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Data-Driven Design for Micromobility

ITE Micromobility Sandbox Design Competition

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1. Executive Summary

In this project, the USC ITE team will provide innovative, yet practical solutions to address the lack of micromobility infrastructure in Las Vegas, Nevada, and Los Angeles, California. For Las Vegas, we will specifically be looking at Bridger Avenue from Casino Center Boulevard to Las Vegas Boulevard, and Main Street from Washington Boulevard to 16th Street in Los Angeles. Currently, both sites are extremely vehicle-oriented – sidewalks are too narrow, e-scooters block pedestrians, and micromobility users feel unsafe in the streets. Ultimately, we strive to make the streets more friendly for micromobility users and pedestrians, which would in turn make the two sites more accessible, especially for those without access to single-occupancy vehicles.

For both sites, we propose the implementation of micromobility hubs, where there would be specific space allocated for bicycle and e-scooter parking. These hubs, using RFID technology, would solve issues of undocked e-scooters and bikes that create potential hazards for pedestrians and drivers. Furthermore, we propose a reduction in the size and number of car lanes to make room for fully protected bike lanes. Both sites would have lane reconfigurations, increased streetcar parking, signal phasing, protected intersections, and mode segregation buffers. However, for Los Angeles, we also suggest implementing a pedestrian bridge for pedestrians and micromobility users, as well as repurposing the street parking during rush hour to become a traffic lane.

From extensive research and data analysis, we believe that making these changes to both Las Vegas and Los Angeles sites would be beneficial for all modes of transport. By investing in improving safety for micromobility users and pedestrians, we steer from the traditional engineering norms, which may be met with much opposition. However, our progressive data approach promotes the growth of sustainable, equitable communities, without compromising essential flow of vehicles.

2. Abstract

Traditionally, road designs follow design standards that take a more conservative approach, such as NACTO and AASHTO. Upon examination, we found that these existing standards are based on decade old data points that do not reflect the recent advancement of micromobility demand in our urban landscape. In response to the ITE challenge to better incorporate current and future micromobility options into our cities' infrastructures, we are proposing an innovative-design solution that demonstrates how design standards can be updated to improve efficiency and safety, through the calibration of real-time usage data.

3. Background

As outlined in the competition instructions, the objective of the ITE Micromobility Sandbox Design Competition is to develop cutting-edge solutions to manage the many modes of transportation utilized in urban settings, including current and future micromobility options (ITE). Engineers and planners must first understand the current and potential function of their project site as it relates to the entire livelihood of the city in order to design such solutions, carefully considering the role of micromobility. In this section, we provide a more in-depth description of the Las Vegas and Los Angeles sites, looking at the existing traffic and bike lane infrastructure.

Las Vegas:(Bridger Ave./Casino Center Blvd.--Bridger Ave./Las Vegas Blvd. East-West.)

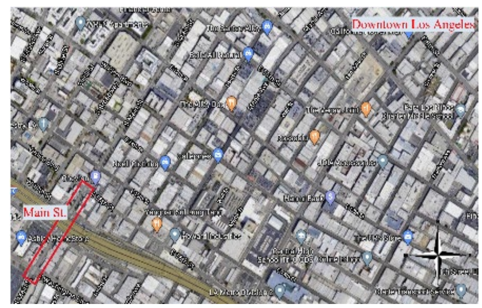
A very segmented city, Las Vegas contrasts between the modern casino strip and the classic, western downtown area. In recent years, the often overlooked downtown has been experiencing a 5.1% increase in occupancy, compared to the 0.8% increase of the Strip (LVCVA). Contrary to the congested downtown areas,

streets such as Bridger Ave. still experience low volumes of traffic. Despite failed efforts of alternative transport modes (light rail implementation), the downtown bike-sharing program launched in 2016 saw over 35,000 trips logged in its first 2 years (RTC).

Bridger Ave., is one of these eastbound/westbound bike corridors, with a bike share dock already located on its intersection with 8th Street. Currently, Bridger Ave. holds 16 blocks of existent on-street dual bike lanes, including on the proposed segment: **Bridger Ave./Casino Center Blvd.--Bridger Ave./Las Vegas Blvd. East-West.**

Los Angeles:*(Main St./Washington Blvd.-Main St./16th St. North-South)*

While Los Angeles is undoubtedly the car capital of the United States, various efforts to make Downtown more walkable have been underway, connecting nearby neighborhoods through implementation of road diets. Moreover, Los Angeles is considered the micromobility capital of America, with over 4,000 e-scooters concentrated in its Downtown area (Nelson 2019).



Main Street in Los Angeles is a prominent northbound/southbound arterial roadway at the core of Downtown LA. However, between the proposed 16th St. and Washington St., Main St. is comparable to Las Vegas' Bridger Ave., with a similar configuration and relative location to its respective Downtown. Similar to Bridger Ave., Main St. also has dual bike lanes for 15 blocks leading to 16th St. to 1st St. Despite this there is no bike lane on our proposed four-block section. The 48 bus travels back and forth on a 10-minute cycle on our proposed segment: **Main St./Washington Blvd.-Main St./16th St. North-South.**

4. Current Issues

The Micromobility Sandbox Design Competition calls on interested teams to design an urban corridor which makes it safe and efficient for all modes of transportation to co-exist, despite differences in moving speed (ITE). To make impactful and innovative designs, it is crucial to deeply investigate the existing challenges that face current or potential travelers at a project site.

Some current issues with both sites regard the low levels of walkability. Intuitively, Las Vegas isn't very pedestrian-friendly; there's no shade on the sidewalk, and it's extremely auto-oriented. Same with the Downtown Los Angeles site—the sidewalks are extremely tight, and the bike lanes don't extend very far, making micromobility users feel unsafe. As outlined in the competition instructions, the objective of this project is to ensure that the Las Vegas and Downtown LA sites are more accessible through alternative means of transportation, specifically micromobility options. Therefore, we prioritize strengthening the bike lane infrastructures in order to minimize potential accidents between drivers, pedestrians, and micromobility users, ultimately making users feel much safer.

Las Vegas: While the two busiest areas of the city stretch 5 miles apart, there is only one bus route—SDX/Deuce––from the infamous Strip (Las Vegas Blvd.) to Downtown Las Vegas. This connective corridor is essentially a highway for 3.5 miles, providing few transport mode alternatives and no options for bikers. Las Vegas Blvd ultimately dies out, bringing little traffic to the Downtown core. In Downtown Las Vegas, there is only one bus line, which runs a singular loop. Micromobility options need to be included within streets to bridge loopholes of mass transit and to unify Las Vegas as a City, rather than two separate hotspots.

Bridger Ave., being only two parallel streets away from Fremont St., provides the locational opportunity to access all of Downtown. Despite Bridger Ave.'s existent 15-block bicycle lanes, inadequate protection from parked cars, fast-moving traffic, and intersections results in a 59/100 "bikeability" rating (Walkscore). Due to Las Vegas Blvd being one of the major roads of the city, 85% of road users travel at an unsafe speed of 38 mph, discouraging bikers and pedestrians to use the corridor.

Los Angeles: A large concern in Los Angeles is the stigma surrounding e-scooters. While this convenient mode of transportation allows for intra-mode travel, it has been criticized for its dock-less feature. In most of the areas, the random parking of the e-scooters often creates a disturbance to both drivers and pedestrians (Nelson 19).

On the proposed Main Street corridor, the Washington Ave. and Main St. intersection is a dangerous crossing for pedestrian and other micromobility users. Traditional design standards only prioritize roadways for optimal vehicular operation. Therefore, our design must incorporate a novel approach to counteract conservative standards which do not consider the need for higher pedestrian access and new micromobility options.

5. Methodology

5.1. Approach

Our team approached this project with a modal-specific design for both project sites. The following section gives a detailed description of our philosophy and approach behind our design, elaborating technically on the design features and their effects on motor vehicles, pedestrians and micromobility users separately under each section.

5.1.1. Motor Vehicles: To maintain stakeholder approval of our design, we prioritized improving or maintaining the existing Level of Service (LOS) for motor vehicles. We first calculated existing congestion levels at PM peak hours for the eight intersections in our designs using an LOS metric resultant of the Volume/Capacity (V/C) and Critical V/C Ratio. The metric ranges from grades A to F, with a LOS of A, indicating the best service, to a LOS of F, signifying the worst service (Thurston Regional Planning Council).

LOS	Max V/C	Description	Traffic Diversion
A	0.6	Free Flow	No Traffic Diversion
B	0.7	Stable Flow (Slight Delays)	No Traffic Diversion
C	0.8	Stable Flow (Acceptable Delays)	Traffic Diversion Unlikely
D	0.9	Approaching Unstable Flow (Tolerable Delay)	Traffic Diversion Possible
E	1	Unstable Flow (Intolerable Delay)	Traffic Diversion Likely
F	N/A	Forced Flow (Jammed)	Diversion

Table 1: LOS congestion metric

To increase street space for pedestrians, micromobility, and safety medians between users travelling at different speeds, we considered the removal of traffic lanes from our corridors. We iterated through multiple lane configurations for our designs and recalculated the LOS for each intersection, eventually deciding on designs that either maintain or improve LOS grades. As a compromise, we prioritized maintaining as much street parking space as possible. This decision would be supported by businesses and other stakeholders who benefit from the availability of parking on the corridor.

5.1.2. Pedestrians: According to the Urban Street Design Guide published by National Association of City Transportation Officials (NACTO), the absolute minimum design width for a through zone of sidewalk is 5-ft. According to the Americans with Disabilities Act (ADA), the preferred minimum width to accommodate two pedestrians passing each other is 6 ft. We evaluated current pedestrian counts on our corridors but with the proposed micromobility improvements, we expect an increase of such counts. Therefore, proposed sidewalk widths take into consideration the increase in the pedestrian activity, frontage requirements, and novel widths of pedestrian walk through zones.

The Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD) recommends a speed of 4 ft/s (2.73 mph) for calculating pedestrian clearance intervals for calculating traffic signals. The speed of an average cyclist is about 13 mph to 15 mph (Road-bike.co.uk). Although e-scooters these days can go as fast as 21 mph (Consumer Reports), the average speed for an e-scooter is 16 mph (Electricscootering.com), nearly 6 times greater than the average pedestrian speed (2.73 mph). Even though e-scooters are not permitted to ride on the sidewalks, from personal observations, e-scooter and bike riders frequently go on the sidewalks because they feel unsafe riding in the streets with cars. As a result of e-scooter and bike riders on the sidewalk, pedestrians are put at risk for collisions from micromobility users. Therefore, our proposed designs aim to make the bike lanes safer for micromobility users. By doing so, bike lane users wouldn't feel the need to ride on the sidewalk due to safety issues, which would in turn benefit pedestrians, ultimately making the streets more walkable.

5.1.3. Micromobility: We first examined the existing conditions for micromobility on Bridger Street, Las Vegas, and Main Street, Los Angeles. These streets are primary bicycle routes in a greater city network, yet they suffer from a lack of friendly "8-to-80" infrastructure. Bridger Street has a 5-ft. wide, standard bike lane, while the Main St. corridor has "Share the Road" signs. On Main St. in particular, bicycles must contend with high vehicle turning volumes on many streets, which is extremely dangerous for bike riders. To increase the safety of bike riders, we need to implement a protected bike lane, separating the bike lanes from the driving lanes. As a template for our design and for our new bike traffic estimates, we used precedents in Austin, TX, and New York City, NY.

Successful micromobility projects such as London's Cycleways and Copenhagen's extensive network of bicycle facilities have incorporated physical protection, wide lanes, and bicycle-friendly destinations. In our new design, we included these aspects to make Bridger Ave. a bicycle and scooter friendly street for commuters, families, and casual cyclists, with three goals in mind. Our first goal is to provide greater physical protection, especially at intersections, through the use of a raised curb and lane markings. Our second goal is to ensure enough space for "conversational riding" and passing, without crashing into parked cars or traffic. Our third goal is to make the bike lane not just a bypass lane, but a thoroughfare where one can stop and park to go to the various destinations on our corridors. To achieve this goal, we studied the zoning of the areas and redesigned micromobility parking areas.

To create safe, accessible parking of micromobility vehicles on our corridors, we addressed the current lack of a designated space for bicycle parking, as well as re-evaluated typical parking schemes for e-scooters. From our personal experience, improperly parked e-scooters can make sidewalks as impassable. Careless e-scooter parking is especially harmful for people who rely on mobility aids, such as wheelchairs, as e-scooters could block a huge portion of the sidewalk and prevent them from passing (WheelchairTravel.org). Therefore, to ensure everyone can safely travel, we implemented designated bicycle and e-scooter areas. To design bicycle and e-scooter parking areas, we referenced the National Association of City Transport Officials (NACTO) recommendations and federal planning guidelines, while also accounting for the future growth of bicycle and e-scooter traffic in both Las Vegas and Los Angeles.

Parked e-scooters blocking the sidewalk (Source: Wheelchairtravel.org)

After further study, we found that these streets have a huge potential for growth. Main Street and Bridger Street are both located very close to their respective Central Business Districts, meaning that many of the trips that pass by are local in nature, and thus accessible through micromobility options. The bicycle traffic model we developed took the huge "untapped market" of potential cyclists and scooter riders into account, with secondary effects from rezoning and a general uptick in micromobility use in the United States. To develop this growth model, we looked at current bike share maps from RTC Southern Nevada and LA Metro, evaluated the walkability of our streets using walkscore.com, predicted population size with censusreporter.com, learned from cycling growth reports from nyc.gov, and calculated the Bike Level of Service/Pedestrian Level of Service using an original model. With awareness of the location of the corridor and the new cycling traffic our design could bring, we concluded that with a fully segregated and sufficiently wide cycle-track and protection at intersections, Bridger St. and Main St. could see an upwards of 400% of the current volume of cyclists, while greatly improving rider safety.

5.2. Project Site 1: Las Vegas
Refer to Exhibit 1

DESIGN HIGHLIGHTS FOR SITE 1:

- Priority Bicycle Phasing
- Increased On-Street Car Parking
- Lane Reconfiguration
- Micromobility Hubs (Bicycle Racks and Mandatory E-Scooter Parking)
- Mode Segregation Buffers
- Protected Intersections and Signal Phasing

5.2.1. Motor Vehicles: The existing low V/C ratios calculated from Las Vegas traffic data (table 2) offered that traffic lanes could be removed on Bridger Ave. without harming LOS. Iterations over different lane configurations for the Las Vegas corridor ultimately led to the removal of eastbound/westbound shared left turn lanes on Bridger Ave. Right turn lanes at the intersections Bridger/3rd and Bridger/4th were also removed. This removal resulted in no significant change in critical V/C ratios (table 2: column 4) and zero changes in LOS (table 2: column 4). Indeed, our vehicular modeling showed that even if an unprecedented 27% increase in volume occurred, all LOS' would remain at A.

Change in Level of Service (LOS)					
Intersection	Critical V/C Before	LOS (BF)	Critical V/C After	LOS (AF)	%Change
Bridger/Casino	0.418	A	0.419	A	0%
Bridger/3rd	0.220	A	0.235	A	7%
Bridger/4th	0.232	A	0.228	A	-2%
Bridger/Las Vegas	0.406	A	0.468	A	15%

Table 2: Change in Level of Service-Las Vegas

The proposed reconfiguration would improve levels of safety, reducing the lanes from 11.5-ft. to 10-ft, which only minimally decreases saturation rates (Vegas 2009), and decreases vehicular speeds from an existing average 38 mph to 25 mph. Scholarly review on research from 2002 to 2013, found comprehensive improvement in car and pedestrian safety as a direct result of the removal of vehicular lanes (Thomas 2013). In addition, the National Cooperative Highway Research Program reported on a study on 15 roadway projects in Iowa as well as 30 in Washington/California that found crash reduction of 47% and 19% respectively from removing lanes (Harkey et al. 2008).

Despite removed traffic lanes, the design notably increases on-street parking from 26 spaces to 31 spaces, generating $3,000 in yearly revenue (Choate 10) and providing additional access to nearby business.

5.2.2. Pedestrians: The existing sidewalk along Bridger Ave. between Casino Center Blvd. and Las Vegas Blvd. is around 10-ft. wide on each side of the street. It consists of a 5-ft. pedestrian through zone, small trees, dustbins, and hydrants along the curb, which separates the pedestrians from the vehicle movements. Considering the required and desired width recommendations from the above-mentioned sources and the predicted increase in foot traffic, our design proposes a 10-ft. wide sidewalk to be kept along Bridger Ave. between Casino Center Blvd and 4th St., while a 9.5-ft. wide sidewalk is suggested from 4th St. to Las Vegas Blvd. These dimensions comprise the through walk way width for sidewalks.

Additionally, there would be a buffer of 2-ft. on each side between 4th St. and Las Vegas Blvd. and a 4-ft. wide buffer along the other two blocks, containing benches and trees. This barrier would taper off near the intersection, moving the bike lane adjacent to the through zone of sidewalk. As we approach the intersection, the buffer zone width and the parking lane together dilute into the Micromobility Hub, a new parking area for bicycles and e-scooters, on Bridger Ave., which will be described in further detail in the following 'Micromobility' section. The ADA ramps offer pedestrians access to the cross walk t Micromobility Hub from the sidewalk, and then to continue to the rest of the crosswalk.

The proposed median of alternating trees and benches would help resolve the issue of different speeds between pedestrians and cyclists, as they would act as a barrier between the walkway and the bike lane. In addition, the wide sidewalk, ranging from 9.5-ft. to 10-ft., would prevent pedestrians from opting to use the bike lane as a walkway when the sidewalk is too crowded. There will be ample space for all pedestrians to walk on the sidewalk.

Victoria Transport Policy Institute (VTPI) explains how motorized travel contributes to public costs, such as maintaining parking and road facilities, traffic congestion, crash risk, and environmental harm. By offering a more walkable corridor, these public costs can be reduced, as some people choose to walk instead of drive (VTPI). In addition, VTPI indicates that businesses can gain profit and even recruit new employees with walkable streets.

5.2.3. Micromobility: Implementing a protected bike lane on both sides of the street with protected intersections would accomplish the three goals indicated above (see Methodology). With this in mind, we propose a raised 6-ft. wide path in each direction**,** with a 2-ft. wide buffer and parking lane protection for both eastbound and westbound cyclists on Bridger Ave. This lane would be wide enough to not be a chokepoint in a robust, highly utilized, protected bike lane network, allowing enough room for passing. The path would be designed in accordance with NACTO guidelines for raised cycle track design, and also protected by parking. The lane would be raised to the sidewalk level and painted green. At smaller alleyways, the sidewalk would narrow, which would enable the bike lane to go closer to the property line. This would enable the midblock alleyways to be protected via a stop sign. At intersections, we propose a protected intersection design in accordance with NACTO guidelines.

We also propose "Micromobility Hubs" at the intersections of Bridger/3rd and Bridger/4th, which would be central parking areas for micromobility. These hubs would include e-scooter parking, as well as shared and personal bike parking. They would be placed on elongated "bend-outs" (Alta Planning, Exhibit 5), part of our protected intersection design, that would be lengthened to fit more bike/scooter parking spots. They would be ranging from 10-ft. to 14-ft. wide, and the total length of each bend-out would be about 60 ft. With four total hubs, each would comprise part of the mandatory e-scooter parking areas. Although dock-less e-scooters have proven to be convenient for many users, the potential danger to pedestrians must be resolved, and may be a long-term solution as e-scooter usage evolves. We recommend that e-scooter companies and the City of Las Vegas work together to enforce these parking zones using technologies such as radio-frequency identification (RFID Inc), as current geofences would have much less accuracy in determining whether a scooter was in a designated parking zone.

Las Vegas Micromobility Predictive Model				
Mode of Transport	**Initial Traffic Volume**	**Growth from Increase in Protection**	**Secondary Growth from Economic Factors**	**New Traffic Volume**
Bikes	150	176	114	440
E-scooters	5	145	74	214
Total	155	321	188	654

Table 3: Micromobility Predictive Volumetric Model-Las Vegas

Solar-powered charging capabilities will be installed in the shared bicycle docking stations to support e-bikes, and the Hubs would additionally be fitted with a bicycle tire pump and a map of the Micromobility Hubs in Las Vegas. The arrangement of the universal docks was inspired by NACTO's Bike Share Station Siting Guide (NACTO). In total, our hubs have a capacity of 80 e-scooters, 60 shared bikes, and 60 personal bikes. These capacities are based on our predictive model growth volumes, with the assumption that only about 1/3 of total trips will begin or end on our corridor (Table 3).

To ensure the safety of bike lane users, we are also incorporating signal phasing at our intersections. All intersections in our three-block stretch would have bicycle traffic signals. At the two busiest intersections in our design (Bridger/Casino Center and Bridger/Las Vegas), there would be an 8-second bicycle scramble (a modification of the "pedestrian scramble") at the beginning of the cycle to ensure cyclists and e-scooter riders can make safe turns onto these busy streets. All vehicle traffic would be halted to allow cyclists to cross diagonally or parallel to the streets. The smaller intersections (Bridger/3rd and Bridger/4th) would have a protected intersection (Alta Planning), which allows for increased visibility of crossing micromobility users and pedestrians. In addition, the mandatory e-scooter parking located on the Micromobility Hub would prevent sidewalk blockages from incorrectly parked e-scooters, which could cause injury to pedestrians.

Similar to the sidewalk improvements, micromobility improvements could help shift some vehicle traffic to micromobility traffic, reducing the public cost of automobile generated noise and air pollution throughout the corridor. More accessible micromobility also could increase profits of businesses on Bridger St, as more people may utilize the new bike lanes for exercise or to travel farther than they would just on foot. Additionally, many government services like the postal office, courthouses, marriage houses, exist within these streets, all of which need to be accessible for all. As we incorporate safer bike lanes and accommodate e-scooters, Downtown Las Vegas would become more equitable, including people who rely on alternative, more affordable modes of transportation than single-occupancy vehicles.

5. 3. Project Site 2: Los Angeles

Refer to Exhibit 2

DESIGN HIGHLIGHTS FOR SITE 2:

- Bicycle and Pedestrian Overpass
- Increased On-Street Car Parking
- Lane Reconfiguration
- Micromobility Hubs (Bicycle Racks and Mandatory E-Scooter Parking)
- Mode Segregation Buffers
- Peak Hour Parking Lane Repurposing
- Protected Intersections and Signal Phasing

5.3.1. Motor Vehicles: The Los Angeles intersections yielded higher traffic volumes than Las Vegas intersections (Table 2), some requiring capacity increases to alleviate strained Critical V/C ratios. At Main/Washington, currently flowing at a LOS of D (Critical V/C: 0.870) see Table 4, most of the issue stems from the East-West

Washington Blvd volume which produced a critical V/C of 0.488. While it is arguable that the Main Street travelling north-south doesn't encounter the same LOS problems as Washington Blvd, LOS is a comprehensive metric, therefore our design alleviate such intersection congestion by adding one lane Northbound and one lane Southbound at Main/Washington. This ultimately improved our LOS on the corridor to a grade of C (Critical V/C: 0.789). On subsequent intersections, Main/17th and Main/18th, we removed one northbound lane and one southbound lane, minimally sacrificing critical V/C levels while maintaining LOS ratings of A. At Main/16th, one of the three northbound lanes were removed to gain space for pedestrians and micromobility, leaving the critical V/C and a LOS grade of A unchanged. Additionally, our vehicular modeling showed that even if an unprecedented 12% increase in volume occurred, all LOS' would remain at A as seen in Table 4.

Change in Level of Service (LOS)					
Intersection	Critical V/C Before	LOS (BF)	Critical V/C After	LOS (AF)	%Change
Main/Washington	0.870	D	0.789	C	-9%
Main/18th	0.517	A	0.596	A	15%
Main/17th	0.450	A	0.532	A	18%
Main/16th	0.473	A	0.473	A	0%

Table 4: Change in Level of Service-Los Angeles

Additionally, with the repurposing of the street to prioritize the safety of micromobility users and pedestrians, vehicle speeds would be decreased from 30 mph to 25 mph, and this would be done with an induced effect of reducing lanes from 10-ft. to 9-ft, as well as a change in the posted speed limit.

Despite the addition of Micromobility Hubs, which would be built in existing parking spots in this Los Angeles corridor, the design notably increases on-street parking from 15 spaces to 21 spaces, generating additional $10,050 in yearly revenue (Reynolds 2), and providing additional access to nearby business.

During peak traffic hours, 7-9am and 4-6pm, the parking spaces on the east side of Main St. would be deemed unusable and converted to a through lane, reducing northbound congestion. This would be indicated with proper signage. The west side of Main St. would have parking available at all hours, due to the Micromobility Hubs being placed on that side, which would prevent the conversion to a through lane. Because Main St. has a couple of bus routes running on it, we are also maintaining the existing parking bans in front of the bus stops to allow for passengers to enter and exit.

5.3.2. Pedestrians: The existing intersection at Main St. and Washington Blvd. has a rail track on Washington Blvd passing through the intersection. With the pedestrian volume already being high at the intersection, the footfall is believed to further increase with the introduction of the Micromobility Hub. This makes it unsafe for the pedestrians to cross the intersection along with the e-scooters and bikes at the same time. Therefore, we propose a 12-ft wide bridge overpass at the intersection solely dedicated to pedestrians, bikes, and e-scooters. The ramps of the bridge begin slightly south of the intersection on Main St., ascending up to the overpass. The ramps descend back down after the intersection to mid-block on Main St. The bridge joins the 12-ft. wide sidewalk on Main St. from where people can access the bus stops near the intersection. The ramps are designed with an incline of 3.8° above horizontal in compliance with the ADA requirements. Throughout our corridor, the sidewalk width is usually 10.5-ft., varying to 14-ft., with a 2 ft. wide landscape buffer on the curb edge to maintain distance between the pedestrians and micromobility users.

The overpass makes passing Washington Blvd. monumentally safer, all vehicle and light rail traffic averted. Moreover, the buffer between the bike lane and sidewalk protects pedestrians from fast moving cyclists and scooters.

As in Las Vegas, the increased walkability of this Los Angeles corridor has the potential to divert some vehicle traffic to foot traffic and increase customers to local businesses, decreasing public costs and increasing profits for business owners.

5.3.3 Micromobility: Similar to the Las Vegas design, we propose that the path on Main Street to be a 6-ft wide raised cycle track protected from the parking lane by a 2-ft. wide buffer. In addition, it will be separated from the sidewalk via planters. With a parking lane, the cycle track has two layers of protection from the driving lanes. However, certain areas have inadequate space to preserve parking, thus the removal of the parking lane is recommended. We believe that the 2-ft. wide buffer will still provide an adequate level of comfort for all micromobility users utilizing the cycle track. At 16th St., 17th St., and 18th St., we propose implementing a protected intersection. At Washington Blvd. and Main St., we would create a cycling/pedestrian overpass on each side of the street, which would be 14-ft. wide. Of this space, 2 ft. will be for fencing, 6 ft. for the bike lane, and 6 ft. will be for the sidewalk.

The protected intersections would enable cyclists to feel safer and have increased visibility for turning cars. Moreover, the cycling/pedestrian overpass would protect cyclists and pedestrians from the light rail traffic and busy intersection of Washington St., along with providing benefits for vehicular users through the addition of traffic lanes. By fully segregating pedestrians and cyclists at this intersection, we could eliminate many turning conflicts and ensure that pedestrians and cyclists have a clear right-of-way in a multi-modal intersection. Additionally, to ensure the safety of bike lane users, we are also installing signal phasing at our intersections. All intersections in our three-block stretch would have bicycle traffic signals, giving e-scooter users and cyclists a head start.

Los Angeles Micromobility Predictive Model				
Mode of Transport	**Initial Traffic Volume**	**Growth from Increase in Protection**	**Secondary Growth from Economic Factors**	**New Traffic Volume**
Bikes	300	307	182	789
E-scooters	108	76	102	286
Total	408	383	284	1075

Table 6: Micromobility Predictive Volumetric Model-Los Angeles

As mentioned in the motor vehicles design, Micromobility Hubs would be placed in the southbound parking lane between 18th and Washington, and southbound parking lane between 16th and 17th, replacing a total of six car parking spots. To enforce the mandatory e-scooter parking zones, city officials must coordinate with e-scooter companies to establish “no docking zones” for any place within our three blocks stretch outside of the designated docking zone. Like Las Vegas Micromobility Hubs, RFID technology could assist the enforcement of this e-scooter parking area. In total, these hubs have room for 60 e-scooters, 30 personal bikes, and 30 bike share bikes. This is based off of our predictive model (Table 6), and assuming that not many cyclists will be starting or ending from this corridor, due to most nearby points of interest being located in downtown Los Angeles, about a mile North. In fact, the bike lane in our design connects to an existing bike lane on Main St that previously terminated at 16th street, allowing micromobility users on our corridor to be safely connected with downtown Los Angeles.

Some business owners may be in disagreement with our decision to remove six on-street parking spaces for our Micromobility Hubs, worried that less accessibility for drivers would decrease revenue. However, according to multiple studies conducted in cities like San Francisco, Portland, Toronto, etc., incorporating more space for micromobility in place of automobile parking has little to no impact on business, with some instances proving to have a positive impact on business (CityLab). Moreover, the Micromobility Hub would increase the monetary value of parking along the Main St. Corridor, as they would have room for up to *60 e-scooters (Equation 1), which could provide, assuming a moderately high scooter turnover rate of 5.5 trips/day per scooter, and $16 of revenue per scooter per day (Quartz), and up to $5,280 of taxable revenue in the form of taxing scooter trips. This amounts to just under $220 an hour of parking revenue, which would more than make up for the lost parking revenue under our new design.

$$\#Escooter\ parking\ spaces\ = \frac{4000\ Escooters}{200\ blocks} \times 3\ blocks\ =\ 60\ E - Scooters$$

Equation 1

*60 e-scooters came from the above calculations: According to the LA Times, downtown LA has about 4,000 e-scooters, so we came up with the following calculation to determine parking for e-scooters in our corridor.

6. Recommendations/Conclusion

In downtown Las Vegas, Los Angeles, and other urban centers, multimodal roads are necessary to meet the travel demand of an ever-increasing population. The current design standards are outdated, mainly prioritizing automobile traffic, and have scarcely considered the multi-modal usage of streets. Due to a lack of infrastructure, these thoroughfares have failed to properly accommodate cyclists and pedestrians, as well as users of shared micromobility vehicles. The current design standards keep cyclists and drivers safe, but they fail to properly protect the newer modes of transportation that are entering the market. These technologies were created to help reduce the usage of cars for shorter trips, but they are not being utilized in a proper manner due to the lack of infrastructure to support it.

Based on our data analysis, our recommendation is the utilization of our aforementioned roadway designs for Bridger Ave., in Las Vegas, and for Main St., in Los Angeles. In terms of improving safety, the usage of the following should be implemented: a reduction in the number and size of traffic lanes, a fully protected bike lane, a protected intersection at each intersection where micromobility and motorized vehicles interact, and a pedestrian and micromobility overpass over Washington Blvd, which has a street-level light rail line running on it. The existing standards are biased to believe that wider driving lanes are the gold standard for safety, but the data proves that overall safety for pedestrians and motor vehicles is increased with narrower driving lanes and physical protection between pedestrians and micromobility users. To increase the accessibility of micromobility use into the streetscape, Micromobility Hubs should be implemented. These innovative spaces would help the city maintain a clean and orderly aesthetic, while keeping individual and transportation company property safe from theft and destruction.

Our team set out to improve the traditional engineering standards that typically rely on data points that no longer reflect what our streets look like today. It is our belief that roadway design standards should involve data-driven decision-making processes, so that our roads can be used more efficiently. As engineers and planners, we need to take every opportunity we can to make sure our roads match the growth and change of transportation needs. The projects we work on last for years to come, so using past and current data helps us project what would be needed in the future. Using this data, we must work towards making our cities more sustainable, equitable, and accessible for all, and we believe that implementing our design will.

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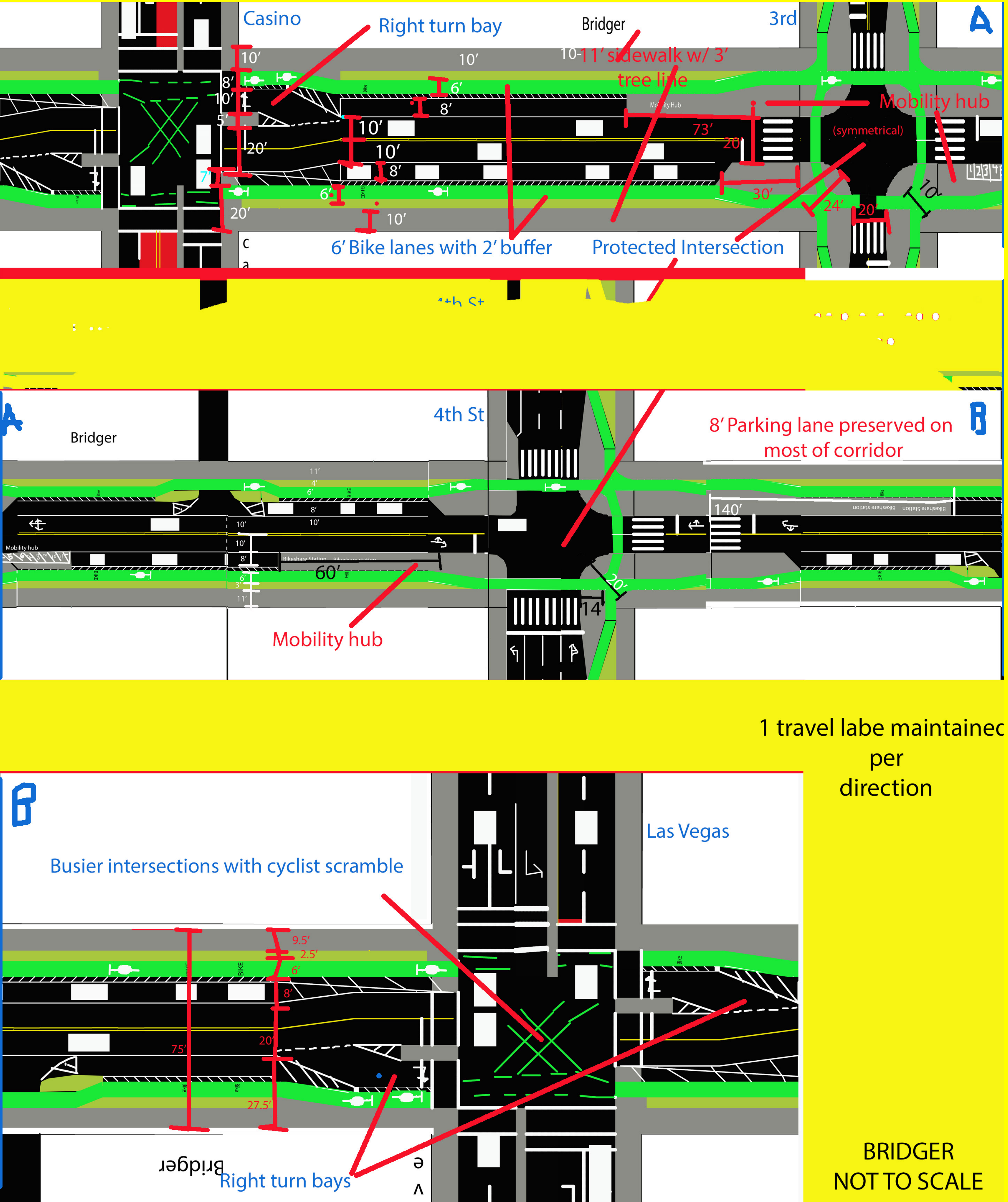


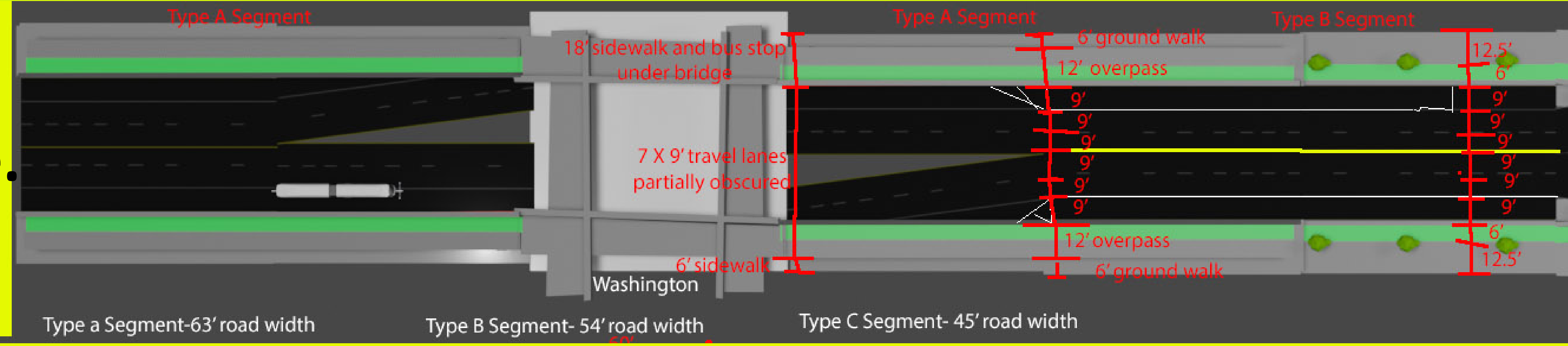
Exhibit 1: Las Vegas - Bridger Ave.

Aerial Design and Dimensioning

Element	Casino Center to 3rd	3rd to 4th	4th to Las Vegas
Total Street Width (ft)	80'	80'	75'
Sidewalk Widths (ft), (EB/WB)	10'/10'	10'/10'	9.5'/9.5'
Sidewalk/ Bike Lane Buffer Widths (ft)(EB/WB)	4'/4'	4'/4'	2'/2'
Bike Lane Widths (ft), (EB/WB)	6'/6'	6'/6'	6'/6'
Bike Lane /Car Buffer Widths (ft), (EB/WB)	2'/2'	2'/2'	2'/2'
Parking Lane Widths (ft), (EB/WB)	8'/8'	8'/8'	8'/8'
Traffic Lane Widths (ft), (EB/WB)	10'/10'	10'/10'	10'/10'

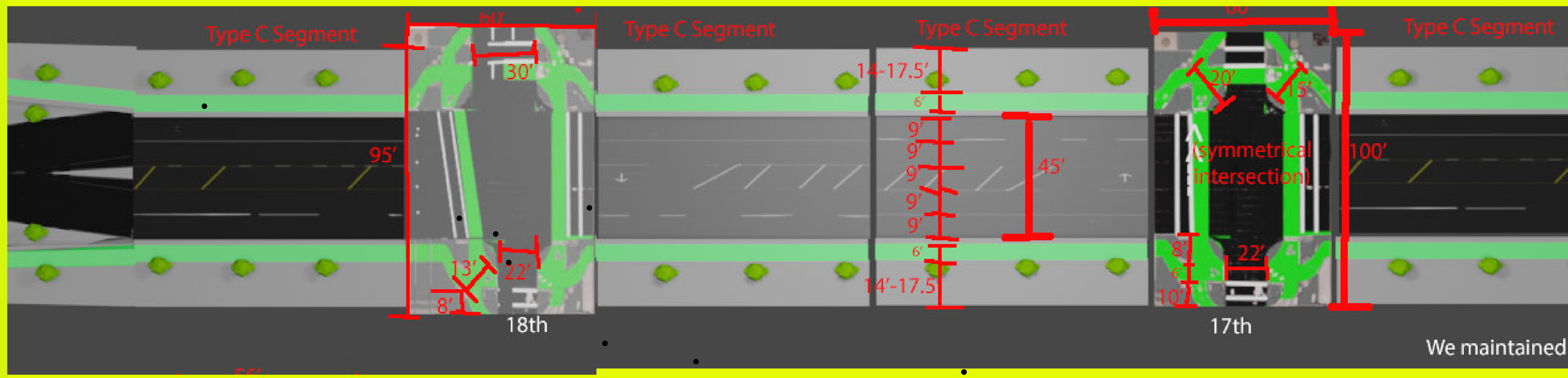
Exhibit 2:
Los Angeles - Bridger Ave.
Aerial Design and Dimensioning

Element	Washington-18th	18th-17th	17th-16th
Total Street Width (ft)	95'	95'	95'
Sidewalk Widths (ft), (EB/WB)	12.5'/12.5'	14'/14'	12.5'/12.5'
Buffer Between Sidewalk and Bike Lane Widths (ft), (EB/WB)	2'/2'	3'/3'	2'/2'
Bike Lane Widths (ft), (EB/WB)	6'/6'	6'/6'	6'/6'
Bike Lane /Car Buffer Widths (ft), (EB/WB)	2'/2'	2'/2'	2'/2'
Parking Lane Widths (ft), (EB/WB)	9'/9'	N/A	9'/9'
Through Lane Widths (ft), (EB/WB)	9'/9'	9'/9'	9'/9'
Number of Through Lanes (EB/WB)	2/2	2/2	2/2
Center Turn Lane Width (ft)	N/A	9'/9'	N/A



Green- Bike Lane
Black- Travel Lane

Grey- Sidewalk
Orange- bus stop



We Maintained at least 2 travel lanes per direction

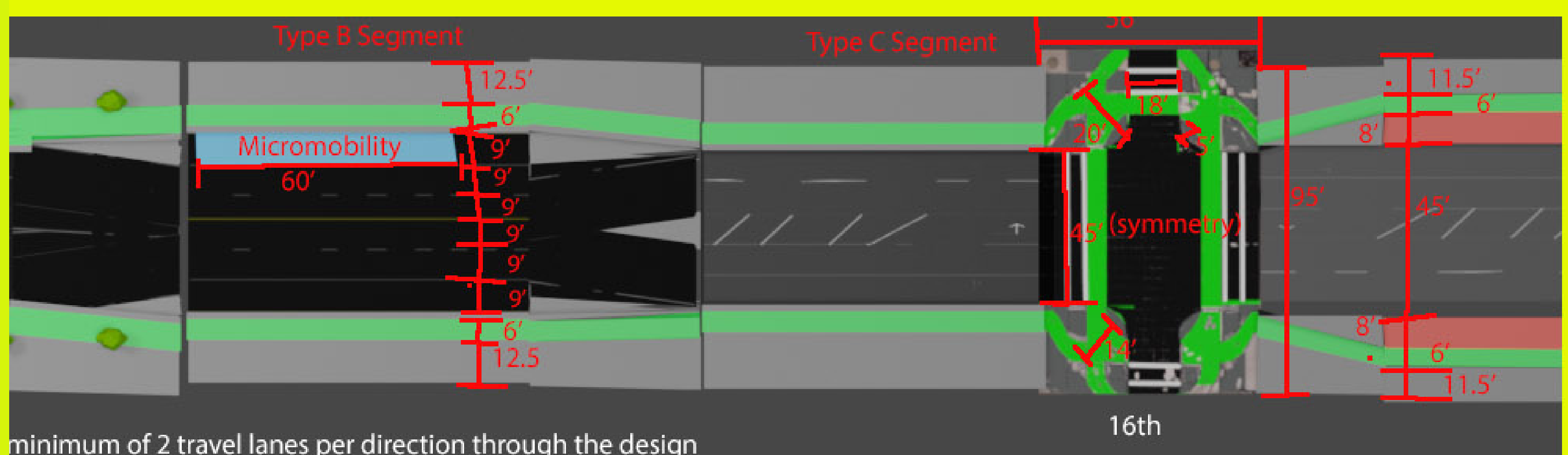
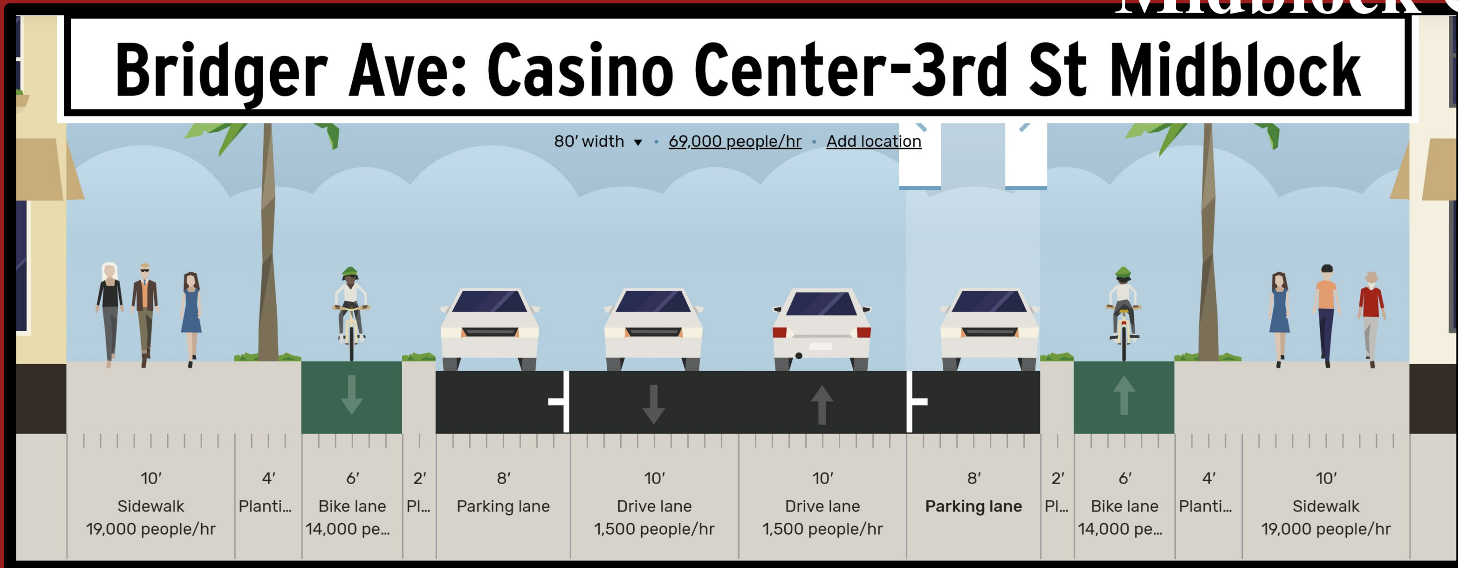
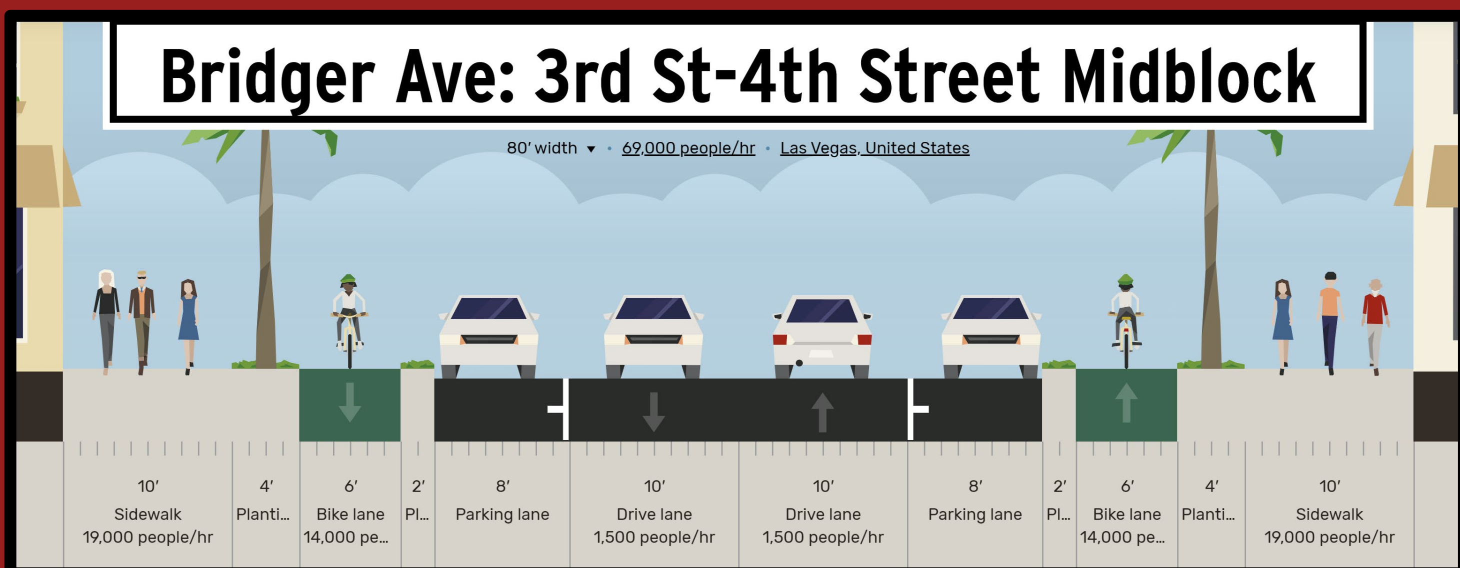
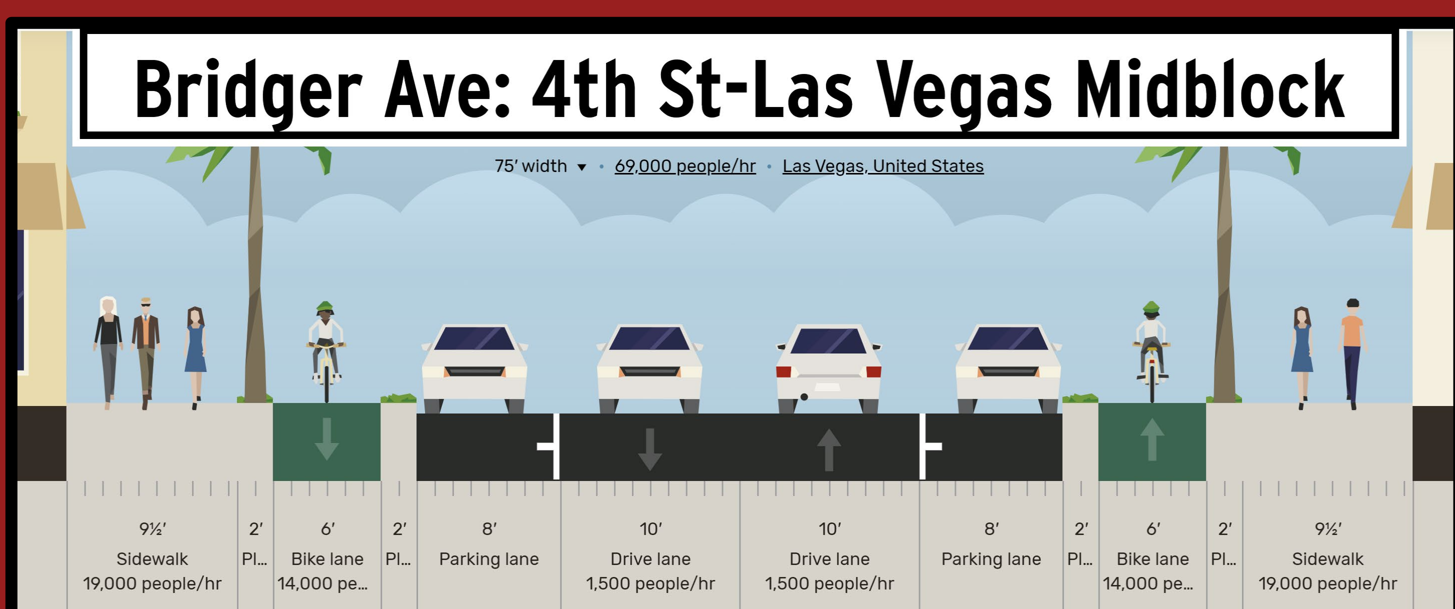


Exhibit 3: Midblock Cross Sections

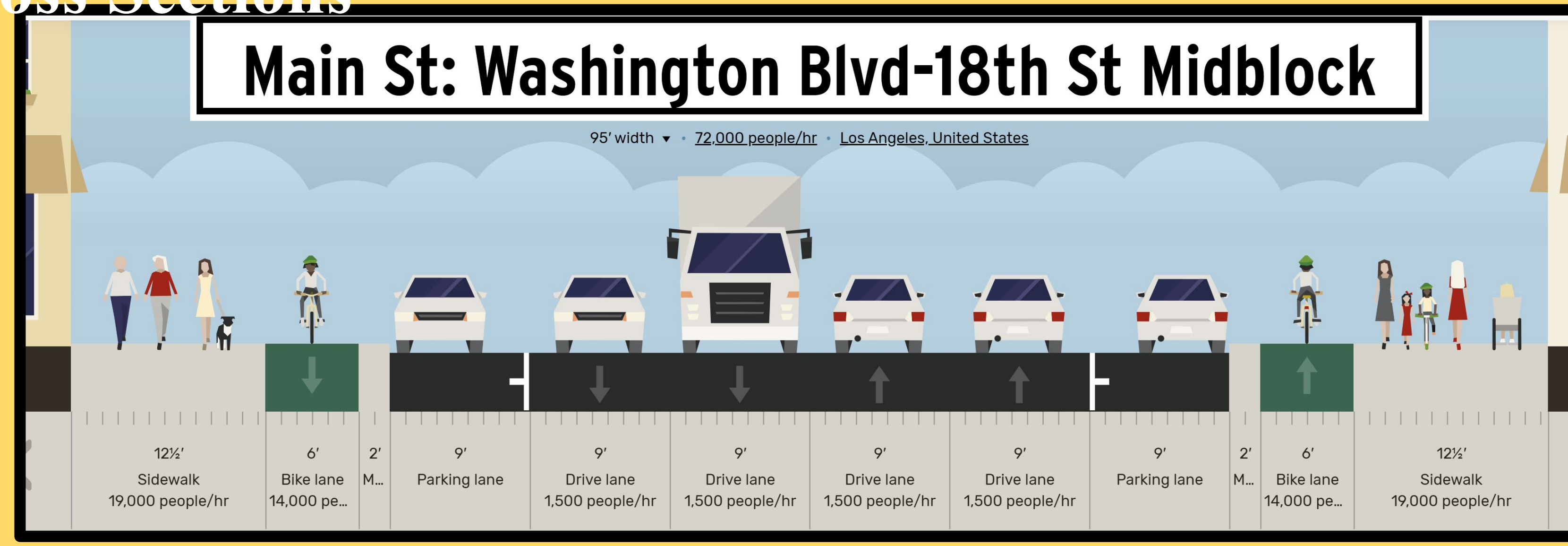
Site 1: Las Vegas

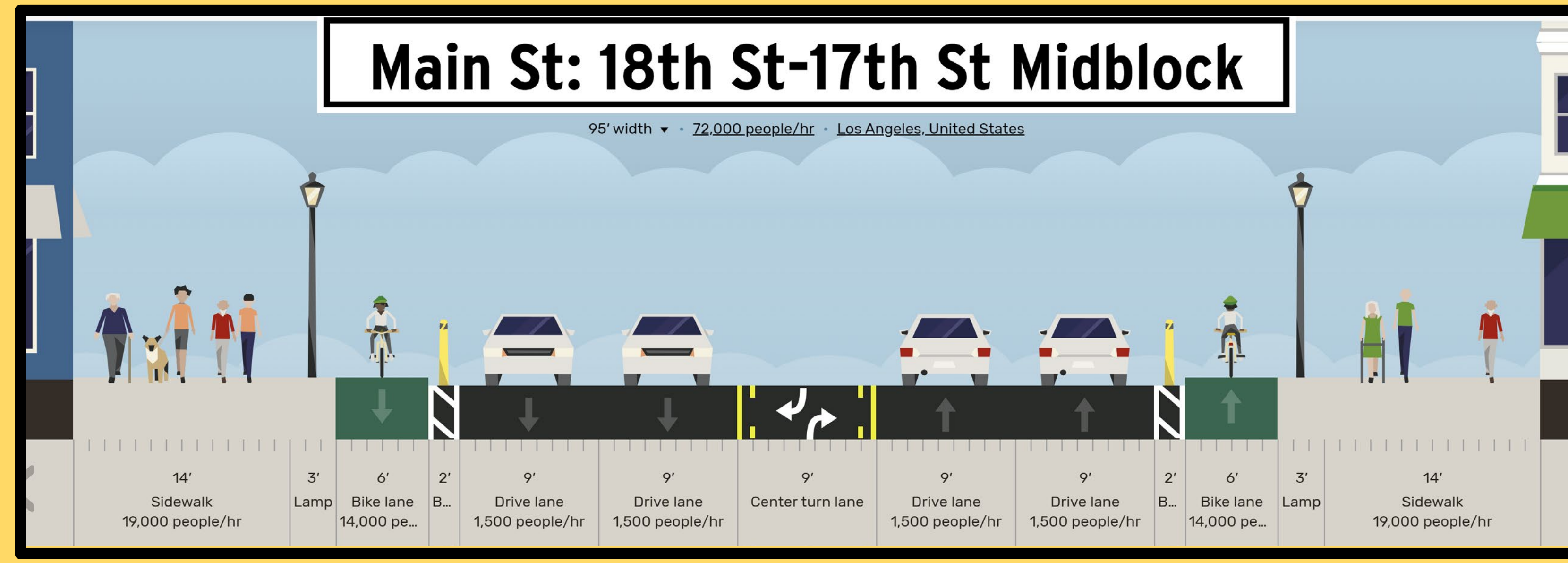


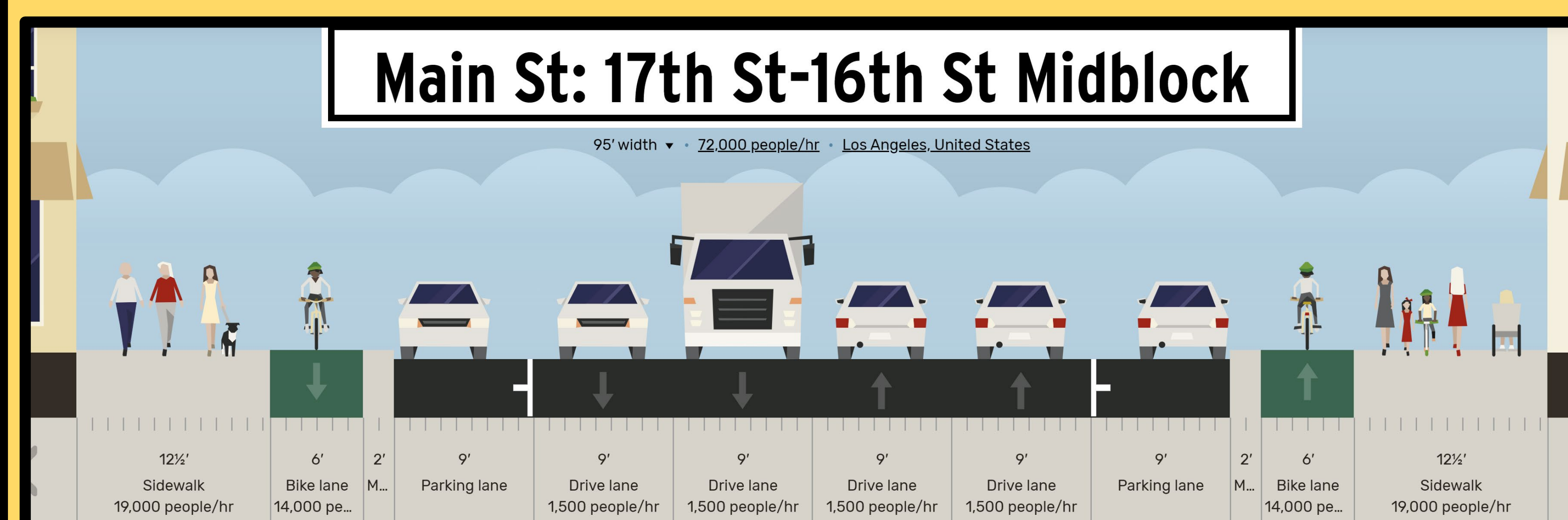




Site 2: Los Angeles

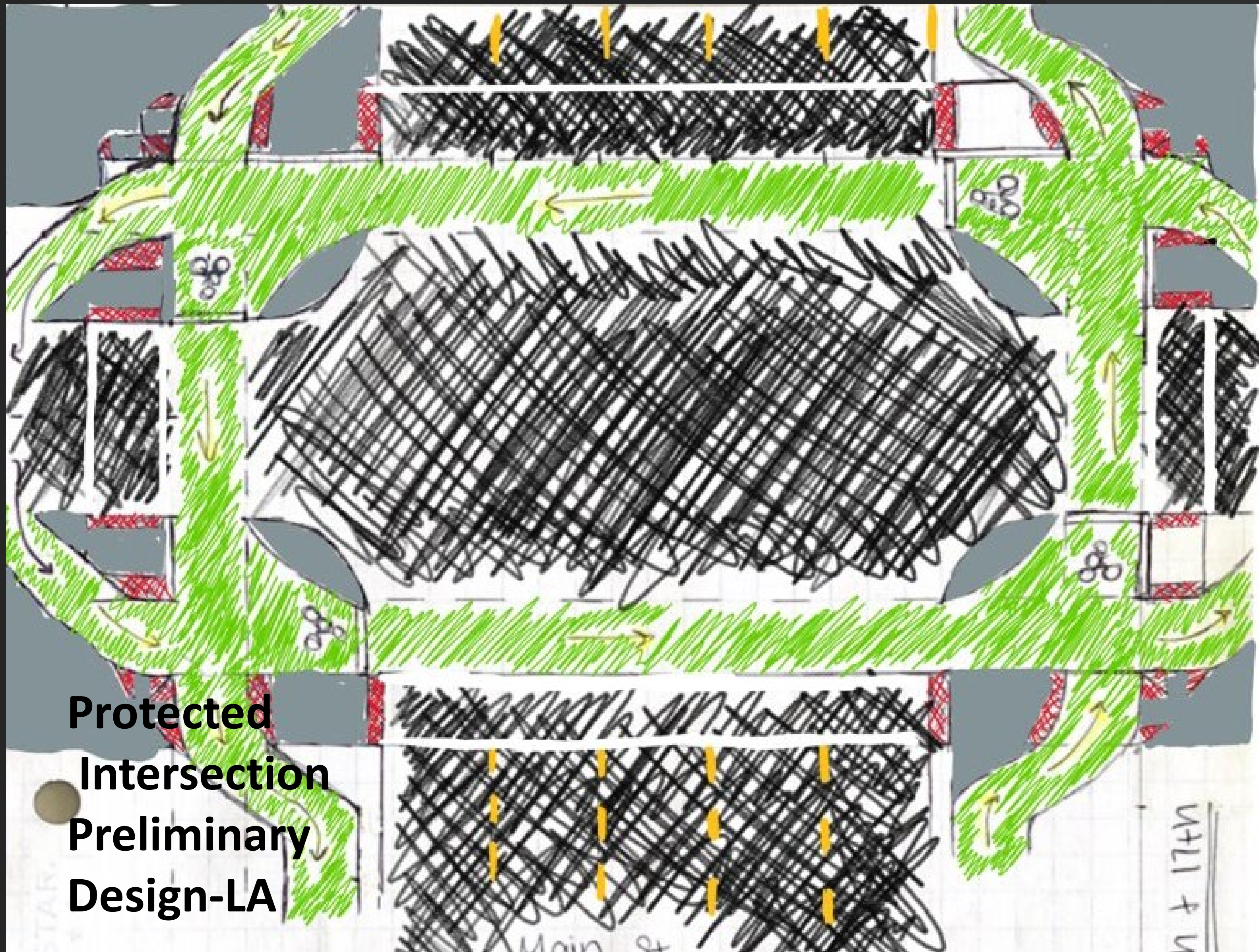






Design Elements

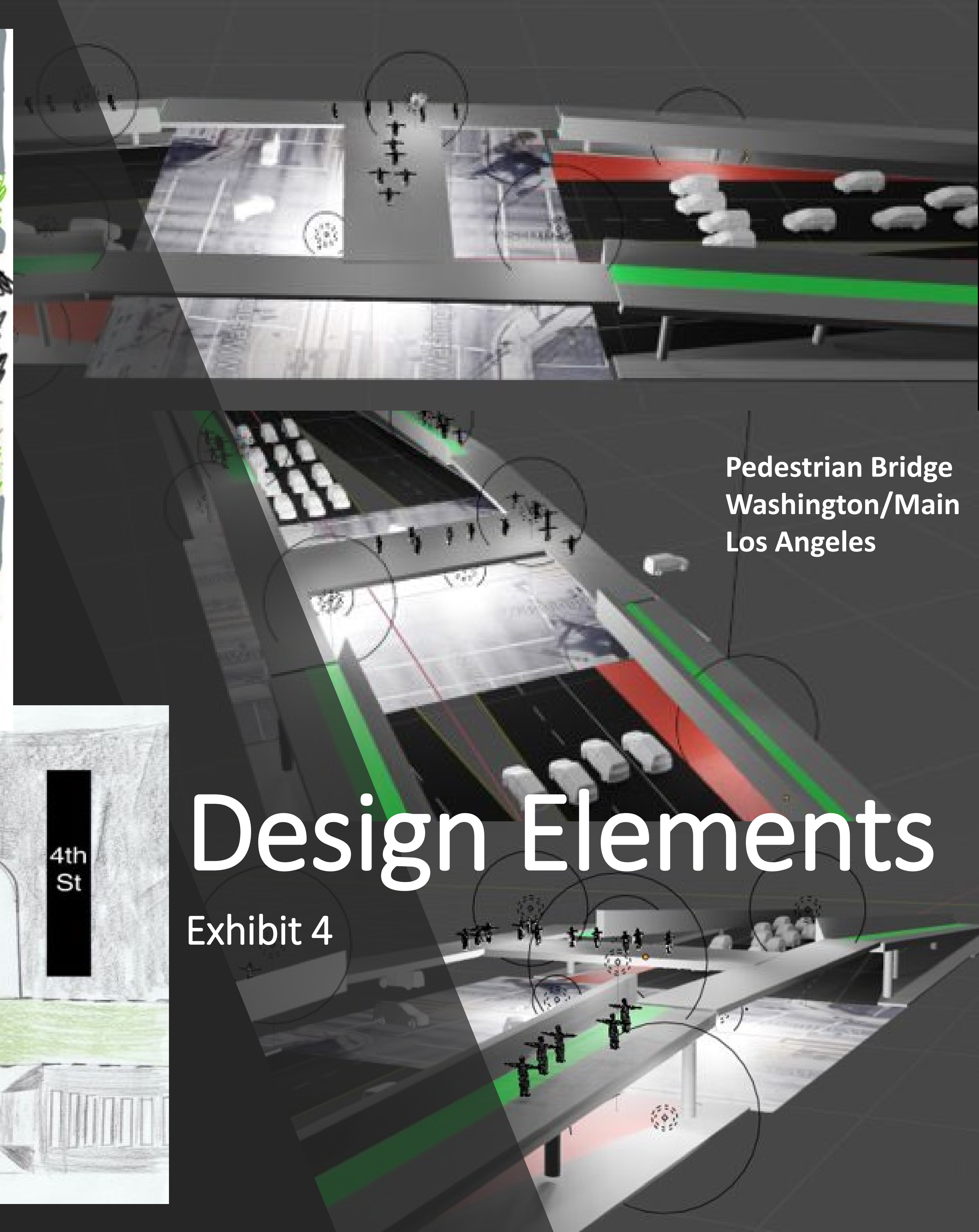
Exhibit 4



Protected Intersection Preliminary Design-LA

Mobility Hub-Las Vegas

Not drawn to scale



Pedestrian Bridge
Washington/Main
Los Angeles