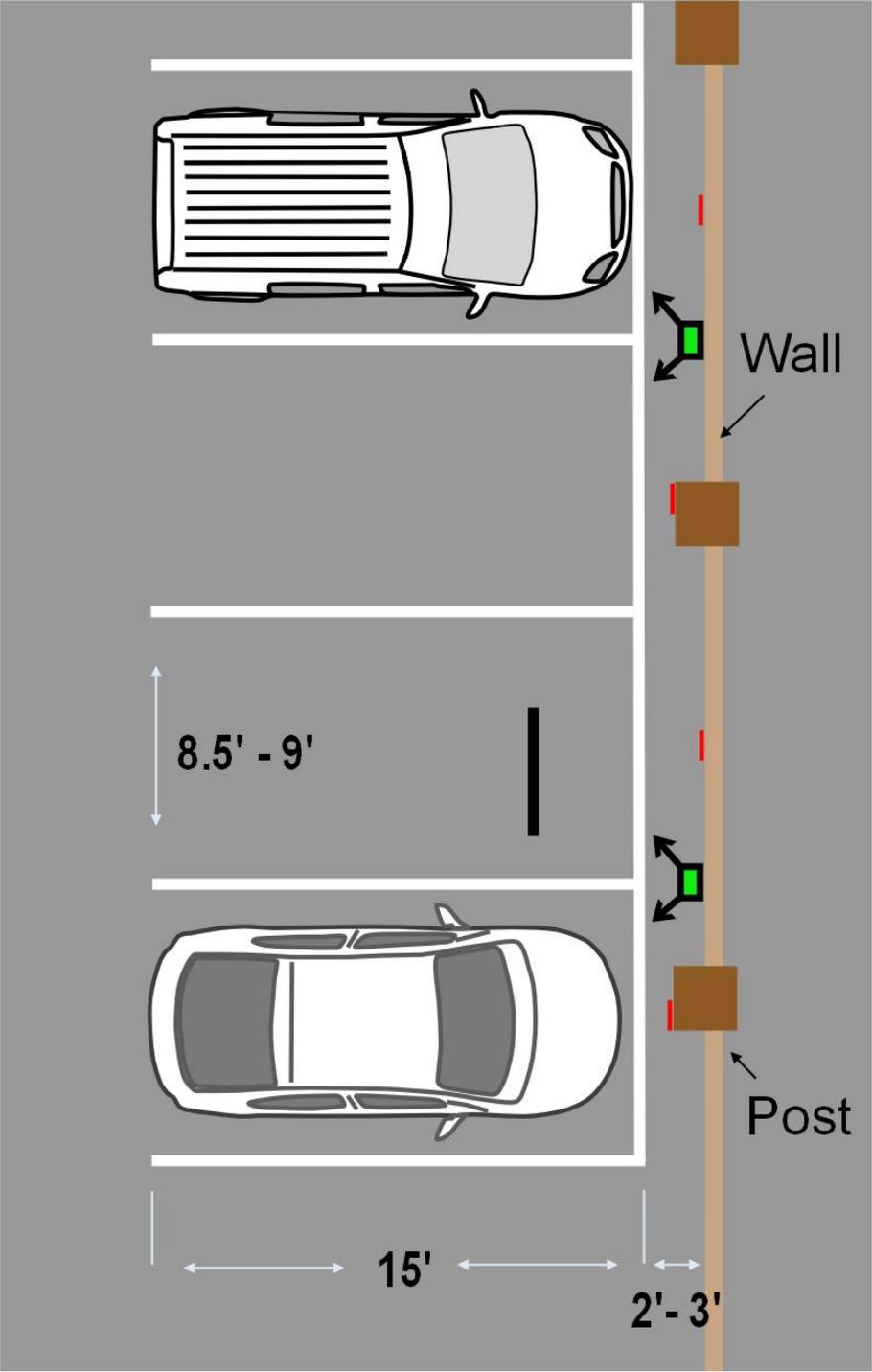
Wheelchair access to the rear of the parking stalls is illustrated in this ADA-accessible charging station layout. The access aisle is clearly marked and connects to the sidewalk by an accessible ramp. Striped areas at the sides of the vehicles are for moving in and out of the vehicle and using the charging cable. Curbs separate these areas from the sidewalk to discourage their use as access aisles connecting to the sidewalk.



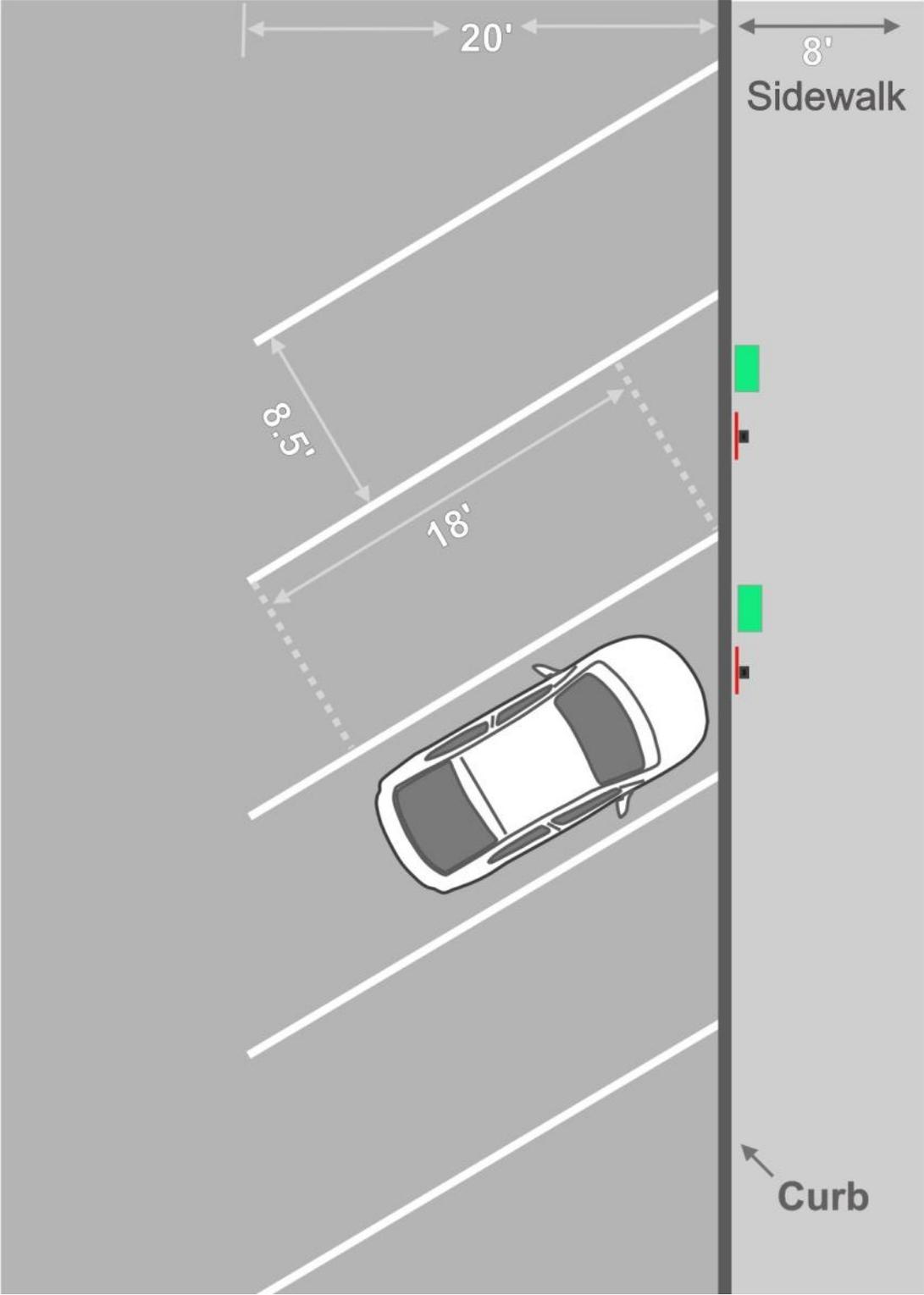
Multi-unit housing often has landscaping between parking and sidewalks. In the scenario shown below, the parking lot designer used short, 16-foot long parking stalls and assumed that vehicles would overhang the curb by up to 2 feet. This eliminates the need for wheel stops. The charging station includes a new concrete pad set behind the curb. Parking vehicles can avoid the EV supply equipment and users can safely maneuver in front of the vehicles. Electrical conduit to the charging station can be placed beneath the landscaping. Set the signs 7 feet high to reduce potential for injury.



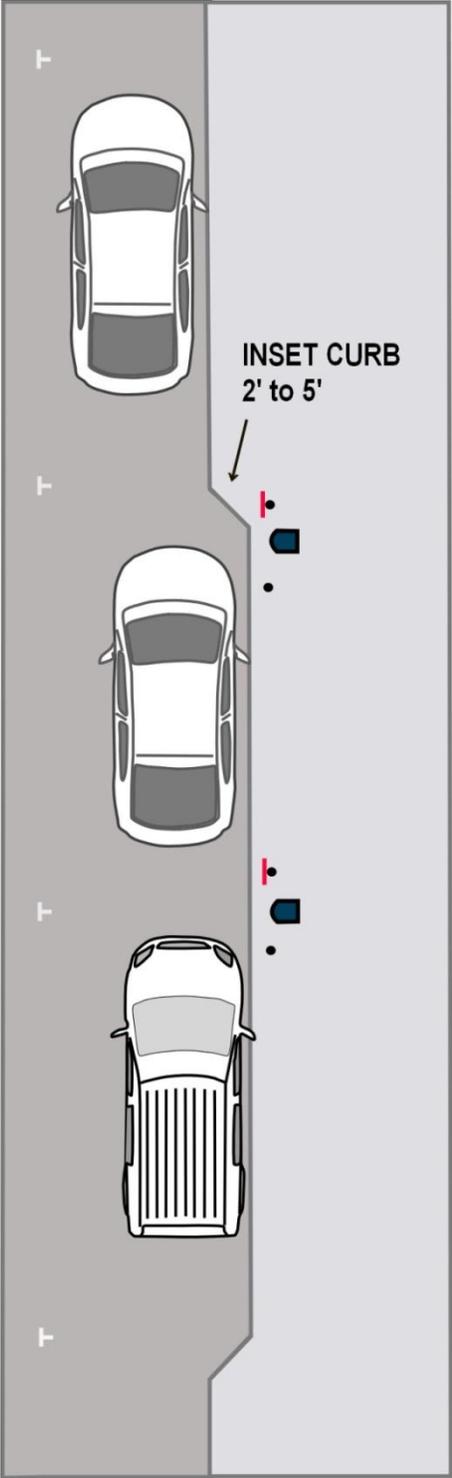
Parking structures constrain options for charging station installation. However, posts along walls sometimes create buffer areas for wall-mounted EV supply equipment. This design locates the equipment between parking stalls to maximize access and protection. Wheel stops are only needed where the posts do not adequately protect the EV supply equipment.



At angled parking, EV supply equipment should be placed where it can best take advantage of the triangular space in front of the parking stall. Wheel stops and bollards may not be necessary if the curb adequately functions as a barrier.



The following example for parallel parking creates a buffer between the parked EV and passing vehicles. This design can only be executed where sidewalk width is adequate. Behind the EV supply equipment, the sidewalk needs to maintain adequate width to accommodate use by persons with disabilities. This design shows bollards placed on both sides of the EV supply equipment so that it can be located close to the curb.



## 6 CONCLUSION

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*Site Design for Electric Vehicle Charging Stations* offers context for how to design EV charging stations in a variety of parking facility types. It provides background on the underlying parking facility design and function. Additionally, it demonstrates how to create convenient and safe charging stations.

Every charging station design will offer a different set of issues. The design templates shown in Section 5 provide examples that can be adapted to address a range of physical conditions.

For further information regarding this report and access to other information on siting and designing charging stations, visit [www.sustainabletransportationstrategies.com](http://www.sustainabletransportationstrategies.com) or contact David Mayfield at 503-701-0142.