

## ABSTRACT

Title of Document: COMPLETE STREETS CODE FOR  
ROADWAY FACILITY IMPROVEMENT IN  
COLLEGE PARK CAMPUS, THE  
UNIVERSITY OF MARYLAND – A  
CONTEXT-SENSITIVE APPROACH

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This design-research thesis suggests that the improvement of campus roadway facilities using Complete Streets principle and practices can enhance the overall pedestrian experience. Campus Drive, one of the main arterials in the College Park campus of the University of Maryland, will be used as a case study. Heavily used by a variety of users, often conflicting with one another, University of Maryland Campus Drive would benefit from a major planning and design amelioration to meet the increasing demands of serving as a university main street. The goal of this thesis project is to prioritize the benefits for pedestrians in the right-of-way and improve the

pedestrian experience on campus. This goal also responds to the recent Facilities Master Plan vision of building a more walkable campus. The goal of this design-research thesis will be achieved focusing on four aspects. First, design and plans will discourage cut-through driving to reduce vehicular traffic volume on Campus Drive in order to reduce pedestrian and vehicle conflicts. Second, plans and designs will clarify cyclists' use of the right-of-way and create a built environment that will reduce and hopefully eliminate current riding on pedestrian sidewalk. Third, the case study seeks to improve public transit facilities on Campus Drive to better serve users of which the majorities travel as pedestrians on campus. Finally, the case study seeks to improve pedestrian facilities to enhance pedestrian connectivity, accessibility, and overall experience on University of Maryland Campus Drive.

Campus Drive roadway facilities will be inventoried. Roadway segments typologies will be identified and classified. A toolkit, road improvement design interventions, will be developed based on this classification. An improved master plan will be developed utilizing the toolkit while considering the specific site context around specific segments and the overall functions carried by Campus Drive as a campus main street. Detailed plans and designs will be developed for focus areas that demonstrate the goals and objectives.

The outcome of the design-research thesis project is expected to serve as an example of implementing Complete Streets principles and practices in urban commuter university campuses, where transportation needs and institutional functions interact with each other.

COMPLETE STREETS CODE FOR ROADWAY FACILITY IMPROVEMENT IN  
COLLEGE PARK CAMPUS, THE UNIVERSITY OF MARYLAND  
– A CONTEXT-SENSITIVE APPROACH

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# Table of Contents

Acknowledgements.....	ii
Table of Contents .....	iv
List of Figures .....	vii
List of Illustrations .....	ix
Acronyms .....	xvi
Introduction.....	1
Chapter 1: Literature Review .....	3
1.1 Multi-Layer Transportation Model.....	3
1.2 Context-Sensitive Solutions.....	5
1.2.1 Definition .....	5
1.2.2 Planning .....	5
1.2.3 Design .....	12
1.3 Complete Streets .....	16
1.3.1 Definition .....	16
1.3.2 Benefits .....	16
1.3.3 Case Study .....	17
Chapter 2: Main Campus, University of Maryland, College Park.....	25
2.1 Methodology.....	25
2.2 Scope.....	25
2.2.1 Site .....	25
2.2.2 Districts .....	26
2.3 Existing Facilities.....	28
2.3.1 Vehicle .....	29
2.3.2 Cyclist .....	33
2.3.3 Pedestrian.....	35
2.3.4 Roadway Segment Facility Typology.....	38
2.4 2011-2030 Facility Master Plan Survey .....	40
2.4.1 Overview .....	40
2.4.2 Data Analysis .....	41
2.5 Issues Statement.....	44

2.5.1 Right-of-Way (R-o-W) Conflicts.....	44
2.5.2 User Experiences in Multi-modal Transportation Environments .....	45
2.5.3 Interrelationship with Institutional Aspects .....	45
Chapter 3: Campus Complete Streets Code.....	47
3.1 Objectives .....	47
3.2 Roadway Segment Typology.....	47
3.2.1 Group 1 .....	47
3.2.2 Group 2 .....	50
3.2.3 Group 3 .....	54
3.3 Improvements towards Complete Streets .....	56
3.3.1 Fundamental Infrastructure.....	56
3.3.2 Complete Street Elements.....	60
3.4 Improvement Combination Themes and Installation Examples.....	83
3.4.1 Main Street.....	84
3.4.2 Pedestrian Boulevard.....	88
3.4.3 Public Transit Hub.....	92
3.4.4 Bike Route .....	94
3.4.5 Arboretum .....	98
3.5 CCS Code Applicability Charts .....	101
3.5.1 Color Code.....	101
3.5.2 Applicability and Flexibility .....	102
Chapter 4: Campus Drive.....	103
4.1 Site Analysis .....	103
4.1.1 Scope.....	103
4.1.2 Pilot Closure.....	104
4.2 Segment Facility Analysis .....	105
4.2.1 Topography and Context.....	105
4.2.2 Pedestrian Facilities .....	108
4.2.3 Active Bike Route.....	112
4.2.4 Public Transit Facilities .....	113
4.2.5 Conflict at Intersections .....	115
4.2.6 Overall Facility Completeness Assessment.....	117



4.3 Master Plan .....	120
Chapter 5: Summary and Conclusion .....	121
5.1 Summary and Implications .....	121
5.2 Future Suggested Research .....	122
5.3 Conclusion .....	123
Appendix 1 Campus Drive Roadway Facility Analysis Quantitative Graphics .....	124
Appendix 2 Campus Complete Street Code Illustration Graphics .....	130
References .....	134

## List of Figures

Figure 1 .....	4
Figure 2. ....	6
Figure 3. ....	7
Figure 4. ....	11
Figure 5. ....	14
Figure 6. ....	18
Figure 7. ....	19
Figure 8. ....	20
Figure 9. ....	20
Figure 10. ....	22
Figure 11. ....	22
Figure 12. ....	24
Figure 13 .....	26
Figure 14. ....	38
Figure 15. ....	44
Figure 16. ....	45
Figure 17 .....	46

Figure 18 ..... 115

## List of Illustrations

Illustration 1 A light congestion on one of the arterials could lead to the failure of the whole network due to spillover effects. ....	12
Illustration 2 Main campus districts. Source of information: Facility Master Plan Updated 2011. University of Maryland, 2011 .....	28
Illustration 3 Campus roadway facilities. ....	29
Illustration 4 Vehicle lane width distribution. ....	30
Illustration 5 Shuttle-UM on-campus routes.....	31
Illustration 6 Parking lots and garages (on-street parking is not included). ....	32
Illustration 7 Planning on demolition and preservation of existing parking facilities (FMP vision referenced). ....	33
Illustration 8 Current frequently used cycling routes are mostly overlapping on Campus Drive (EW) and Regents Drive (SN), two of campus' main arterials. ....	34
Illustration 9 Roadway types along ABR. Vehicle lanes wider than 10 feet are not overlapping with ABR. ....	35
Illustration 10 Pedestrian trail, path and sidewalk distribution on campus. ....	36
Illustration 11 Frequently used pedestrian routes on campus. ....	37
Illustration 12 Roadway segment typology classified by vehicle Lane and pedestrian sidewalk. ....	39

Illustration 13 Roadway segment typology sections. ....	40
Illustration 14 Travel mode choices to/from campus against living distance from campus. Source of information: FMP Survey of Transportation and the Campus Environment. 2010.....	41
Illustration 15 Travel mode choices from place to place on campus. Source of information: FMP Survey of Transportation and the Campus Environment. 2010....	42
Illustration 16 Typo 1. 4 Lanes with median. ....	48
Illustration 17 Typo 2. 4 Lanes with central turning lane.....	49
Illustration 18 Typo 3. 4 Lanes with/without extra lane in one direction.....	50
Illustration 19 Typo 4. 2 Lanes with central turning lane.....	51
Illustration 20 Typo 5. 2 Lanes with median. ....	52
Illustration 21 Typo 6. 2 Lanes with one-side parking lane. ....	53
Illustration 22 Typo 7. 2 Lanes with/without extra lane.....	54
Illustration 23 Typo 8. 1 Lane with one-side parking lane. ....	55
Illustration 24 Typo 9. 1 Lane.....	56
Illustration 25 Traffic signal lights. ....	57
Illustration 26 Pedestrian Sidewalks.....	58
Illustration 27 From left to right, downwards: Shared lane, regular bike lane, contraflow bike lane, one-side bike lane, centered bike lane, buffered bike lane and bike track.....	59

Illustration 28 ADA accessibility examples on sidewalks and across medians.....	59
Illustration 29 Downwards, left to right: Painted markings buffer, bike racks, meadow buffer, terraced meadow buffer, bioswale buffer, terraced bioswale buffer.....	60
Illustration 30 Shared Space. ....	62
Illustration 31 Mountable Curbs. ....	63
Illustration 32 Raised Crosswalk. ....	64
Illustration 33 Extended Public Transit Stop Island and Curved Bike Lane. ....	65
Illustration 34 Pedestrian-Scale Road Lamps. ....	66
Illustration 35 Boardwalk over Infiltration Area. ....	67
Illustration 36 Periodical Pedestrian Plaza. ....	68
Illustration 37 Median Park. ....	69
Illustration 38 Parking Lane Pocket Park. ....	70
Illustration 39 Improved Way-Finding. ....	71
Illustration 40 Public Transit Stop Shelter.....	72
Illustration 41 Pedestrian-Dominated Intersection. ....	73
Illustration 42 Bulbout with Attractive Drainage Facilities.....	74
Illustration 43 Bulbout Extension Park.....	75
Illustration 44 Periodical Parking. ....	76
Illustration 45 Cobble Stone Infiltration Strip. ....	77

Illustration 46 Public Arts .....	78
Illustration 47 Permeable Pavements on Pedestrian Crosswalk. ....	79
Illustration 48 Permeable Pavements on Pedestrian Sidewalk. ....	80
Illustration 49 Permeable Pavements on Bike Lanes.....	81
Illustration 50 Permeable Pavements on Light-Load Vehicle Lanes.....	82
Illustration 51 Permeable Pavements on On-Street Parking Lots.....	83
Illustration 52 Design Example 1: 4 lanes with median. Improvement on pedestrian facilities, biking facilities, public transit facilities and planting. ....	84
Illustration 53 Design Example 2: 4 lanes with central turning lane. Improvement on pedestrian facilities, biking facilities, public transit facilities and planting.....	85
Illustration 54 Design Example 3: 4 lanes with/without extra lane. Improvement on pedestrian facilities, biking facilities and planting. ....	86
Illustration 55 Design Example 4: 2 lanes with median. Improvement on pedestrian facilities, green infrastructure and planting. ....	87
Illustration 56 Design Example 5: 2 lanes. Improvement on biking facilities, pedestrian facilities, green infrastructure and planting. Incorporated with the Purple Line. ....	88
Illustration 57 Design Example 1: 2 lanes with parking lane. Improvement on pedestrian facilities, green infrastructure and planting. ....	89
Illustration 58 Design Example 2: 2 lanes. Improvement on biking facilities,	

pedestrian facilities and planting. ....	90
Illustration 59 Design Example 3: 1 lane with parking lane. Improvement on pedestrian facilities and planting. ....	91
Illustration 60 Design Example 4: 1 lane. Improvement on pedestrian facilities and planting. ....	92
Illustration 61 Design Example 1: 2 lanes. Improvement on public transit facilities, pedestrian facilities and planting. Incorporated with the Purple Line. ....	93
Illustration 62 Design Example 2: 2 lanes. Improvement on public transit facilities and planting. Incorporated with the Purple Line. ....	94
Illustration 63 Design Example 1: 4 lanes with median. Improvement on public transit facilities, biking facilities, pedestrian facilities and planting.....	95
Illustration 64 Design Example 2: 2 lanes with median. Improvement on biking facilities, pedestrian facilities, green infrastructures and planting.....	96
Illustration 65 Design Example 3: 2 lanes with parking lane. Improvement on biking facilities, pedestrian facilities and green infrastructures.....	97
Illustration 66 Design Example 4: 2 lanes. Improvement on biking facilities and green infrastructures. ....	98
Illustration 67 Design Example 1: 2 lanes with median. Improvement on biking facilities, pedestrian facilities, green infrastructures and planting.....	99
Illustration 68 Design Example 2: 1 lane with parking lane. Improvement on	



pedestrian facilities, green infrastructures and planting. ....	100
Illustration 69 Design Example 3: 1 lane. Improvement on pedestrian facilities, green infrastructures and planting.....	101
Illustration 70 Campus Drive and proposed the Purple Line layout in main campus. ....	103
Illustration 71 Campus Drive site context. ....	104
Illustration 72 Campus Drive Topography. ....	106
Illustration 73 Campus Drive Slope Map. ....	107
Illustration 74 Campus Drive Vegetation Coverage. ....	108
Illustration 75 Campus Drive pedestrian path intersection linear density (quantity per ¼ mile). ....	109
Illustration 76 Campus Drive pedestrian crosswalk linear density(quantity per ¼ mile). ....	110
Illustration 77 Campus Drive pedestrian path intersection / crosswalk linear density unmatch. ....	111
Illustration 78 Campus Drive pedestrian pedestrian facility completeness. ....	112
Illustration 79 Campus Drive ABR overlapping. ....	113
Illustration 80 Campus Drive public transit stops.....	114
Illustration 81 Campus Drive conflict points between vehicle/bicycle and pedestrian. ....	116

Illustration 82 Campus Drive conflict points among vehicle/bicycle.....	117
Illustration 83 Campus Drive Composite Connectivity Indices. ....	119
Illustration 84 Campus Drive overall facility completeness assessment. ....	120
Illustration 85 Campus Drive improvement master plan.....	120

## Acronyms

<b>ABG</b>	<b>Arboretum and Botanical Garden</b>
<b>ABR</b>	<b>Active Bike Route(s)</b>
<b>AASHTO</b>	<b>American Association of State Highway and Transportation Officials</b>
<b>BCM</b>	<b>Brand concept mapping</b>
<b>CCS Code</b>	<b>Campus Complete Street Code</b>
<b>CSS</b>	<b>Context-Sensitive Solutions</b>
<b>FHWA</b>	<b>Federal Highway Administration</b>
<b>FMP</b>	<b>Facility Master Plan (refers to 2011 – 2030 Update if not specified)</b>
<b>ITE</b>	<b>Institute of Transportation Engineering</b>
<b>R-o-W</b>	<b>Right-of-Way</b>
<b>UMCP</b>	<b>University of Maryland, College Park</b>
<b>WMATA</b>	<b>Washington Metropolitan Area Transit Authority</b>

## Introduction

In both historical and modern cities, urban streets perform multiple functions in addition to connecting people and places that are set apart by distance. Because 80% of the public realm can be made up of streets, there are many other important functions outside of mobility, including economic and social functions (BECK, 2009, ODPM, 2003).

However, most streets designed in the 20<sup>th</sup> century suffer from separation of mobility and other functions, which casts negative effects on economy, community, public health and safety, and many other aspects of urbanized society (ITE, 2010). Serving as part of the community's transportation network, the University of Maryland, College Park (UMCP) campus streets are affected by these mobility-focused road design practices. Cut-through traffic through the university also presents problems to campus daily operation. The 2011-2030 Updated Campus Facility Master Plan (FMP) sees transportation issues as one of the top priorities for the next two decades.

Since the majority of the campus population travels as pedestrians on campus, to a (FMP 2010, from which data will be analyzed in the following chapter), the campus is considered a community where walkability should be improved. Thus this project applies Context-Sensitive Solutions, which are designed specifically for transportation systems.

As Context-Sensitive Solutions, Complete Streets practices aim at restoring the complex functions of urban streets and promote the concept "Streets as Places" in state and lower jurisdiction levels. Most practices are performed at the municipal scale and target urban communities. Utilizing Context-Sensitive Solutions, which promote a collaborative and multidisciplinary process (ITE, 2010); this thesis project develops a Campus Complete

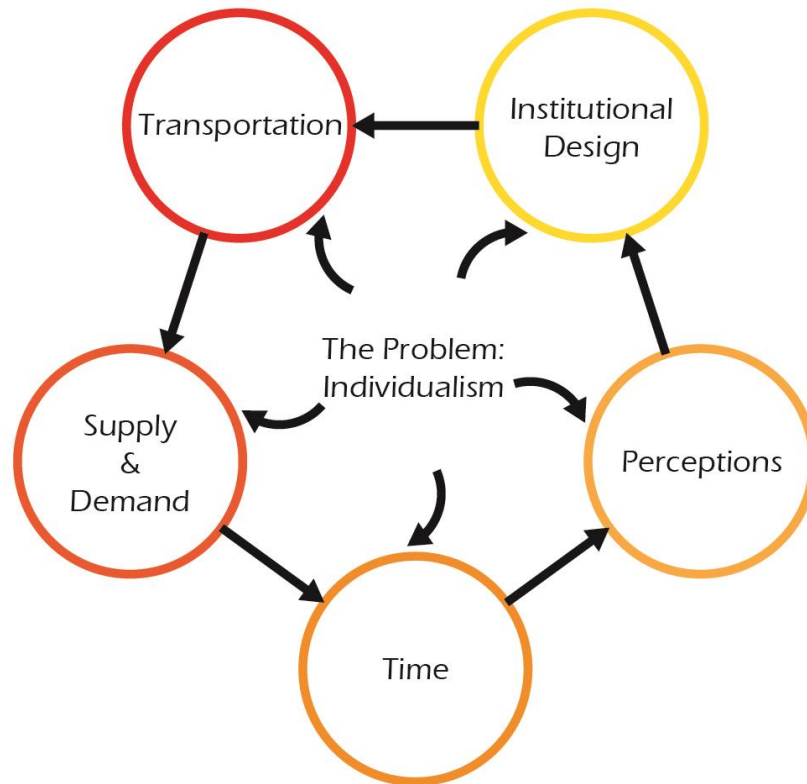
Street Code under the scope of the FMP, which provides guidance for improving campus roadway segments using Complete Streets principles.

# Chapter 1: Literature Review

## 1.1 Multi-Layer Transportation Model

Transportation planning and facility design in university campus contexts is as complex as in urban walkable communities, because campus streets carry no fewer functions than urban walkable community streets. Though sharing similar spatial and temporal traffic patterns with the city road network, urban university campus streets have some unique features that need to be taken into consideration. Obviously as academic institutions, university campuses require stringent safety, legal and environmental restrictions on traffic (especially vehicular traffic) travelling on inner road networks. As will be revealed in the survey report, the majority of roadway users adopt non-automobile transportation modes on the UMCP campus. Transportation problems and institutional problems are closely connected in university campus environments. Kronlid (2008) argued that the intimate psychological and physiological relationship between transportation facilities and their users discriminates the preferences. In 2010, Ferreira and Batey's study quoted this claim and further pointed out that these preferences in return influence the development and interaction between facilities and users. This interaction implies that transportation planning on university campuses is constrained by institutional design and needs, and vice versa. With this inner relationship, problems cannot be effectively solved unilaterally. Ferreira and Batey's multi-layer transportation model, seen in Figure 1, reveals a connection linking transportation back to institutional design through three layers: supply and demand, time and perceptions. Within this loop the problems develop and exacerbate themselves. This model was developed from the study of University of

Coimbra (UC) campus in Coimbra, Portugal, which is located in a university town comparable to College Park. These studies also imply that perceiving the problem from an appropriate perspective is critical to the subsequent performance of improved road segments. (Ferreira and Batey, 2007)



**Figure 1 Five layers approach to transportation problems. Source of information: Ferreira and Batey, 2007**

Based upon the interrelationship between transportation and institutional functions of campuses, a practice of roadway facility improvement using Complete Streets principles will predictably benefit both.

## 1.2 Context-Sensitive Solutions

### 1.2.1 Definition

In 2007, the American Association of State Highway and Transportation Officials (AASHTO) and the Federal Highway Administration (FHWA) produced a Context Sensitive Solutions Strategic Planning Process report. They define Context sensitive solutions (CSS) as a collaborative, interdisciplinary approach that involves all stakeholders in providing a transportation facility that fits its setting. It is an approach that leads to preserving and enhancing scenic, aesthetic, historic, community and environmental resources, while improving or maintaining safety, mobility and infrastructure conditions. (AASHTO / FHWA, 2007)

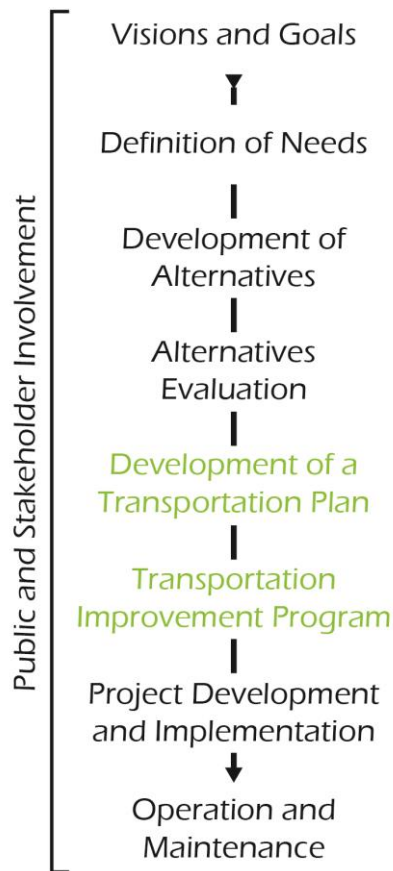
While conventional transportation engineering interprets roadway function as singly supporting mobility, a CSS perspective perceives urban roadways as part of the city infrastructure that carry multiple functions other than mobility, including economic, social, recreational functions and more.

### 1.2.2 Planning

#### 1.2.2.1 CSS in the Campus Transportation Planning Process

In general, transportation planning is a process of balancing the demands of all stakeholders in the transportation system. An effective transportation planning process should be continuous, comprehensive and collaborative (ITE, 2010).





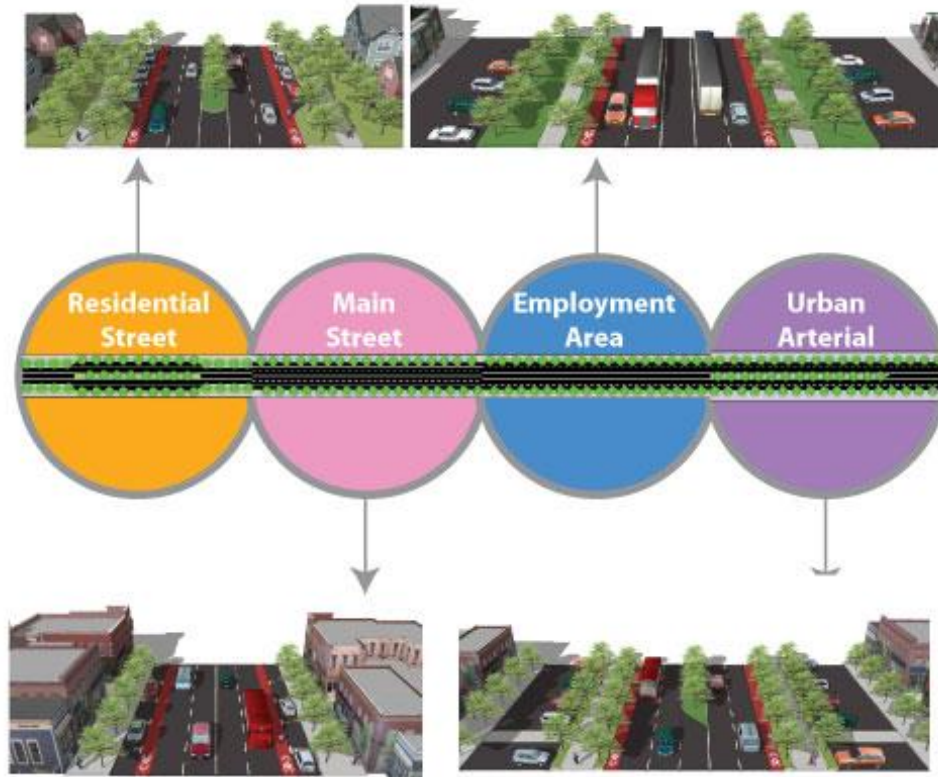
**Figure 2 Transportation planning process. Source of information: Kimley-Horn and Associates, Inc.**

CSS adds a variety of factors, including land use, transportation and infrastructure demands, to conventional transportation planning, and these additions allow agency goals and objectives to be reflected in the early stages of the entire process. Meanwhile, CSS helps identify and localize transportation issues, facilitating agreement on changes and their possible outcomes.

A Complete Streets policy is a perfect example of applying CSS in transportation planning. Many states and municipalities have adopted various localized Complete Streets policies and benefited in many aspects, from the living environment to public

health. Recent years have seen roadway designs that incorporate CSS principles follow the gradient of development patterns. This inclusion of CSS enhanced the flexibility and creativity of Complete Streets practices in areas with unconventional conditions.

(AASHTO / FHWA, 2007)



**Figure 3 Context-Sensitive Solutions. Source: PLANiTULSA, 2012.**  
<http://www.planitulsa.org/files/context-sensitive.jpg>.

An FHWA safety review found that properly applying Complete Streets design elements can improve the safety of all roadway users (Campbell et al., 2004). Another study found that installing these elements reduced pedestrian risk by 28% (King et al., 2003). Several other reports and organizations, including the National Conference of State Legislators, also indicated that Complete Streets policies effectively improve public health by

encouraging healthier travel means, especially walking and biking (Teach, Robbins and Morandi, 2002). A study done by Powell et al. in 2003 found that the percentage of people who meet recommended physical activity levels has a positive correlation with whether there are safe places to walk within certain range from their home. The Institute of Medicine recommendations for fighting childhood obesity revealed a direct link between implementing Complete Street policies and improved public health (Koplan et al., 2004).

#### 1.2.2.2 Campus Road System and City Road Network

As an urban university, the University of Maryland is embedded in the city of College Park, which locates in an increasingly urbanized metropolitan corridor (University of Maryland, 2011). Campus streets more or less undertake functions of connecting College Park and its neighboring municipals, resulting in cut-through traffic (mostly vehicular) bringing negative impacts on campus operations. For example, current UMCP campus transportation regulations require cyclists to share the vehicle lanes, but in most cases this particular regulation is not well followed. One of the major reasons is that drivers cutting through campus are unfamiliar with campus transportation regulations.

In order to improve campus transportation situation, dealing with issues created by cut-through traffic is inevitable.

### 1.2.2.3 A Framework for Campus Roadway Design

In this project, the campus context perimeter is identified by the edge of on-campus activity destinations and campus entrances. Within a campus context, the major objective of transportation facilities is to support campus user mobility and other functions, and a sub-context will be identified to endow roadway segments with greater diversity and richer details.

Although site context shapes the framework of roadway segment design, in return the design will contribute to define and shape the context as much as adjacent land uses and buildings do. A 2010 ITE report recommended that transportation planning should support the context while being clearly focused on it at early project stages (ITE, 2010). Conventional roadway design determinations include roadway functional classification, traffic volume and design speed, which all aim to evaluate vehicular mobility and accessibility. Besides these, CSS involves new determinations regarding multimodal safety and mobility, and supporting nearby activities. Conventional and additional determinations are the two dimensions in designing the Campus Complete Streets Code (CCS Code), in which the former is constant and the latter is variable (see 3.1).

### 1.2.2.4 Features that Create Context and Sub-Context

Land use is commonly used in transportation planning and design as a criterion for characterizing the site and identifying vehicular traffic generator. However, because campuses are typically considered a single land use type, this is not as suitable at the campus scale.

Other features used in CSS planning include site design, urban form, and building design. In this project, site features are used instead of urban form.

Context zones in CSS follow a gradient of development patterns, ranging from two rural context zones, four urban context zones, to one district context zone. This project uses a set of smaller scale context zones (sub-context zones) using existing campus districts as criteria. These sub-context zones combine with roadway segment functions to determine design parameters, referred to as “themes” in the CCS Code (see 3.3).

#### 1.2.2.5 Roadway Segment Typology Classification

Like context-creating features and context zones, the scale of roadway classification in CSS needs to be adjusted to fit campus context. According to Institute of Transportation Engineering’s identification of components on a typical roadway section, roadside is where the majority of improvements in this projects being applied. The vehicle lanes will largely remain unchanged as a major topic in Transportation Demand Management (TDM).



**Figure 4 Components of a typical roadway section. Source of information : ITE.**

Explained by Supply and Demand theory, a change in the cost (or price) of travel results in a change in the quantity consumed (Wikipedia, 2013). Although either increasing road capacity (supply) or reducing traffic volume (demand) seems to be a theoretically efficient solution, in practice, latent demand (the phenomenon that more resources are consumed after supply increases) needs to be considered in order to increase capacity. Otherwise it is highly possible that the whole project results in failure. In the year 1924, Bion J. Arnold, a Chicago consultant, prepared a report to the Los Angeles Board of Harbor Commissioners, in which he recommended several transportation improving measures. In this report, he presciently proposed in a corridor paralleling the shoestring annexation strip to San Pedro, eight railroad tracks flanked by grade-separated roads, to be known as the "auto speedway" (Robert, 1999). This proposal was considered as a great foresight, which designed to meet higher transportation demands than actual in his time. But decades later, Los Angeles was well-known as the ultimate of Urban Sprawl and for its shocking traffic congestion (Wendell, 1999). This induced traffic appears when new automobile trips were generated. It happens when people choose to travel by car instead of public transport, or decide to travel when they otherwise would not have (Litman, 2011). During the past half-century, several solutions of increased of supply and reduction of demand was in play, but the results are not as satisfying as expected. On the other hand, remove vehicle lanes carelessly could also lead to serious consequences. Spillover effects mostly caused by "rat running" (or "cut-through running") from congestion of arterial roads affect and threats amenity and safety of

nearby communities with secondary roads and streets go through, Sometimes could lead to a massive congestion in part of the network and subsequently network failure.



**Illustration 1** A light congestion on one of the arterials could lead to the failure of the whole network due to spillover effects.

Thus in this project, campus streets are classified by facility, and further categorized by traveled ways, for layout of vehicle lanes will remain unchanged as possible and used as control to track the changes of other components.

### 1.2.3 Design

#### 1.2.3.1 Definitions

Definitions used in this thesis are similar to those in CSS, adjusted from ITE 2010 report,

A Context-Sensitive Solutions to fit campus environment:

- Context — encompasses a broad spectrum of environmental, social, institutional and historical aspects of the campus and its population. Context can be the built environment or part of the natural environment.
- Streetside—the public right of way, typically includes planting area and sidewalk, from the back of the curb to the front property line of adjoining parcels. (ITE, 2010)
- Traveled way—the public right of way between curbs that includes parking lanes and the travel lanes for private vehicles, operations and maintenances, transit vehicles and bicycles. Medians, turn lanes, transit stops and exclusive transit lanes, curb and gutter and loading/unloading zones are included in the traveled way (ITE, 2010).

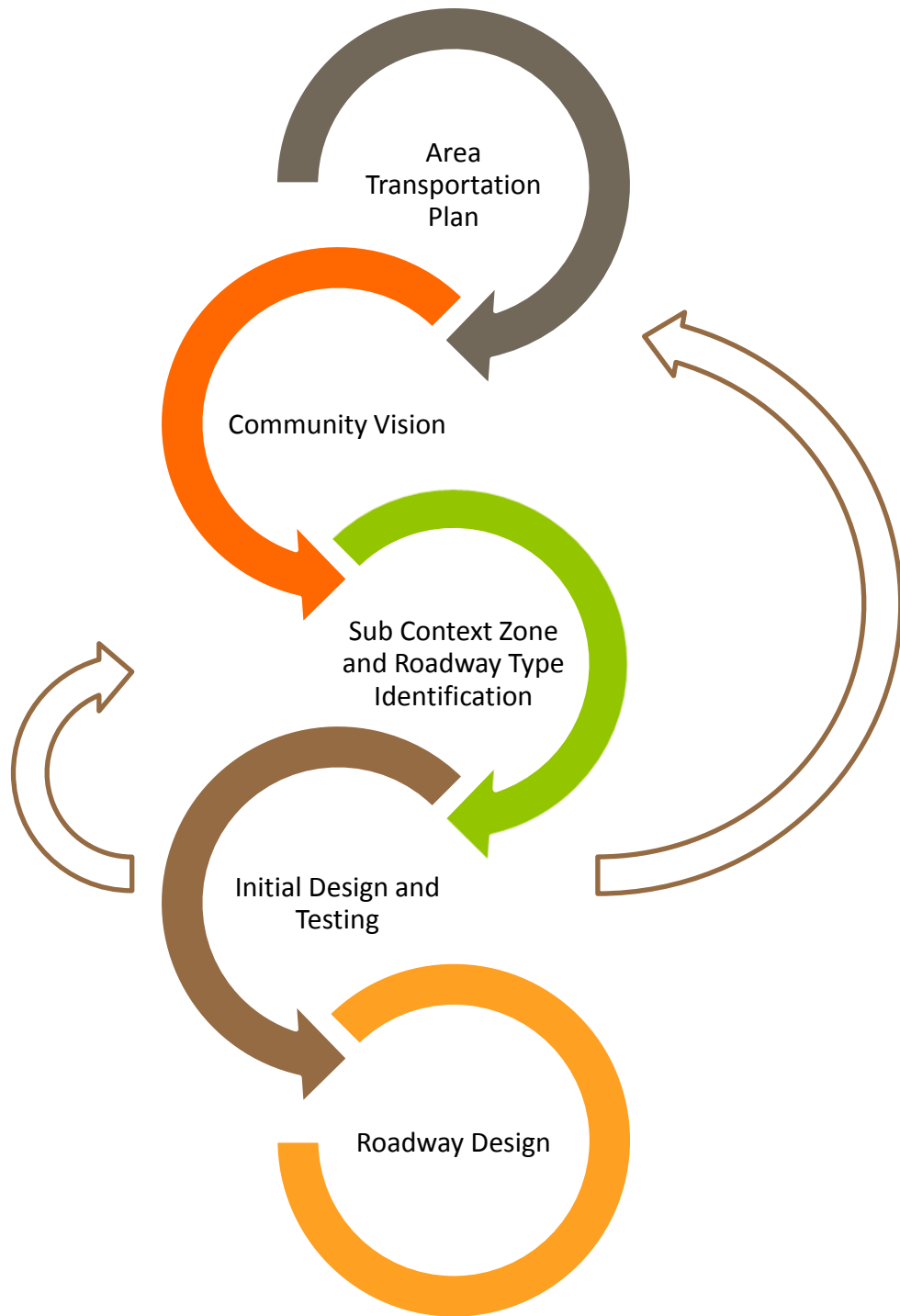
As mentioned in the introduction part, intersections will not be discussed in details as this thesis is focusing on direct segments. Designing intersections using CSS and Complete Streets principles is open to future research.

#### 1.2.3.2 Overview of the Design Process

The five-stage design process recommended by ITE encompasses the transportation planning processes mentioned in Chapter 2. As this process is universal applicable in terms of project type and context, it is adopted in the developing process of this thesis.

**Figure 5** presents the workflow of this process.





**Figure 5 Roadway design stages. Source of information: Kimley-Horn and Associates, Inc.**

### 1.2.3.3 Applicability

The thesis applies all stages of this process. Based on the transportation plan and community vision provided by campus FMP, sub context zones and roadway typologies are identified in Part 3 and Part 5. The outcome, CCS Code, serves as guidance for future roadway improvement / design

### 1.2.3.4 Flexibility in Design Controls

Regardless the application of CSS in this thesis project, design controls recognized by AASHTO including functional classification, traffic volume and level-of-service, design vehicle and driver and target speed (AASHTO, 2004, ITE 2010) are regarded not-negotiable. Thus except expansion and increase in lanes, no modifications made on traveled ways will affect vehicular traffic from transportation engineering perspectives during the design process.

### 1.2.3.5 Constrained Right-of-Way

The prime nature of roadway segment design is balancing the desired roadway elements with Right-of-Way constraints. (ITE, 2010) For example, by installing bike lanes to a certain roadway segment, which clarifies cyclists' R-o-W, could possibly results in increasing in traveled way width, and extended the distance for pedestrians crossing the road, thus negatively impacts walkability.

With a various setbacks from the buildings adjacent to roadways in main campus, most

segments falls into optimal conditions, the most ideal condition identified by ITE. The thesis prioritizes design elements into two levels, fundamental improvements with the highest priority and landscape elements with lower priority. Thus increases the adaptability and flexibility of the CCS Code.

## 1.3 Complete Streets

### 1.3.1 Definition

According to the definition of National Complete Streets Coalition, Complete Streets are streets for everyone. They are designed and operated to enable safe access for all users, including pedestrians, bicyclists, motorists and transit riders of all ages and abilities.

(Smart Growth America, 2013)

### 1.3.2 Benefits

Complete Streets principles and practices have been evaluated through various studies on their performances and benefits. Their performance in improving public safety and health are significant. A Federal Highway Administration safety review found that designing streets with pedestrians in mind, e.g., sidewalks, raised medians, turning access controls, better bus stop placements, better lightings, traffic calming measures, and treatments for disabled travelers, and other treatments, can improve the safety of all roadway users (Campbell et al, 2004). Another study found that installing these features reduced

pedestrian risk by 28% (King et al., 2003).

It has been suggested by a variety of reports and organizations including National Conference of State Legislators that by promoting walking and bicycling, complete streets policies could improve public health (Robbins and Morandi, 2002). One study found that 43% of people with safe places to walk within 10 minutes of home met recommended physical activity levels, while just 27% of those without safe places to walk were active enough (Powell et al., 2003). The Institute of Medicine recommends fighting childhood obesity by changing ordinances to encourage construction of sidewalks, bikeways, and other places for physical activity (Koplan et al., 2004).

There are no studies regarding assessment and evaluation on Complete Streets practices in university campuses found yet (see 5.3 Future Study), but with educational green infrastructures and public arts being installed on campus roadway segments, and related student involvement programs being proposed, their institutional benefits are supported by both the literature and this case study.

### **1.3.3 Case Study**

#### **1.3.3.1 State of Oregon: Bike Bill and University Program**

Section 366.514 of the Oregon State Statutes requires that all roadway construction and reconstruction must include bicycle and pedestrian facilities. Additionally, at least 1 percent of all state funding received by local governments must be spent on bicycle and pedestrian improvements. The law (Figure1) was approved by using the argument that

bicycle and pedestrian facilities were necessary to ensure that schoolchildren had safe routes to school. However, during the first 20 years, many local governments simply ignored the requirements. In 1992, advocates from the Bicycle Transportation Alliance sued the City of Portland for noncompliance. The bike bill was clarified that all construction and reconstruction must accommodate bicyclists and pedestrians (Figure2). In transportation planning, adding the required construction up front is much cheaper than a retrofit.



**Figure 6 Oregon Governor Tom McCall signs the Bicycle Bill into law. Source: <http://activetransportation.ca/category/usa/portland/> Accessed May 05, 2013.**



**Figure 7 Car Free Day 2011 in the City of Corvallis. Source:** <http://sustainablecorvallis.org/2011/10/corvallis-2nd-annual-world-car-free-day/> Accessed: May 05, 2013.

As a result of this aggressive law, Oregon has been the pioneer in bike and pedestrian improvement. Enforced by the bike bill, 97 percent of the City of Corvallis' main roads have bicycle lanes on them (Figure3). Corvallis also has the highest rate of commuting by bike in the country (OSU, 2013). The roads planning also met the alternative transportation needs of Oregon State University (OSU). Recent survey demonstrated that 40 percent of the University employees ride the bus, walk or bike to work. Similarly, 30 percent of students come to school by biking and more than half using alternative forms of transportation(OSU, 2013). Besides having easy access to bike lanes, extensive bicycle parking facilities of can also contribute to the success. Portland State University provides two secure bicycle garages (Figure4) and the PSU Bike Hub, an on-campus repair shop focused on teaching bicycle maintenance (PSU, 2013).



**Figure 8 Bike garage in Portland State University. Source: <http://www.pdx.edu/news/psu-named-%E2%80%9Cbicycle-friendly-university%E2%80%9D-national-bike-summit> Accessed: May 05, 2013.**



**Figure 9 Bike lanes in the City of Corvallis. Source: <http://oregonstate.edu/sustainability/blog/2011/06/exciting-bicycle-research-project-coming-to-corvallis/> Accessed: May 05, 2013.**

### 1.3.3.2 City of Chicago: Complete Street Policy, Training and Implement

The City of Chicago adopted a complete streets policy in October 2006. The policy states, “The safety and convenience of all users of the transportation system including pedestrians, bicyclists, transit users, freight, and motor vehicle drivers shall be

accommodated and balanced in all types of transportation and development projects and through all phases of a project so that even the most vulnerable—children, elderly, and persons with disabilities—can operate safely within the public right of way.” (COME-ON-IN, 2013)

The Chicago Department of Transportation worked with the Chicago Metropolitan Agency for Planning to sponsor a series of training sessions for city planners, engineers, and project managers. The workshops helped to increase a greater awareness of complete streets issues and a better understanding of potential design considerations. According to pedestrian program coordinator, the project “aims to identify opportunities and challenges in existing city policies and practices and to create a series of recommendations to address these.” The city hopes to operationalize complete streets in all phases of a project including planning, design, construction, and maintenance.

The City of Chicago’s Bicycle Program within the Chicago Department of Transportation has installed bike lanes on streets throughout Chicago since 1995. The majority of bike lanes existing in Chicago have been installed with the assistance of federal funding in the form of the Congestion Mitigation & Air Quality (CMAQ) grant. Between 1995-2008 CMAQ funding providing for the installation of approximately 94 miles of on-street bike lanes and 20 miles of marked shared lanes. (Chicago Bicycle Program, 2013) The program has constructed bike Lanes, marked shared lanes, bike/bus lanes and signed bike route network (Figure 5&6).





Figure 10 Buffered Cycle Lane on Busy Arterial in Chicago, Illinois. Source: <http://spokesdunedin.wordpress.com/2012/11/10/protected-bike-lanes/> Accessed: May 05, 2013.



Figure 11 Chicago's new bike route signage guides bicyclists on the best routes to popular destinations throughout the city. Source: <http://www.walkinginfo.org/faqs/answer.cfm?id=3485> Accessed: May 05, 2013.

### 1.3.3.3 San Francisco: Better Street Plan and Projects

San Francisco's policies encourage a 'complete streets' approach to the design and

management of public right-of-ways that considers the multiple roles that streets play. San Francisco's Transit-First Policy (San Francisco City Charter Section 16.102), voted into the City Charter in 1999, states that the City should prioritize street improvements that enhance travel by public transit, by bicycle and on foot as an attractive alternative to travel by private automobile. The City's Better Streets Policy (San Francisco Administrative Code Section 98.1), adopted in 2006, states that streets are for all types of transportation, particularly walking and transit, and requires City agencies to coordinate the planning, design and use of public rights-of-way to carry out the vision for streets contained in the policy. The Better Streets Plan (aka Complete Street), adopted by the city in December 2010, provides a comprehensive set of guidelines for the design of San Francisco's pedestrian realm:

*“Better Streets are designed and built to strike a balance between all users regardless of physical abilities or mode of travel. A Better Street attends to the needs of people first, considering pedestrians, bicyclists, transit, street trees, storm water management, utilities, and livability as well as vehicular circulation and parking.”*

The Complete Streets Policy (Public Works Code Section 2.4.13) directs the City to include pedestrian, bicycle, and streetscape improvements as part of any planning or construction in the public right-of-way. (SF Better Streets, 2013) Better Street Project focuses on following project types (Figure7): activating street space, greening and storm water management, pedestrian safety and traffic calming, reclaiming roadway space, other streetscape elements (lighting, special paving, street furniture and etc.)



Figure 12 Better Streets Practices in San Francisco. Source: <http://www.sfbetterstreets.org/>  
Accessed: May 05, 2013.

## Chapter 2: Main Campus, University of Maryland, College Park

### 2.1 Methodology

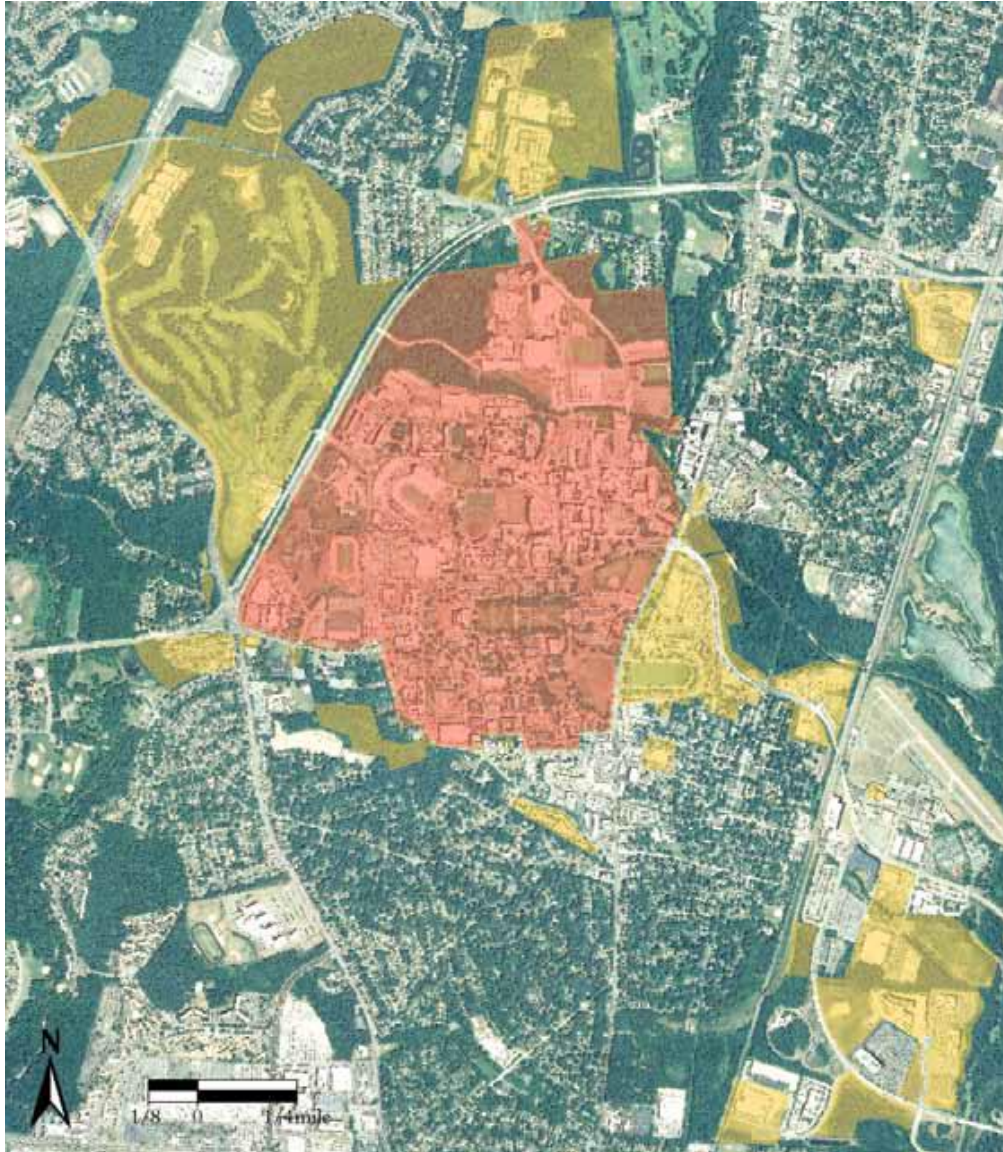
This project adopted a 5-step methodology similar to the typical roadway design process illustrated in 1.2.3.2.

1. Inventory campus roadway facilities from both network and segment scale;
2. Analysis the facility completeness and the vision of FMP, to define the perimeter of the project;
3. Analysis FMP Subcommittee Survey results to involve community vision;
4. Identify and categorize roadway segment typology for design codes.
5. Campus roadway segment improvement design.

### 2.2 Scope

#### **2.2.1 Site**

The site of this thesis is College Park main campus, which is bordered by University Boulevard/U.S. Route 193, Campus Drive, Mowatt Lane, Knox Road, and Baltimore Avenue. (University of Maryland, 2011)



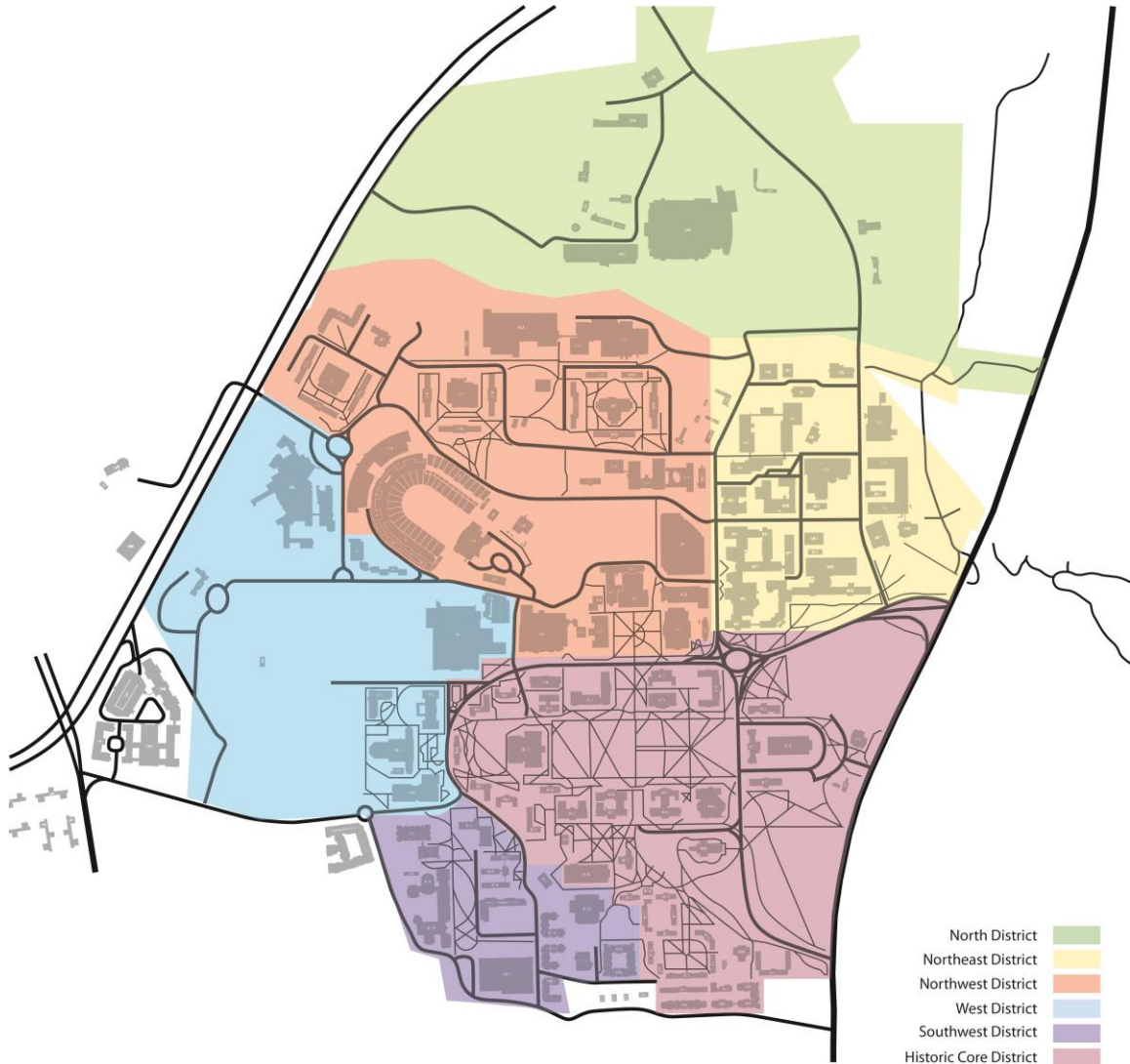
**Figure 13 University of Maryland, College Park campus. Main campus shows as red in the map. Yellow areas are other properties owned by UMCP. Source: FMP II. Introduction**

### **2.2.2 Districts**

Main campus is divided into 6 districts: North District, Northeast District, Northwest District, West District, Southwest District and Historic Core District. Each district has its own customized aesthetic guidance. The guidance is one of the criteria defining CCS

Code themes.

Almost half of North District is covered with vegetation, with greenhouse facilities, Comcast center and adjoining parking lots located in the center. Northeast District is where major STEP disciplines' laboratories and buildings located. Northwest District accommodates sports fields and student dormitory. West District also accommodates some sports fields, and Art and Literature related disciplines' buildings. Southwest District is mainly occupied by Business School, with several student apartment buildings. The name of Historic Core District is self-explanatory. This district is where the oldest buildings in this campus located.



**Illustration 2 Main campus districts. Source of information: Facility Master Plan Updated 2011. University of Maryland, 2011**

### 2.3 Existing Facilities

Although equipped with a relatively complete set of pedestrian facilities matching its proud historical building and landscape, the FMP survey reveals that roadway system in the main campus calls for improvements to better support multimodal transportation (see 2.4). This section is an inventory of the main campus transportation status.

### 2.3.1 Vehicle

As an urban commuter university campus, the main campus provides facilities for the convenience of vehicular travel to/from campus.



**Illustration 3 Campus roadway facilities.**

#### 2.3.1.1 Lane Width

Most campus vehicle lane width is 10 feet, with a few wider segments. Improvements



will require width expansion in most cases.



**Illustration 4 Vehicle lane width distribution.**

### 2.3.1.2 Shuttle-UM

Shuttle-UM is a campus mass transit system serves as an alternative travel mode for commuters. On-campus parts of some certain routes have loops and U-turns on straight roadway segments, which one of the reasons causing congestions during rush hours. One

of the prerequisites for the following design of the CCS Code is that all Shuttle-UM routes are re-planned to eliminate loops and U-turns on straight roadway segments.



**Illustration 5 Shuttle-UM on-campus routes.**

### 2.3.1.3 Parking

Parking facilities are not considered in the design part except on-street parking. FMP envisions pushing major parking lots and garages to the perimeters on the campus thus

create conditions for closure to vehicular traffic beyond campus reach.



**Illustration 6 Parking lots and garages (on-street parking is not included).**



**Illustration 7 Planning on demolition and preservation of existing parking facilities (FMP vision referenced).**

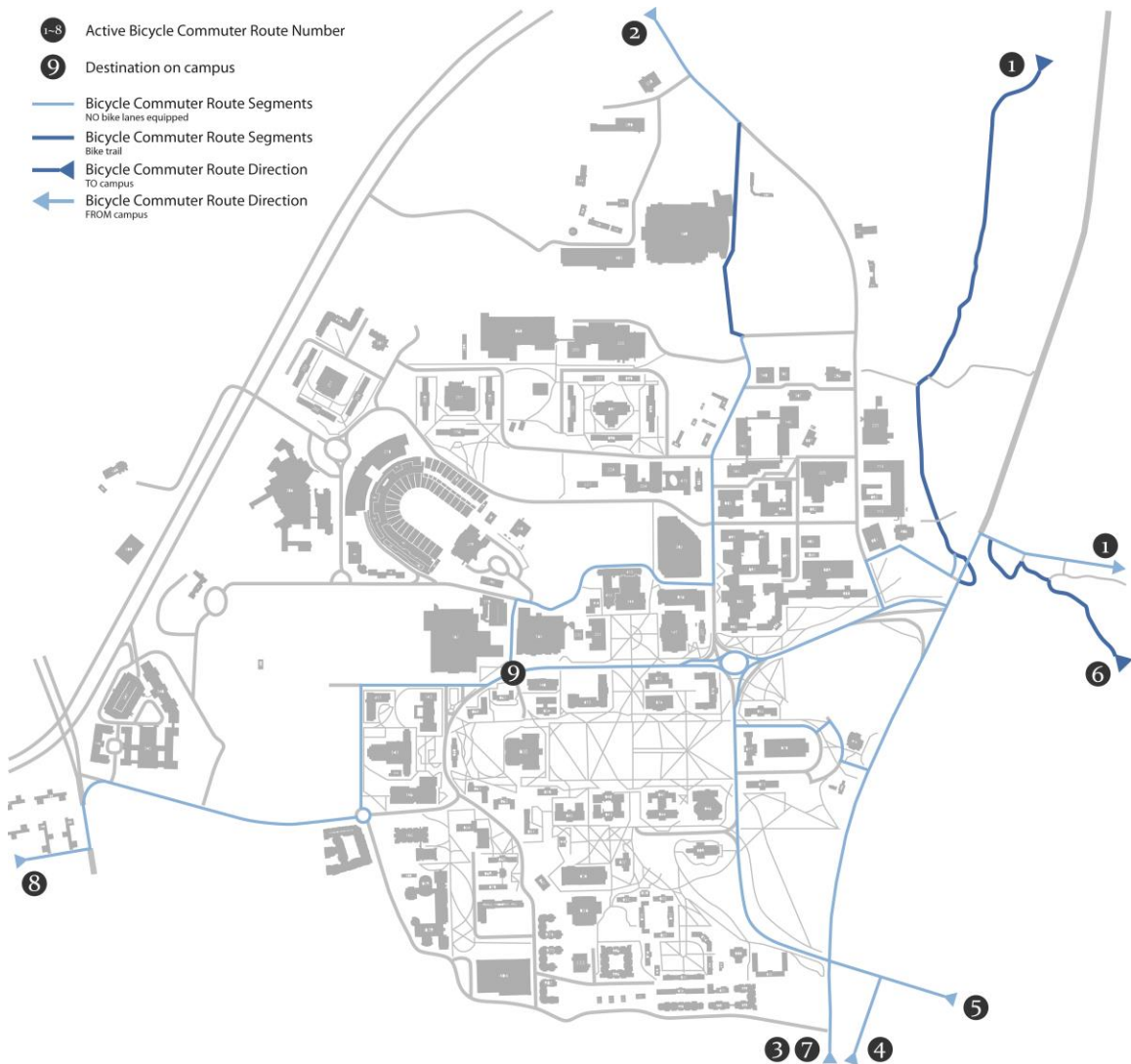
### 2.3.2 Cyclist

According to FMP survey, about 5% of the campus population frequently bikes to/from and on campus. Serving as a promotion of biking on campus responding to the call of campus Department of Transportation Services, Bike UMD community helps formulating biking regulations on campus. Current regulations require cyclists sharing lanes with

vehicular traffic.

### 2.3.2.1 Active Bike Routes (ABR)

Active Bike Routes are suggested routes for cyclists to/from campus. Most on campus sections are missing biking facilities like designated bike lanes or widened shared lanes.



**Illustration 8** Current frequently used cycling routes are mostly overlapping on Campus Drive (EW) and Regents Drive (SN), two of campus' main arterials.



**Illustration 9 Roadway types along ABR. Vehicle lanes wider than 10 feet are not overlapping with ABR.**

### 2.3.3 Pedestrian

Pedestrian facility completeness and coverage are two of the highlights of UMCP campus transportation system. The map of campus pedestrian path distribution shows a pattern of density difference between districts, which shows different characteristics of districts in terms of walkability and pedestrian density.



**Illustration 10 Pedestrian trail, path and sidewalk distribution on campus.**



**Illustration 11** Frequently used pedestrian routes on campus.

### 2.3.3.1 ADA Accessibility

Usually roadway ADA accessibility on roadway segment is achieved by flat curb, ramp and landing on intersections of crosswalks and sidewalks. Although most roadway segments in the campus are equipped with ADA facilities, at some certain locations these facilities are missing.

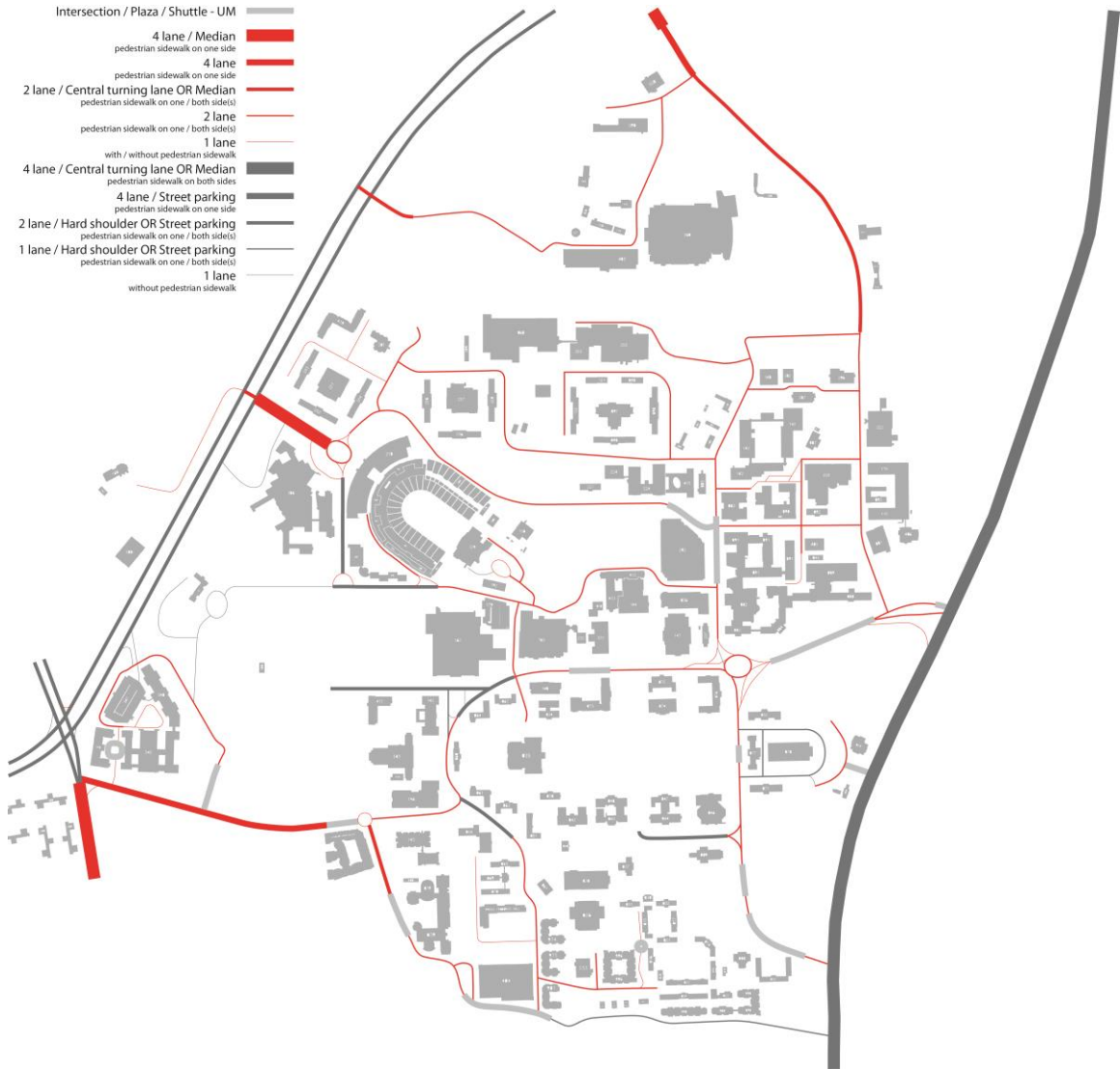




**Figure 14 Missing ADA facilities near “Big M” roundabout.**

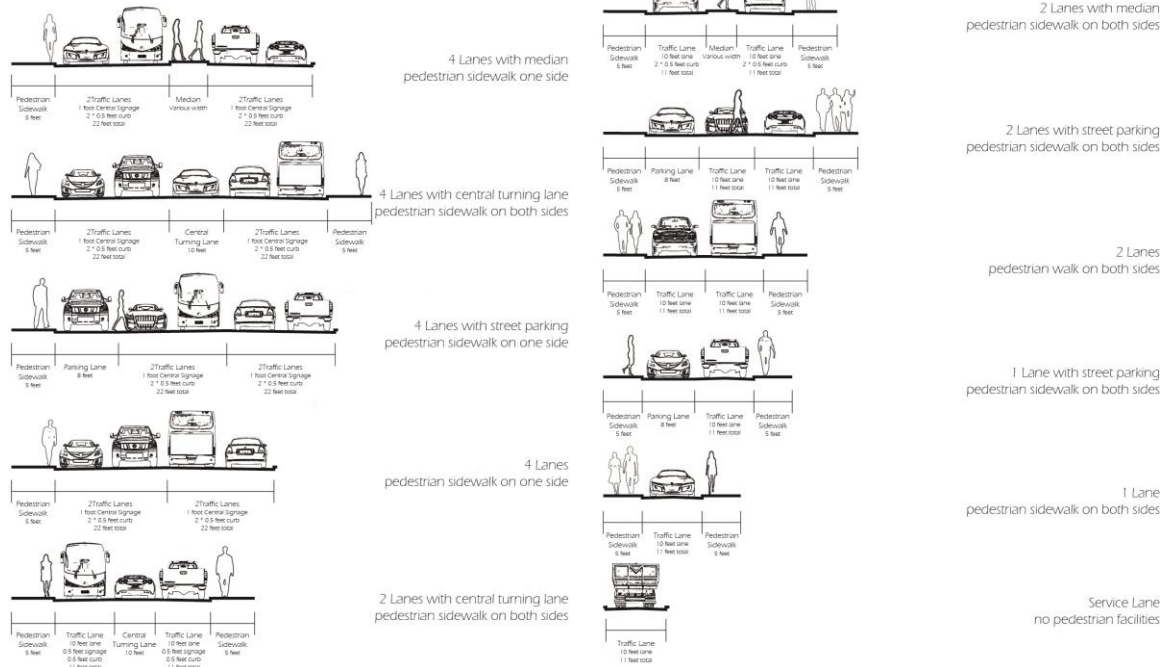
### **2.3.4 Roadway Segment Facility Typology**

The roadway segment facilities have been measured and inventoried as shown in the map and vignette below, which was initially categorized into 11 typologies. As illustrated in 1.2.2.6, they will be reclassified based on their vehicle lane typologies in the following chapter.



**Illustration 12 Roadway segment typology classified by vehicle Lane and pedestrian sidewalk.**

# Roadway Segment Typology



**Illustration 13 Roadway segment typology sections.**

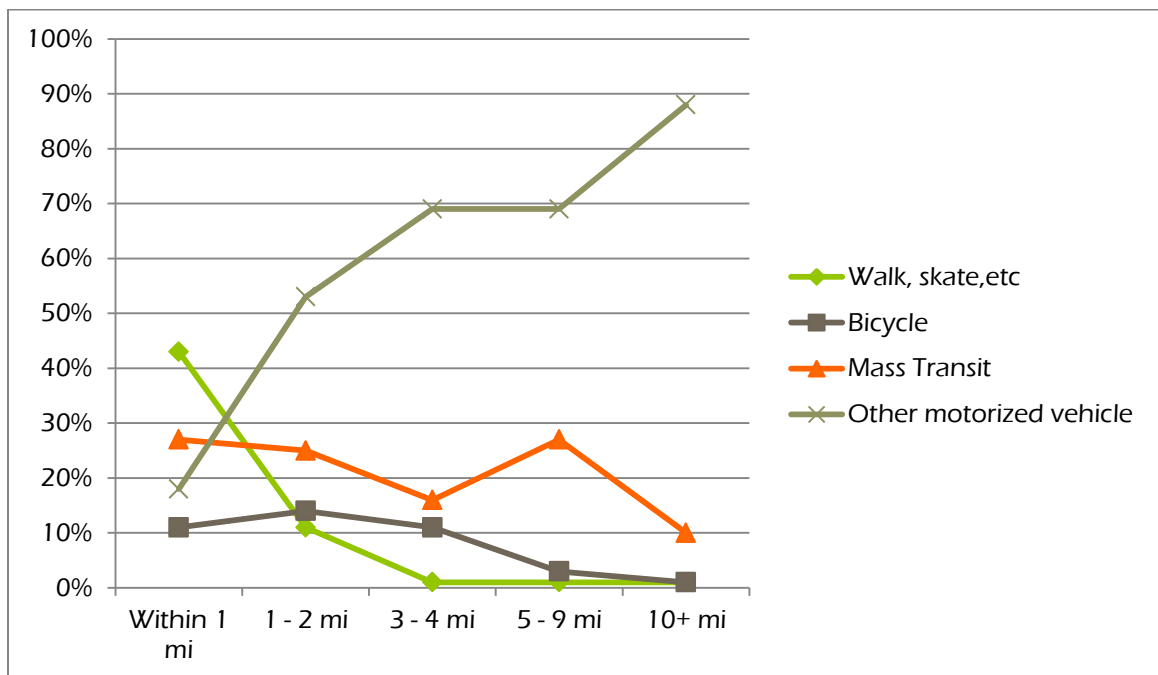
## 2.4 2011-2030 Facility Master Plan Survey

### 2.4.1 Overview

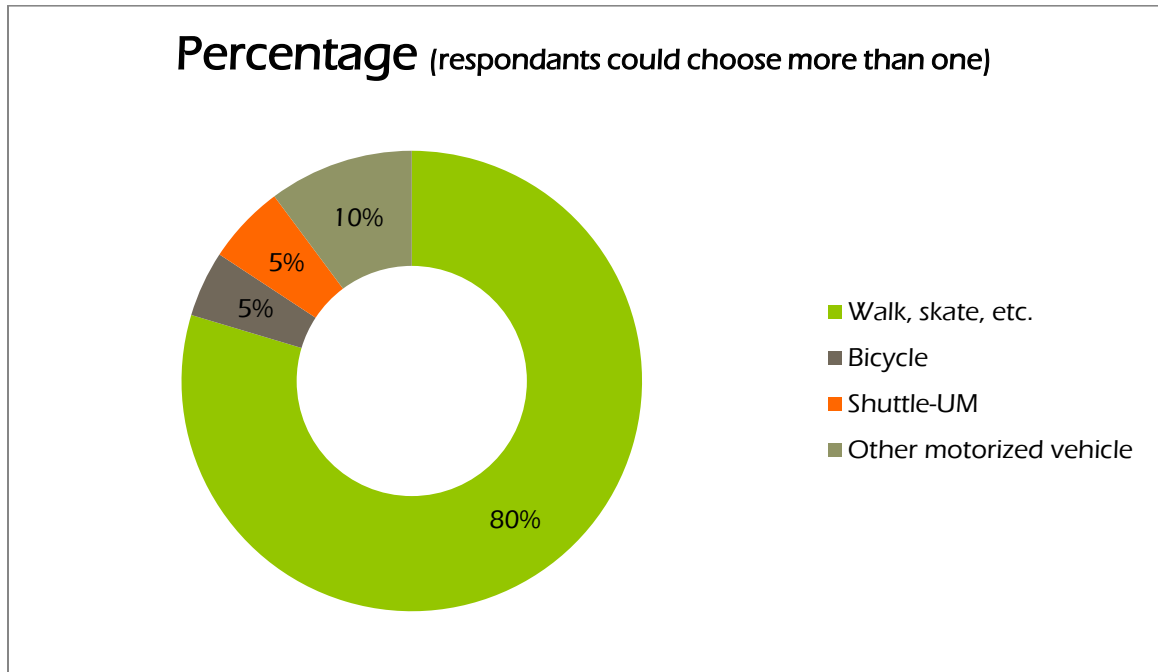
In November, 2010, the FMP Subcommittees launched a survey regarding transportation and campus environment in the campus community. With about 40,000 students and 15,000 faculties/staffs on campus in 2010, the designed sample capacity was to cover random samples of 1/4 the population of both students and faculty/staff. The survey resulted in a responding rate of 14% from students and 29% from faculty/staff, in which students are underrepresented (FMP Subcommittees, 2010).

## 2.4.2 Data Analysis

Through analysis of the survey results, several conditions should be addressed. As living distance to campus increases to about 1 mile, percentage of people choosing to drive to campus individually surge up 35%, and 64% of all respondents adopt driving as their most preferred travel mean for commuting to/from campus. Dramatically, 86% choose to travel as pedestrians (walking, skating, skateboarding, etc.) from place to place on campus. Comparing with living distance statistics and Shuttle-UM transit system catchment areas, it indicates that driving will possibly remain as dominant travel mean for commuting within current FMP scope, but could be gradually cut down by constructing ancillary facilities for alternative transportation.



**Illustration 14 Travel mode choices to/from campus against living distance from campus. Source of information: FMP Survey of Transportation and the Campus Environment. 2010.**



**Illustration 15 Travel mode choices from place to place on campus. Source of information: FMP Survey of Transportation and the Campus Environment. 2010.**

Meanwhile, the campus is relatively walkable with a high degree of pedestrian facility coverage. With 62% demands for somewhat to major improvements towards pedestrian-friendly, further questions on travel experiences reveal conflicts between motorists and pedestrians and cyclists: more than 35% considers conflict with vehicles deteriorates pedestrian experience on campus, while about 45% takes reducing conflict with pedestrians as first priority in improving driving experiences on campus. A few pedestrians and drivers also complaint that conflict with cyclists affects their travel experience. These complaints of conflicts reveal ambiguity in travel priority hierarchy of roadway users, which could be better illustrated and clarified by education and roadway facilities such as markings, crosswalk, signage, stop bars, etc. small population of cyclists lead to relatively few complaints on them. The promoting of cycling is facing obstruction

from multiple aspects. Current requires cyclists to bike on vehicular lanes and follow the same laws and regulations as vehicular traffic. With shared lane markings and signage missing and steep slopes affecting cyclists' travel speed on certain roadway segments, cyclists and drivers usually end up in conflicts on right-of-way. Intimidated cyclists usually choose to ride on pedestrian sidewalks, therefore provoke conflicts with pedestrians. More than half of the survey participants think adding more bike paths will improve biking experience on campus. There is also a call for ancillary facilities including weather-protected bike parking facilities and showering facilities. All these obstacles contribute to the population of cyclists much less than expected, with 82% of respondents never bicycle on campus.

The survey also implies the demand of improving public transit systems to support on-campus travels, with "huge campus scale" and "carrying heavy items" being revealed as top two factors impelling people from walking under certain conditions.

More than 70% of participants have no idea about what an Arboretum and Botanical Garden (ABG) is, in spite of the campus being one and continuously completing.

Open spaces and gathering places are top two most desired outdoor space to be added, followed by plaza and weather-protect parking for bike, scooter and motorcycle, and bus shelter. Except bicycle paths (19%), landscape elements and public art are most favored features by the majority of the participants, with a total percentage of 63%.

## 2.5 Issues Statement

### 2.5.1 Right-of-Way (R-o-W) Conflicts

Complaining over each other among the three major roadway user groups (pedestrian, cyclist and driver) is one of the highlighted issues in the survey. Although these complaints are targeting other user groups' behaviors affecting travelling experiences, lacking facilities clarifying each user group's R-o-W is the major reason behind all these debating. Demanding for biking lanes and paths revealed by the survey verifies this inference.



**Figure 15 Cyclist occupying pedestrian sidewalk.**



**Figure 16** Cyclist occupying pedestrian sidewalk and vehicle lanes.

### **2.5.2 User Experiences in Multi-modal Transportation Environments**

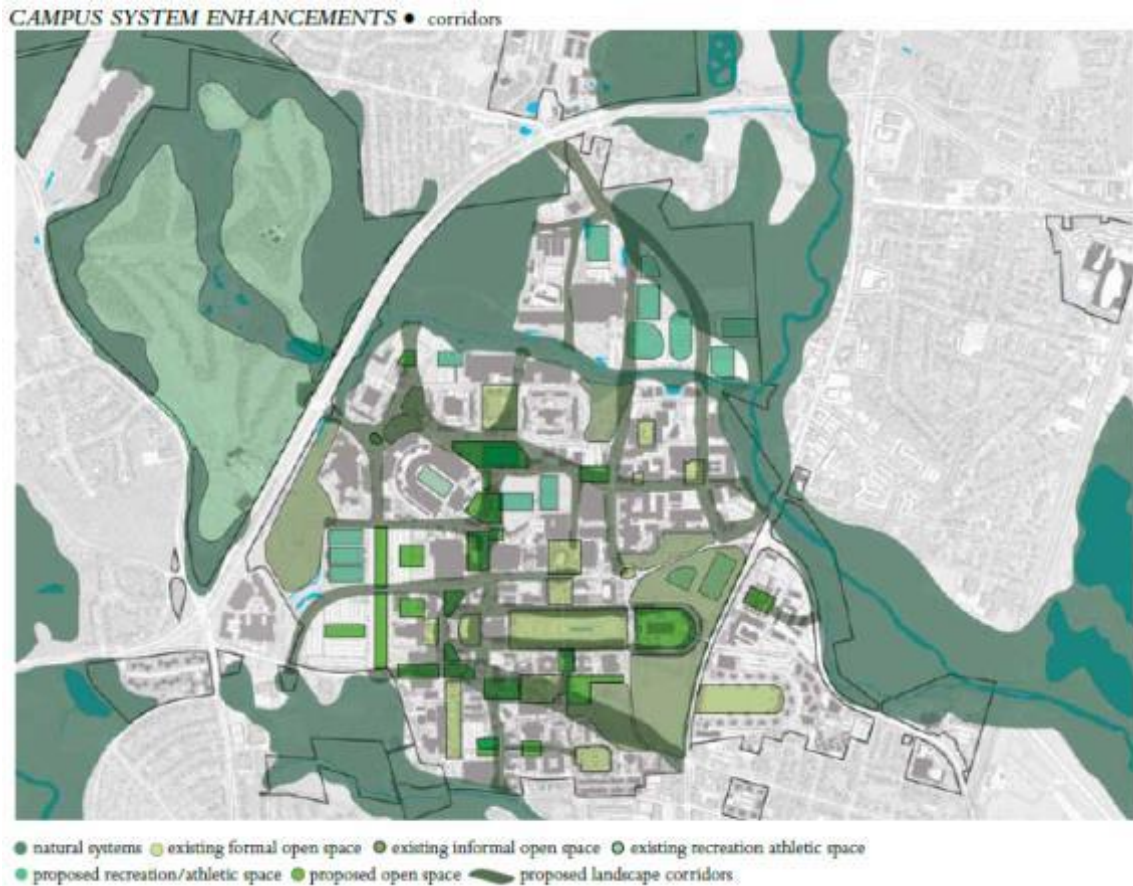
Besides the impacts on travelling experiences from R-o-W conflicts, existing facilities are somewhat lacking the balance between different user groups' demands, which usually resulting in one or more user groups' inconvenience in travelling on campus. User experiences also including stimulation of delight emotions by landscape features, which is an important component of Complete Streets. The survey indicates a strong demand for these features to be added.

### **2.5.3 Interrelationship with Institutional Aspects**

Except features like plaza, seatings, plantings, tree canopy and water features supporting social and recreational activities, campus landscape features also includes green infrastructures. One of FMP's goals is to use ABG to promote environment and



sustainability awareness; meanwhile the survey results calls for an imminent advertising of campus ABG and sustainability. Thus in this project, display / educational function is a prerequisite for all green infrastructures installed on roadway segments.



**Figure 17 Campus ABG and system enhancements, corridors are overlapping roadway systems.**  
**Source of information: FMP VI. Plan and Major Recommendations**

The other aspect of institutional functions is student involvement. Involving students in multiple level of the design process will promote their awareness in both sustainability and university cultural integrity.

## Chapter 3: Campus Complete Streets Code

### 3.1 Objectives

The analysis on campus site context and transportation survey indicates a demand of improving roadway facilities for supporting multimodal transportation and contributing to campus institutional functions. Furthermore, the objectives for roadway segment improve towards Complete Streets have been set by the survey results:

1. Mitigating Right-of-Way conflicts,
2. Improving user experiences, and
3. Achieving campus roadway institutional functions.

### 3.2 Roadway Segment Typology

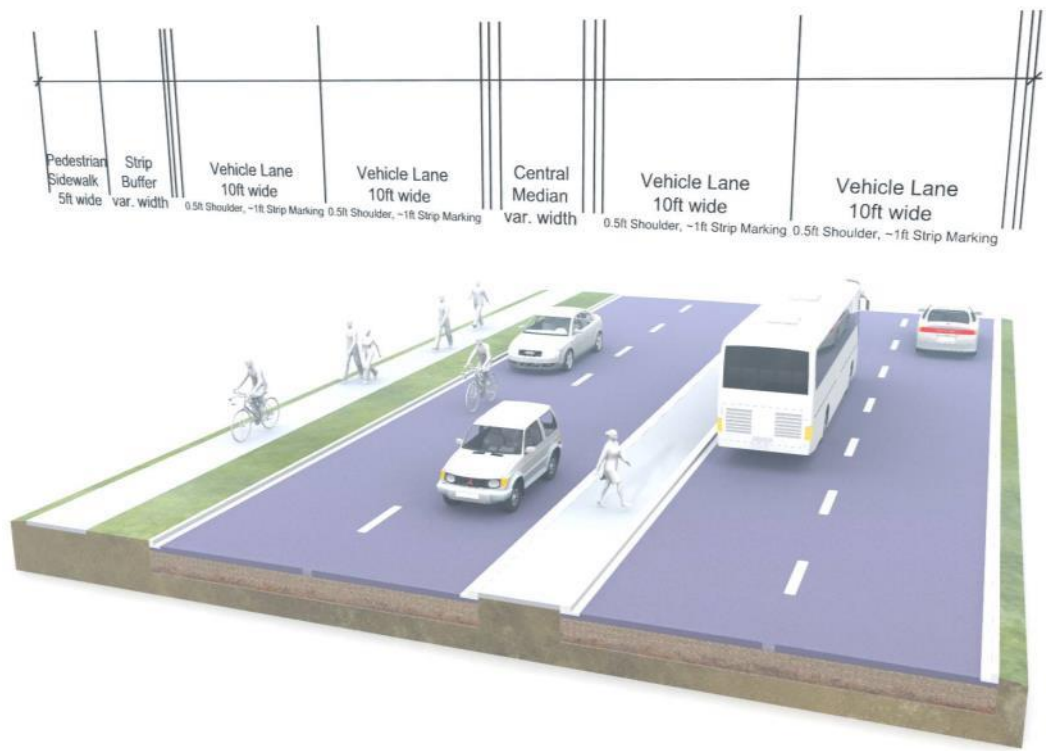
As illustrated in 1.2.2.6, the 9 roadway typologies below are reclassified from 11 typologies identified in the campus using vehicle lane typology as control, which was largely kept constant during the design process. The groups listed out below is only used in the design stage of the Code for better perception of these typologies and will not be reflected in the Code in the consideration of its flexibility.

#### **3.2.1 Group 1**

The first 3 typologies are mainly distributed on the perimeter of campus, which could be

perceived as urban roadway extended into campus reach.

### 3.2.1.1 Typo 1. 4 Lanes with median.



**Illustration 16 Typo 1. 4 Lanes with median.**

3.2.1.2 Typo 2. 4 Lanes with central turning lane.

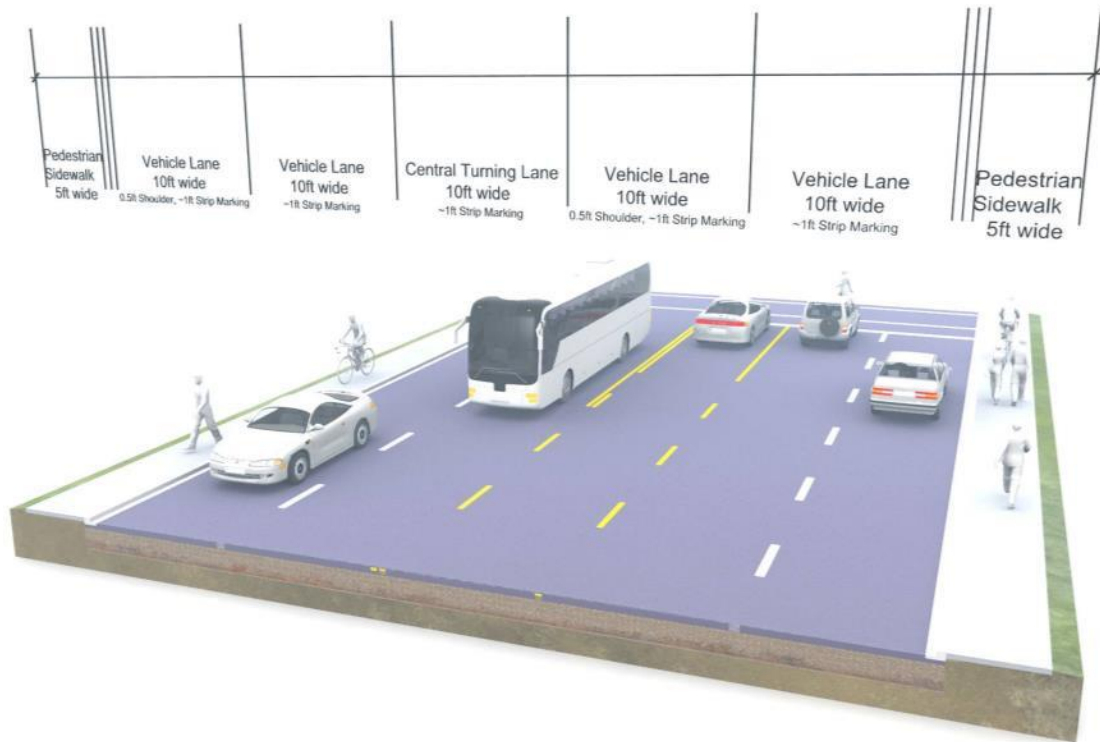
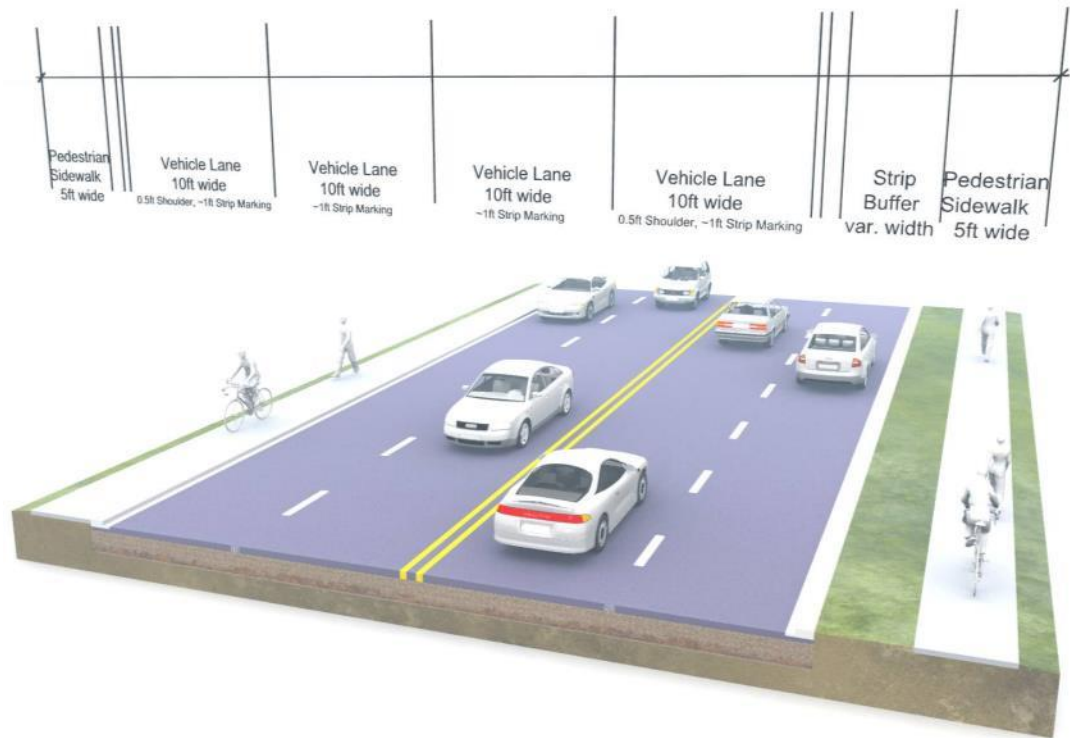


Illustration 17 Typo 2. 4 Lanes with central turning lane.

### 3.2.1.3 Typo 3. 4 lanes with / without extra lane in one direction.

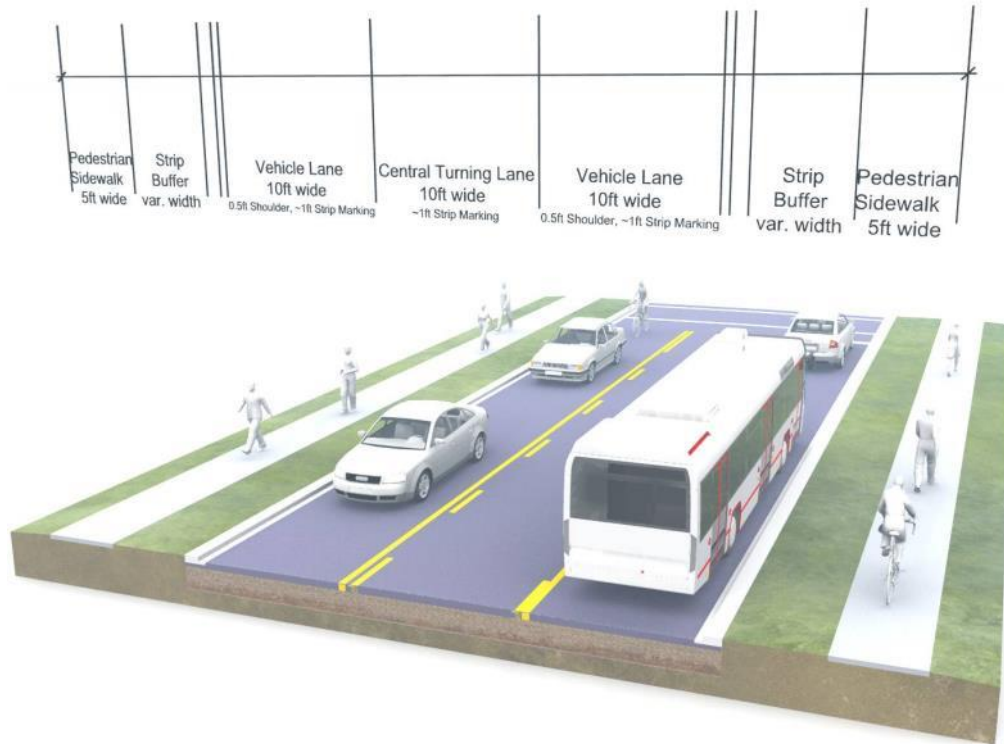


**Illustration 18 Typo 3. 4 Lanes with/without extra lane in one direction.**

### 3.2.2 Group 2

The next 4 typologies are typical forms of campus arterials.

3.2.2.1 Typo 4. 2 Lanes with central turning lane.



**Illustration 19 Typo 4. 2 Lanes with central turning lane.**

3.2.2.2 Typo 5. 2 Lanes with median.



**Illustration 20 Typo 5. 2 Lanes with median.**

3.2.2.3 Typo 6. 2 Lanes with parking lane in one direction.

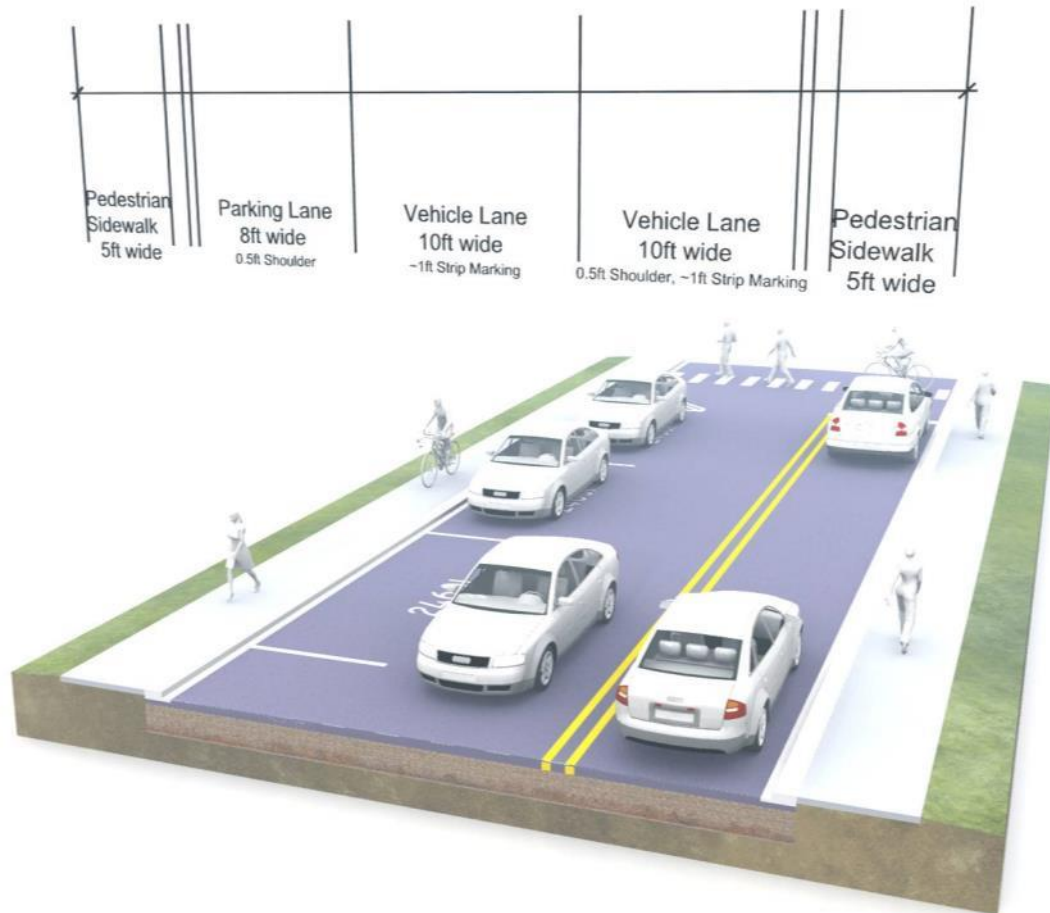
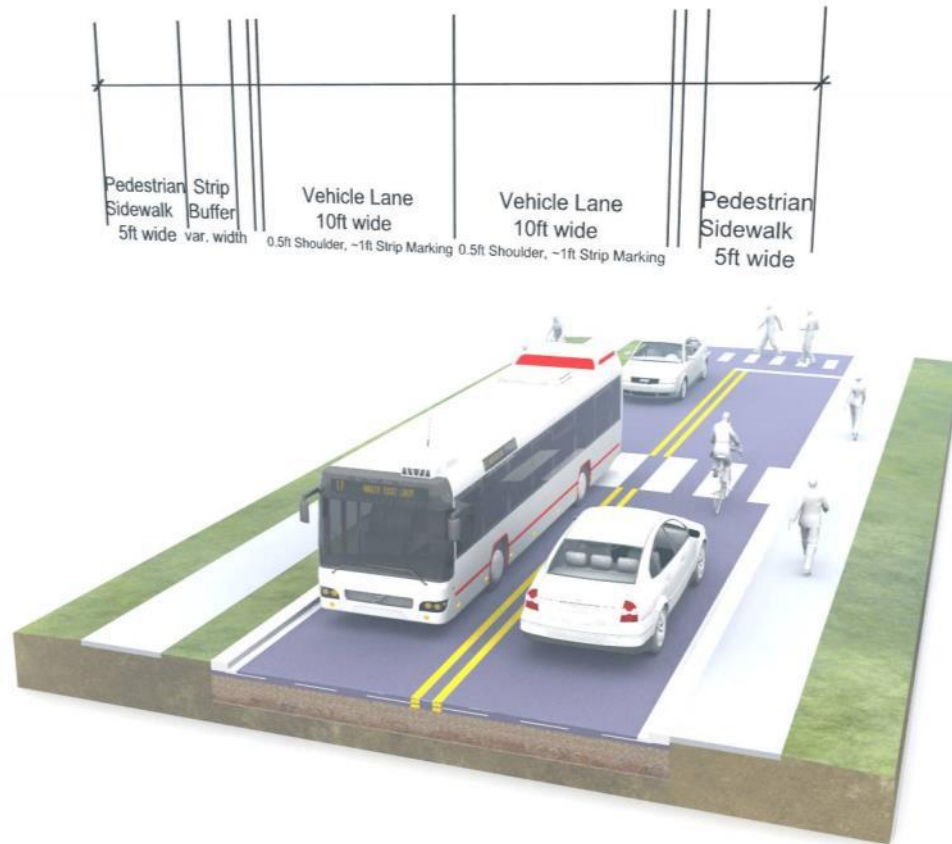


Illustration 21 Typo 6. 2 Lanes with one-side parking lane.



### 3.2.2.4 Typo 7. 2 Lanes with/without extra lane in one direction.

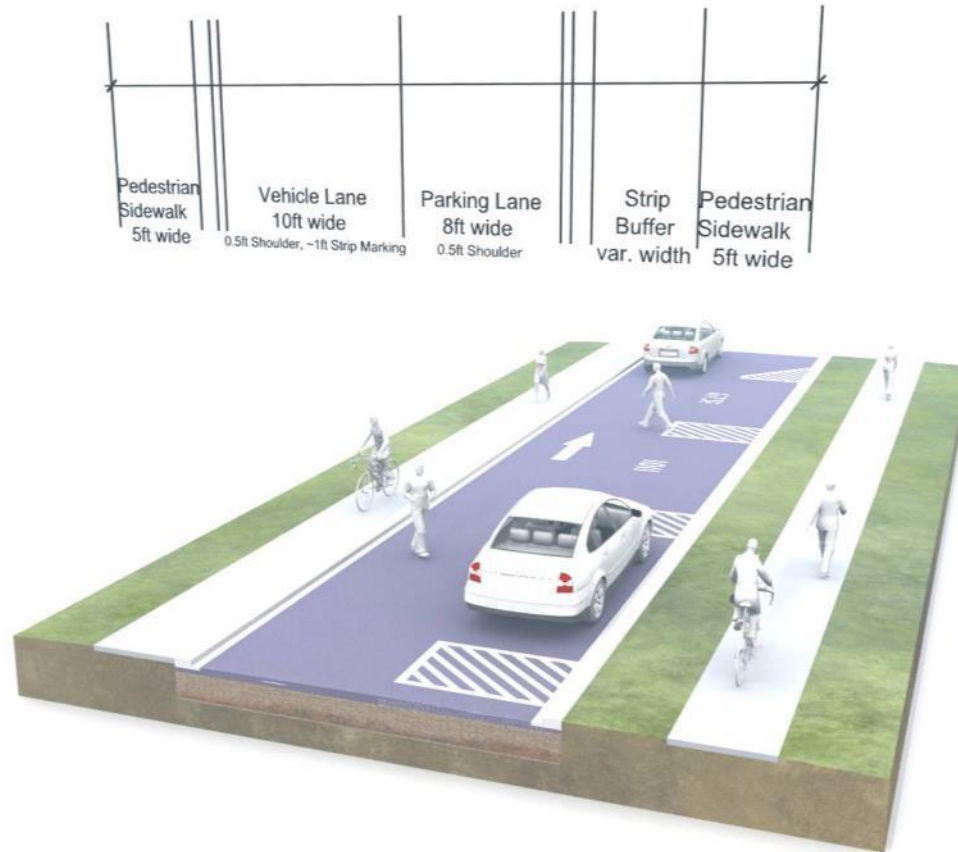


**Illustration 22 Typo 7. 2 Lanes with/without extra lane.**

### 3.2.3 Group 3

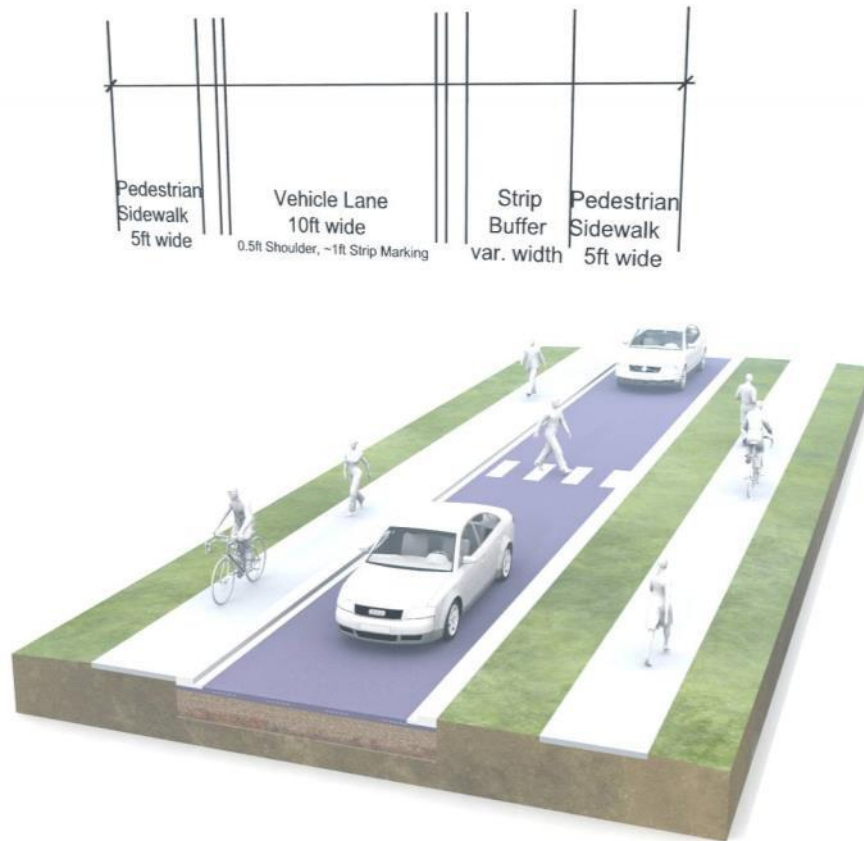
The last two typologies usually presents as collectors or operation/service vehicle routes.

3.2.3.1 Typo 8. 1 Lane with parking lane in one direction.



**Illustration 23 Typo 8. 1 Lane with one-side parking lane.**

### 3.2.3.2 Typo 9. 1 Lane.



**Illustration 24 Typo 9. 1 Lane.**

The 9 typologies listed above are prototypes for subsequent improvements towards Complete Streets.

## 3.3 Improvements towards Complete Streets

### 3.3.1 Fundamental Infrastructure

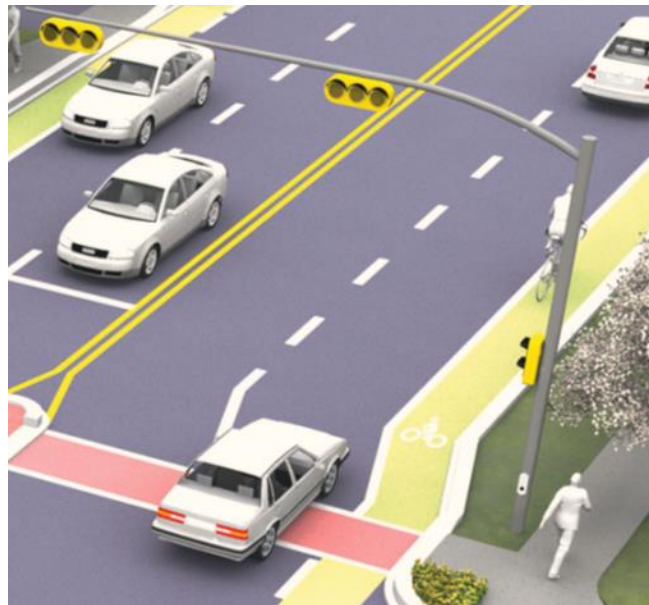
There are 6 groups of improvement elements in this stage. Except for ADA Accessibility,

which is a mandatory improvement, all groups are optional upon site conditions and user demands.

Traffic Signal Lights for pedestrian crosswalks on arterials and intersections, Pedestrian Sidewalks, and Bike Lane and Bike Tracks are provided to solving Right-of-Way conflicts. ADA Accessibility and Buffer improve overall travel experiences of users. Certain types of buffers could be incorporated with stormwater management facilities, public arts or student involvement programs to achieve institutional functions.

### 3.3.1.1 Signal Lights

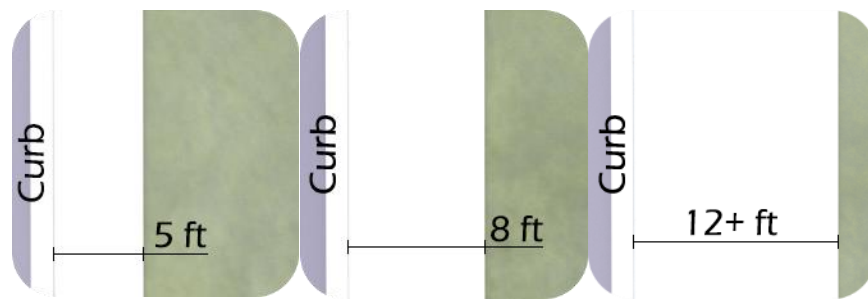
Signal lights can regulate pedestrians' behavior on campus arterials, especially when crossing the street. By controlling pedestrian crossing with signal lights, this improvement make pedestrian movement on arterials traveled ways more predictable for drivers, and thus reduces conflicts over R-o-W and possible subsequent collisions.



**Illustration 25** Traffic signal lights.

### 3.3.1.2 Pedestrian Sidewalk

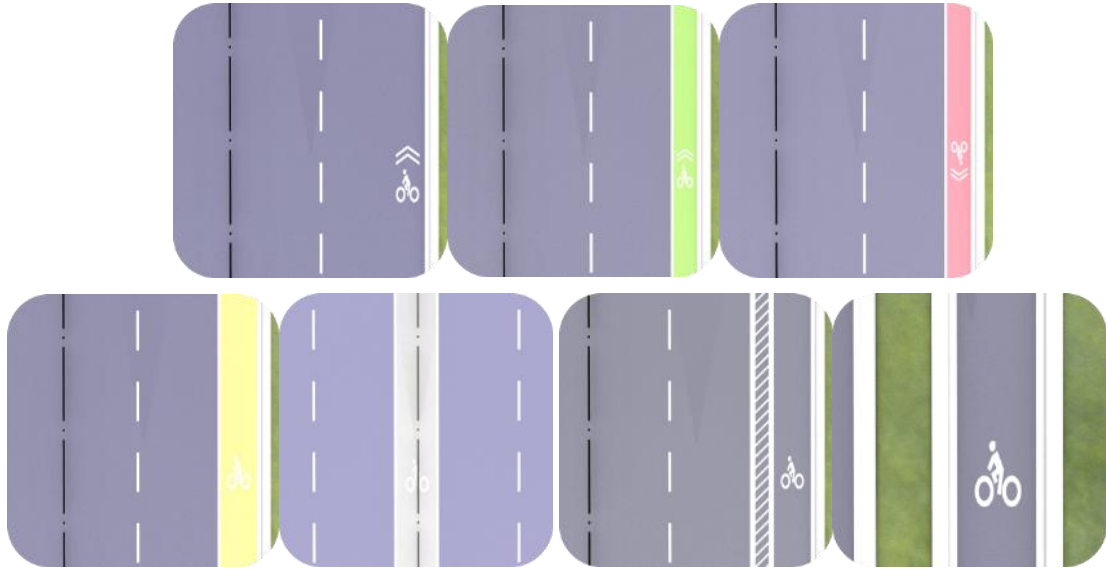
Regular pedestrian sidewalks width is 5 feet and varies along the roadway segment. This variation is supposed to be determined and reflect the volume and frequency of pedestrian usage. Widened sidewalks should be applied on campus arterials where R-o-W needs to be clarified.



**Illustration 26 Pedestrian Sidewalks.**

### 3.3.1.3 Bike Lane and Bike Track

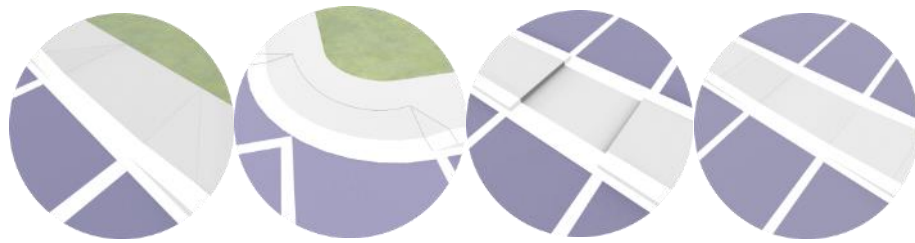
Seven types of bike lanes are recommended for installation along ABR on campus. Designated shared lane occupies the smallest space with minimum width expansion of a vehicle lane from 10 feet to 13 feet. Regular bike lane and contraflow bike lane added alongside vehicle lanes requires a minimum width of 4 feet. One-side bike lane and centered bike lane need minimum width of 6 feet for cyclists travelling in both directions. Painted buffer and other various buffer with different could be added up to make a buffered bike lane or bike track, which provides better safety protection to cyclists with possible additional benefits (see “Buffer” below).



**Illustration 27** From left to right, downwards: Shared lane, regular bike lane, contraflow bike lane, one-side bike lane, centered bike lane, buffered bike lane and bike track.

#### 3.2.1.4 ADA Accessibility

Mainly refers to ADA accessibility to pedestrian facilities from pedestrian, vehicular and public transit R-o-W. Common installation is ramp and landing on sidewalks.

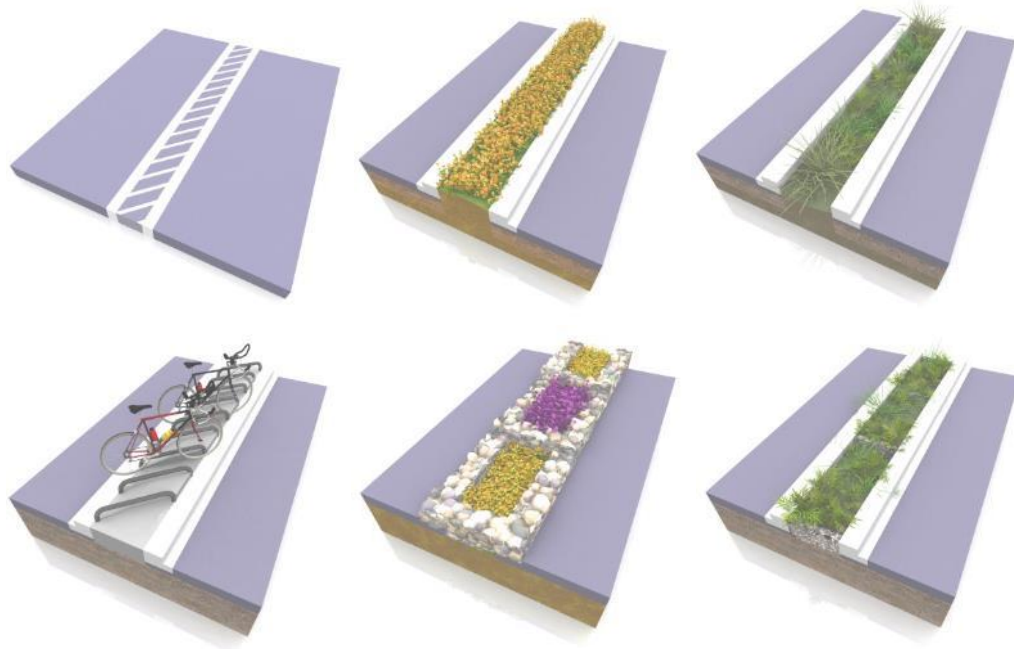


**Illustration 28** ADA accessibility examples on sidewalks and across medians.

#### 3.3.1.5 Buffer

Six types of buffers are recommended in this group. Painted markings and bike racks could be designed by students with creative ideas, bioswale and its terraced version especially for sloped roadway segments could be considered to install on main streets

where the operation of stormwater infiltration can be displayed to the majority of campus population.



**Illustration 29 Downwards, left to right: Painted markings buffer, bike racks, meadow buffer, terraced meadow buffer, bioswale buffer, terraced bioswale buffer.**

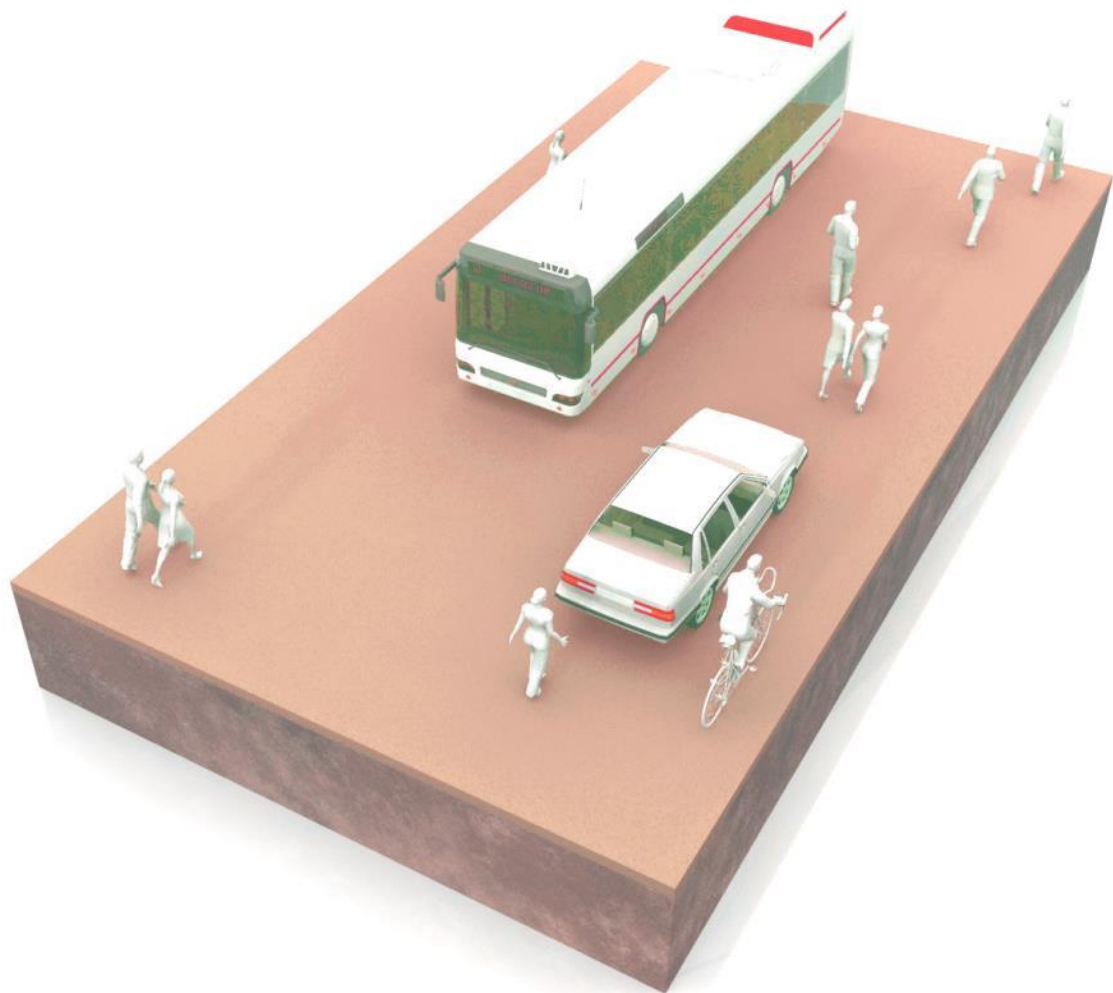
### 3.3.2 Complete Street Elements

Totally 18 categories of Complete Streets element improvements are generalized from the case studies in many municipal Complete Streets practices. All of these improvements are designed to achieve one or more of the three objectives (see 3.1) and can be checked in the CCS Code Chart (see Appendix 2). The Chart also illustrates their applicability towards each of the 9 roadway typologies categorized in 3.1. Illustrations of these improvements are sample designs; the concept is to modularize the improvements to increase flexibility of the Code.

### 3.3.2.1 Shared Space

Shared space is inspired from Netherland Complete Streets practices called “Woonerf”, which is designed to be mainly applied to secondary streets and pedestrian-dominated streets. By removing curbs, distinct pavements, signage and painted markings, this improvement requires all user groups to follow the same traffic regulations on the specific segment. The ambiguity of Right-of-Way in a shared space is engineered-in, which makes collisions become more predictable and easier to be controlled. Meanwhile, it also enables shared space to have a better ADA accessibility in most cases without the necessity of installing dedicated ADA facilities. This method mitigates R-o-W from the opposite direction of conventional solutions and provides a very distinctive experience for all roadway users. It increases the chance for communications among people travelling on streets by all means and provides space for landscaping, large trees, green infrastructures and student activities. In this project, shared spaces are supposed to be distinguished from other street segments by changing the pavement or pavement color (colored asphalt) to indicate the changing of traffic regulations.



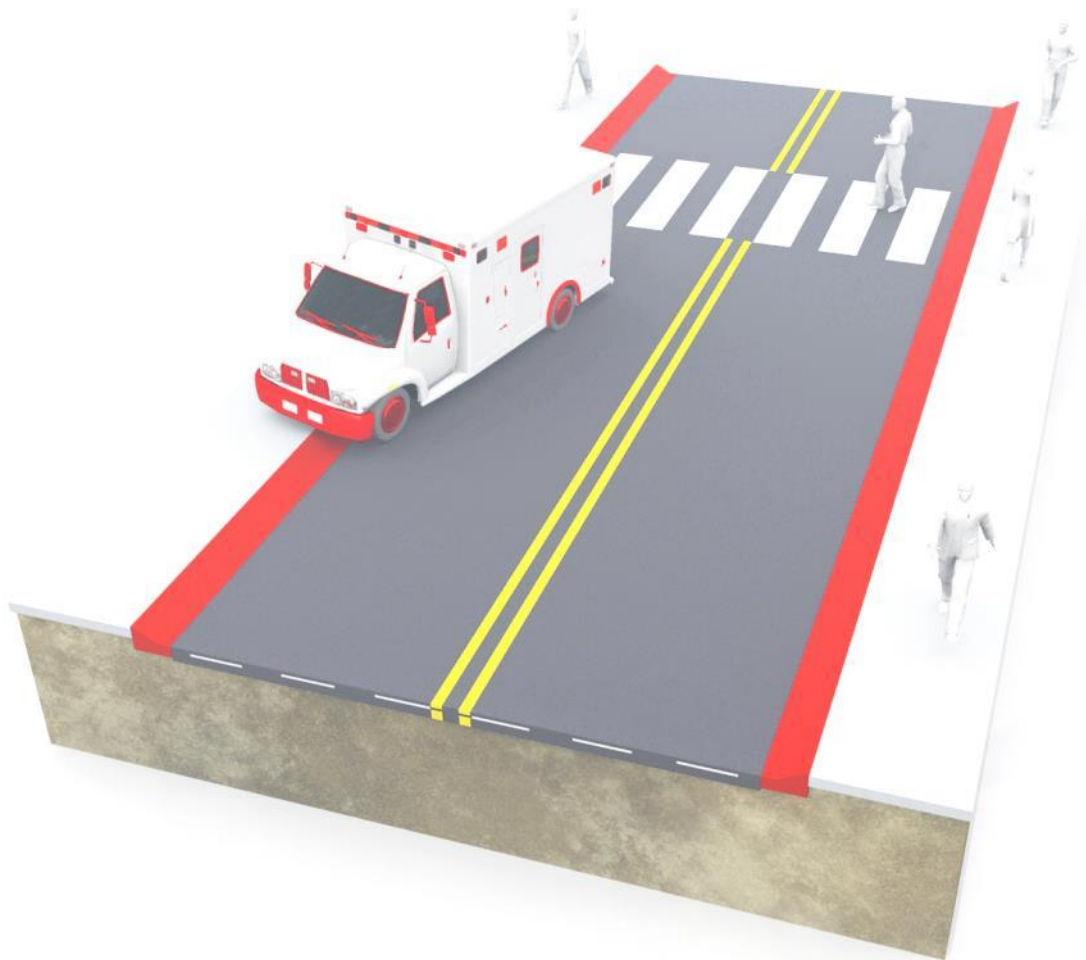


**Illustration 30 Shared Space.**

### 3.3.2.2 Mountable Curbs

Mountable curbs should be considered to be applied with other improvements, for example, Pedestrian Plazas, or individually applied on streets where vehicle lanes are narrowed, in order to increase emergency vehicle accessibility in a crowded area. This improvement is not applicable to all typologies. Warning signage and colors should be incorporated when this improvement being installed. Potential pedestrian risks will

increase if not properly installed.



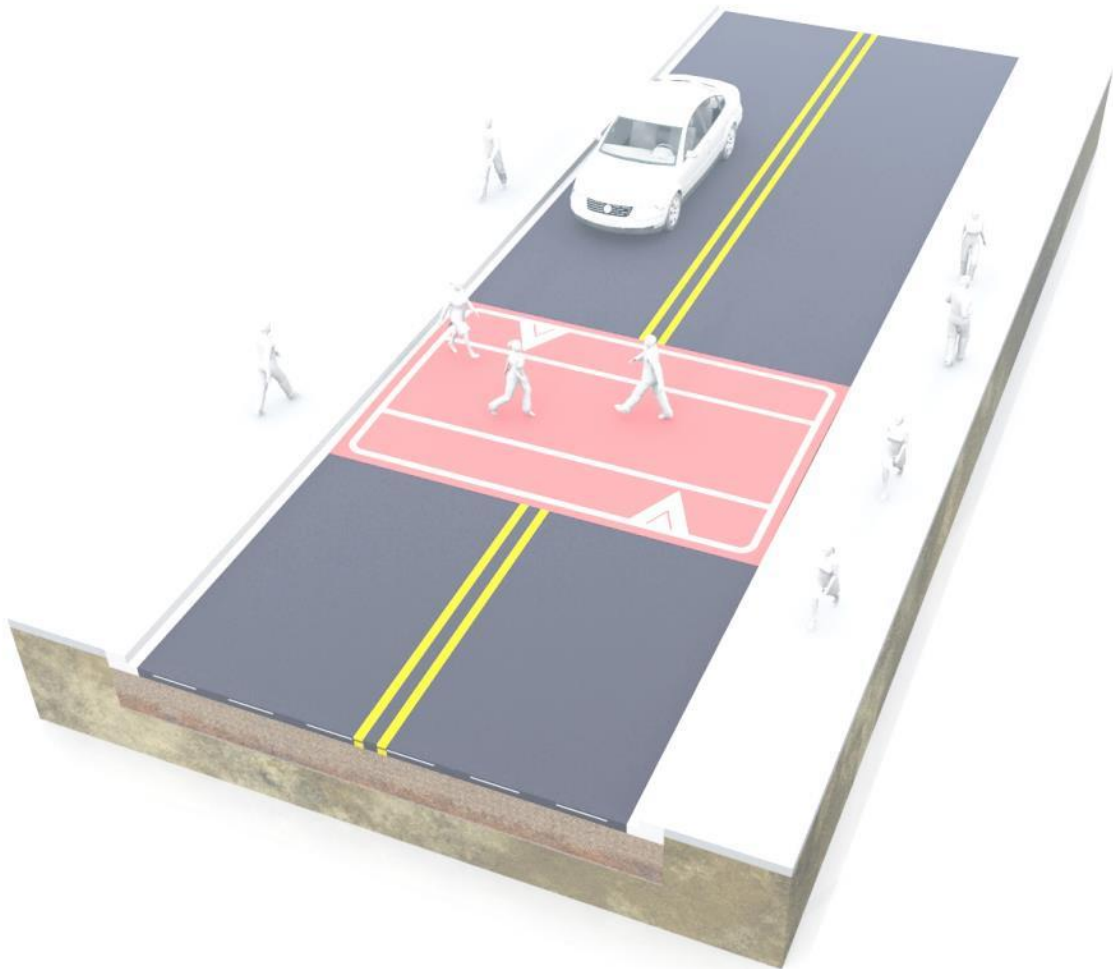
**Illustration 31 Mountable Curbs.**

### 3.3.2.3 Raised Crosswalk

Raised Crosswalk is designed to mainly installed on secondary streets carrying heavy traffics. It will significantly slow down traffic speed with the same effects as raised bumps, as well as increase visibility of pedestrians crossing the streets to drivers.

Although installation brings potential of raising the cost, ADA accessibility is integrated

in this improvement.



**Illustration 32 Raised Crosswalk.**

#### 3.3.2.4 Extended Public Transit Stop Island and Curved Bike Lane

Unlike conventional bus stop designs, especially those with extended parking bay, this improvement keeps transit vehicles in the traffic flow, and eliminates potential collision between transit vehicles and cyclists when adding bike lanes. It also provides more space to public transit users for waiting, and transit vehicles for loading / unloading passengers,

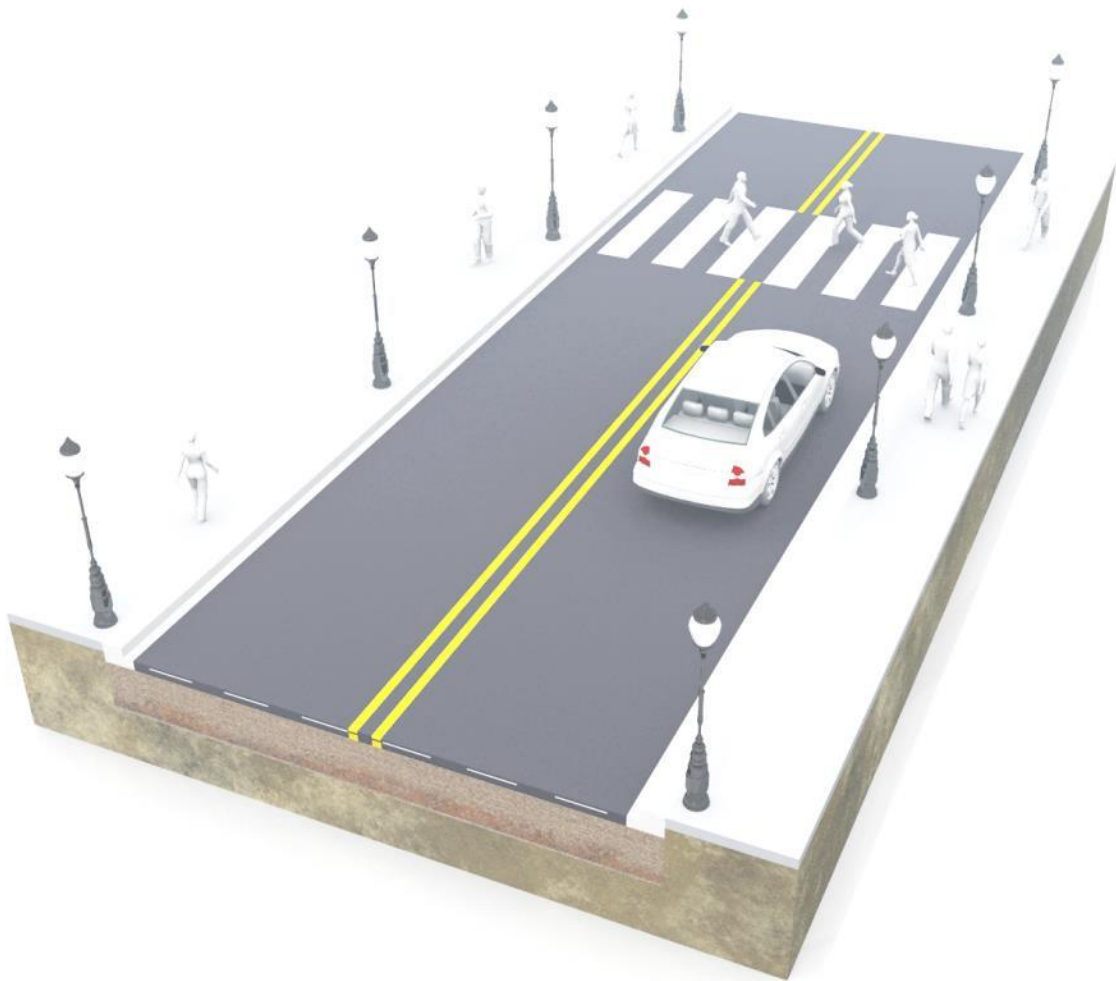
meanwhile separates them from pedestrian flow to increase efficiency. By keeping transit vehicles in the traffic flow, this improvement increases space usage efficiency, helps transit operation keeping their schedule, while in some conventional designs buses need to wait before rejoining the traffic flow. In the meantime, loading / unloading buses in the traffic flow helps control the speed of vehicular traffic, and potentially discourage cut-through traffics as well as promote public transit. Landscape features (meadow, planter, bioretention, public art, etc.) could be installed on both ends of the island. Consider incorporate this improvement with 3.2.2.14 Bulbout Extension.



**Illustration 33 Extended Public Transit Stop Island and Curved Bike Lane.**

### 3.3.2.5 Pedestrian-Scale Road Lamps

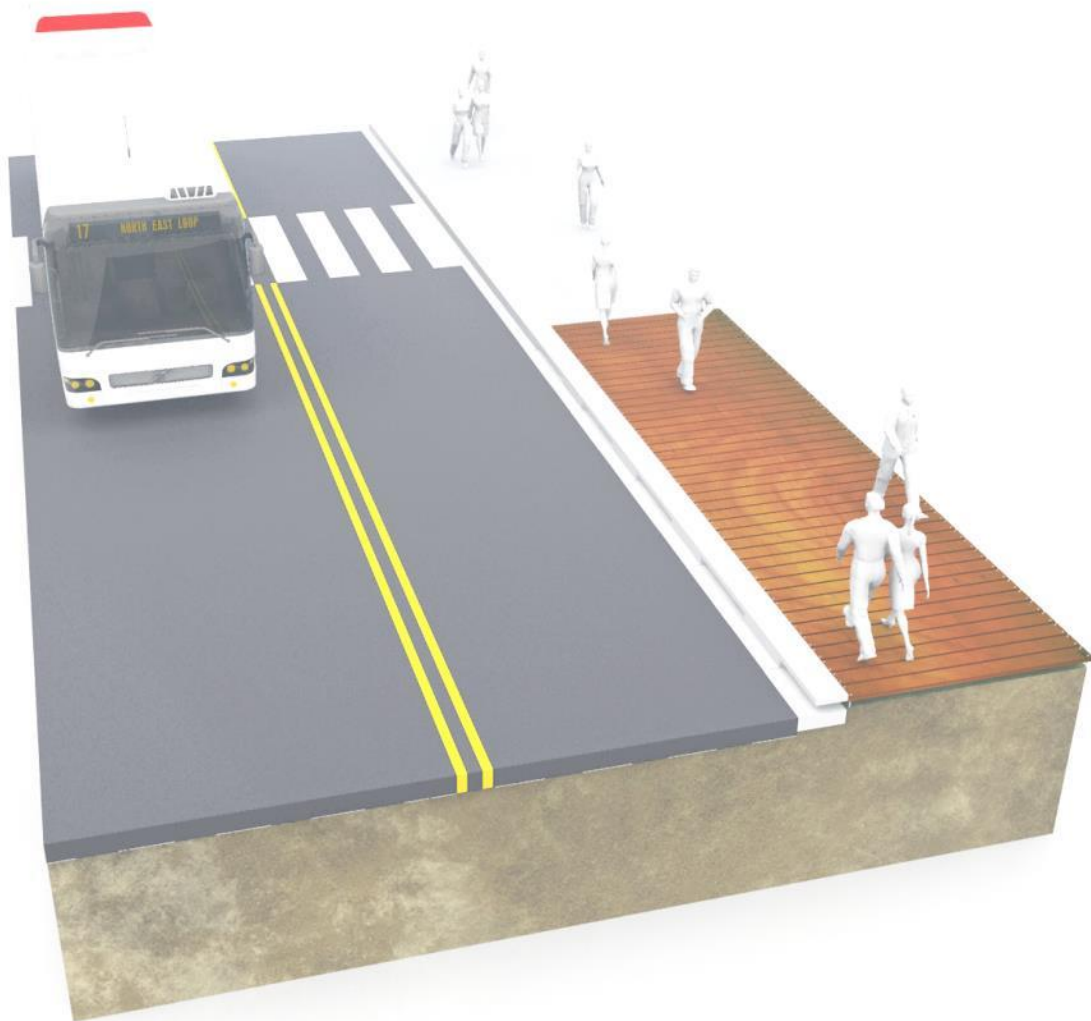
Bring the height of road lamps down to pedestrian scale could not only help increase nighttime illumination and safety, but also promote both daytime and nighttime landscape. With many precast designs, pedestrian-scale road lamps add landscape interests to streets as corresponding to campus historical buildings and landscapes.



**Illustration 34 Pedestrian-Scale Road Lamps.**

### 3.3.2.6 Boardwalk over Infiltration Area

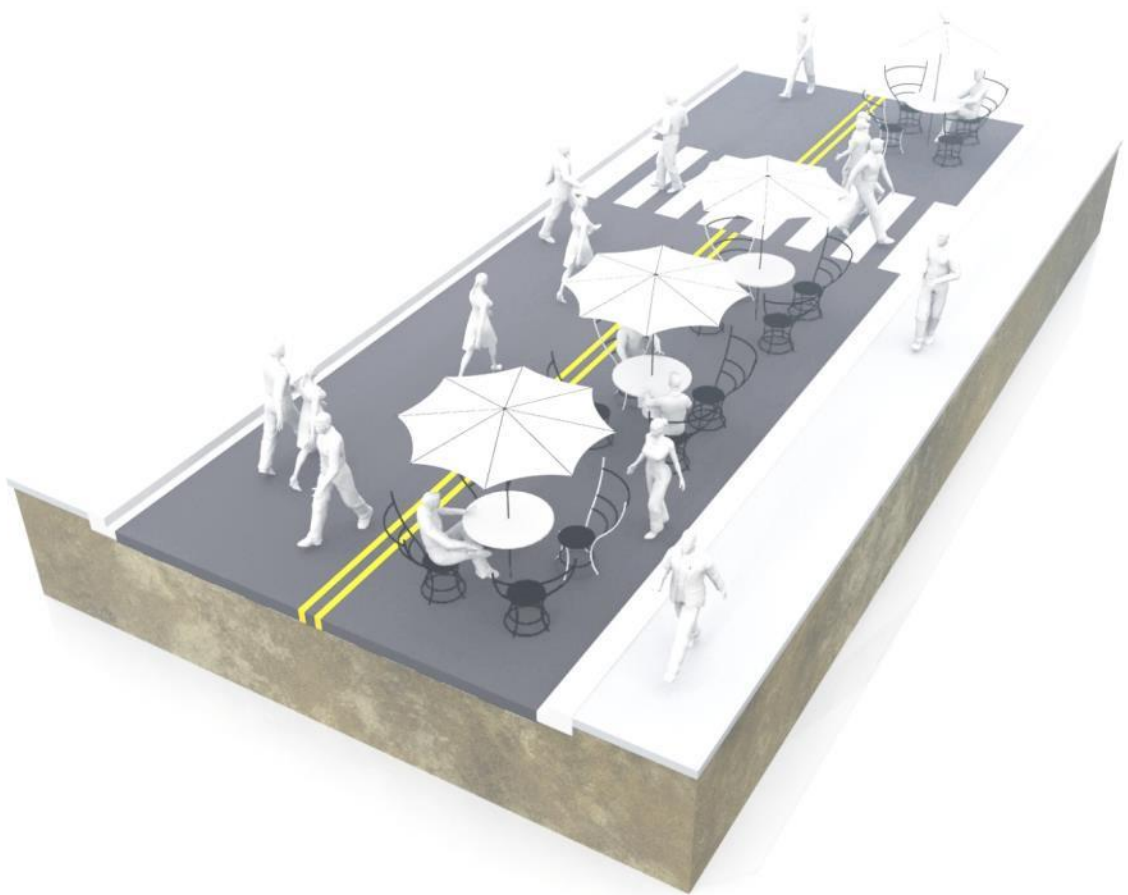
By changing parts of sidewalks into infiltration area, this improvement reduces the impervious footage of roadway facilities. With wood panels paved over these areas, it also adds interesting materials and textures to sidewalk, which has the potential to be expanded into open space.



**Illustration 35 Boardwalk over Infiltration Area.**

### 3.3.2.7 Periodical Pedestrian Plaza

Vehicular traffic volume on campus has a regular pattern during semesters. Track this pattern and periodically close parts of some secondary streets during lowest traffic time in daytime to temporary pedestrian installations to create a pedestrian plaza. This improvement is one of the strongest claims of “Streets as Places”, significantly discourage traffic cut-through.



**Illustration 36 Periodical Pedestrian Plaza.**

### 3.3.2.8 Median Park

Median parks create greenery and significant open spaces for pedestrians on streets, as

well as potentially provide stormwater infiltration area. Installations could be costly if median expansion is needed.



**Illustration 37 Median Park.**

### 3.3.2.9 Parking Lane Pocket Park

Parking lane pocket park is a parcel of green space reclaimed from one or more parking lots. It obviously increases greenery, decreases area of imperviousness, and discourages driving by reducing quantity of parking lots. By adding pedestrian features, it also reclaims pedestrian R-o-W from vehicular facilities. For travelling vehicles, these pocket



parks visually narrow down the streets for traffic calming.

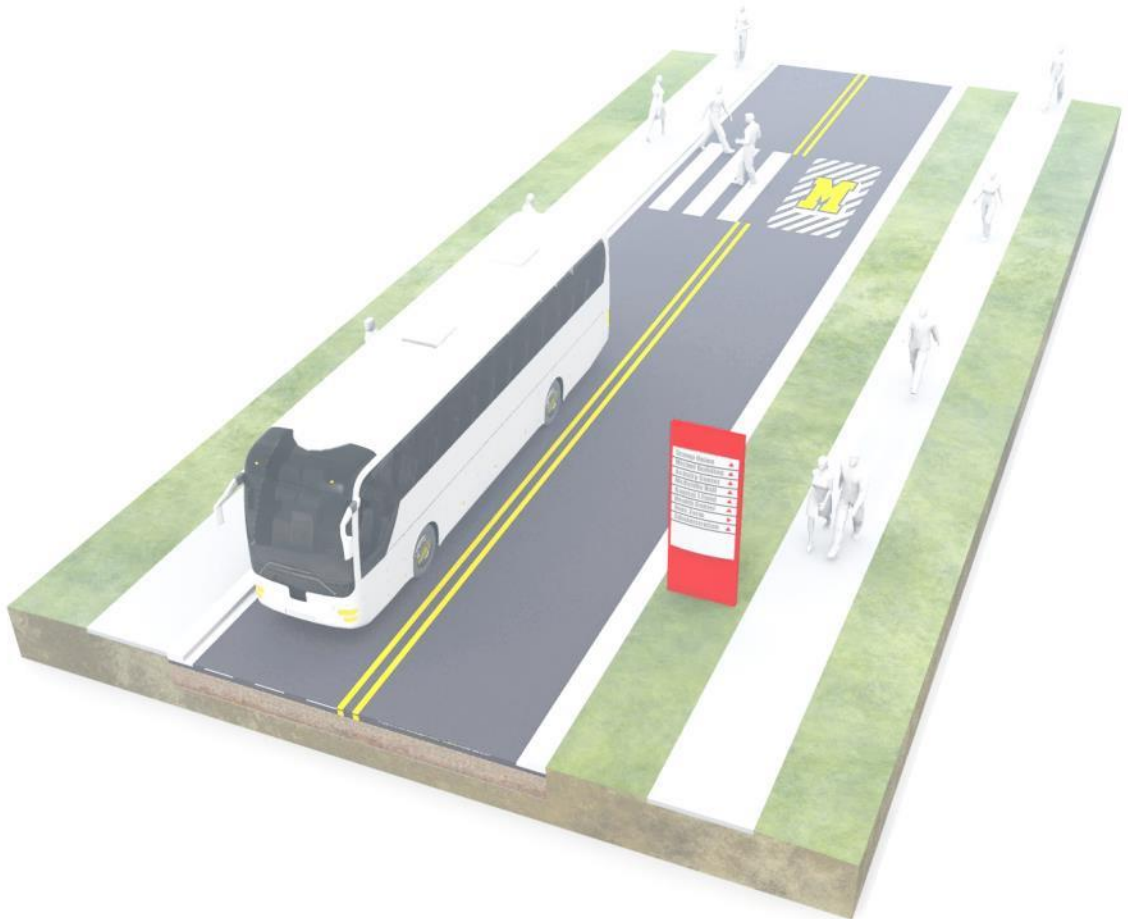


**Illustration 38 Parking Lane Pocket Park.**

### 3.3.2.10 Improved Way-Finding

This improvement is supposed to add additional direction / distance information and potentially campus map for roadway users. Better way-finding can significantly reduce straying traffic and hesitated drivers on campus, as well as improving traffic situation during visiting days and special events. Additionally, this improvement could also

improve the integrity of campus landscape and university branding.



**Illustration 39 Improved Way-Finding.**

### 3.3.2.11 Public Transit Stop Shelter

Many on-campus bus and Shuttle-UM stops are missing weather protected shelters.

Shelters could help promote usage of public transit by protect users from bad weathers.

Meanwhile, creative and proper designs, which could be acquired through student design competitions, contribute to better campus streetscape.



**Illustration 40 Public Transit Stop Shelter.**

### 3.3.2.12 Pedestrian-Dominated Intersection

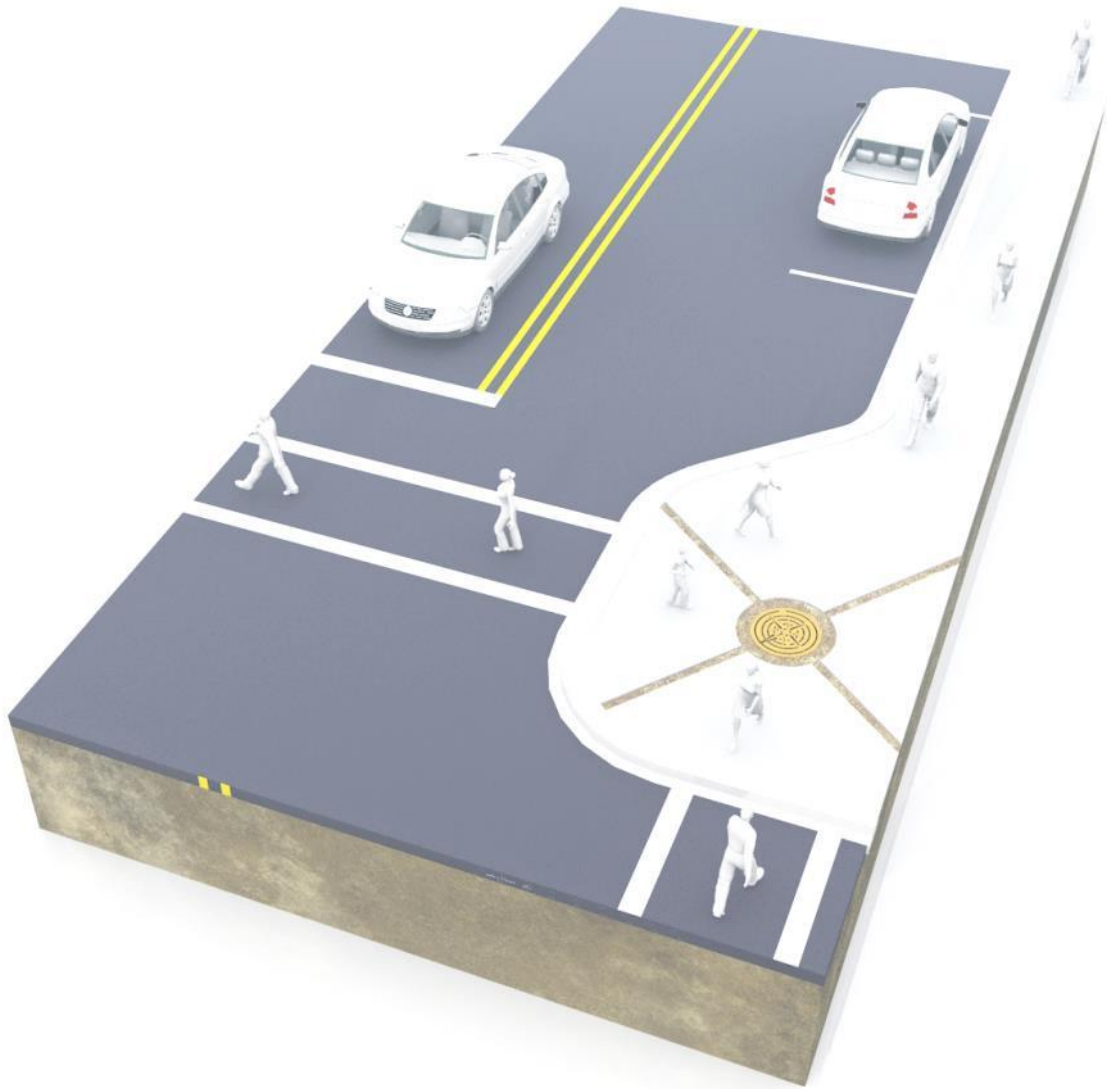
Pedestrian-dominated intersection designs claim pedestrian R-o-W on intersections, and provide convenience for pedestrians crossing streets. Small landscape features could be installed in the center of roadway intersections to imply the dominance of pedestrians on these segments. Many factors need to be considered when applying to streets carrying heavy traffic.



**Illustration 41 Pedestrian-Dominated Intersection.**

### 3.3.2.13 Bulbout with Attractive Drainage Facilities

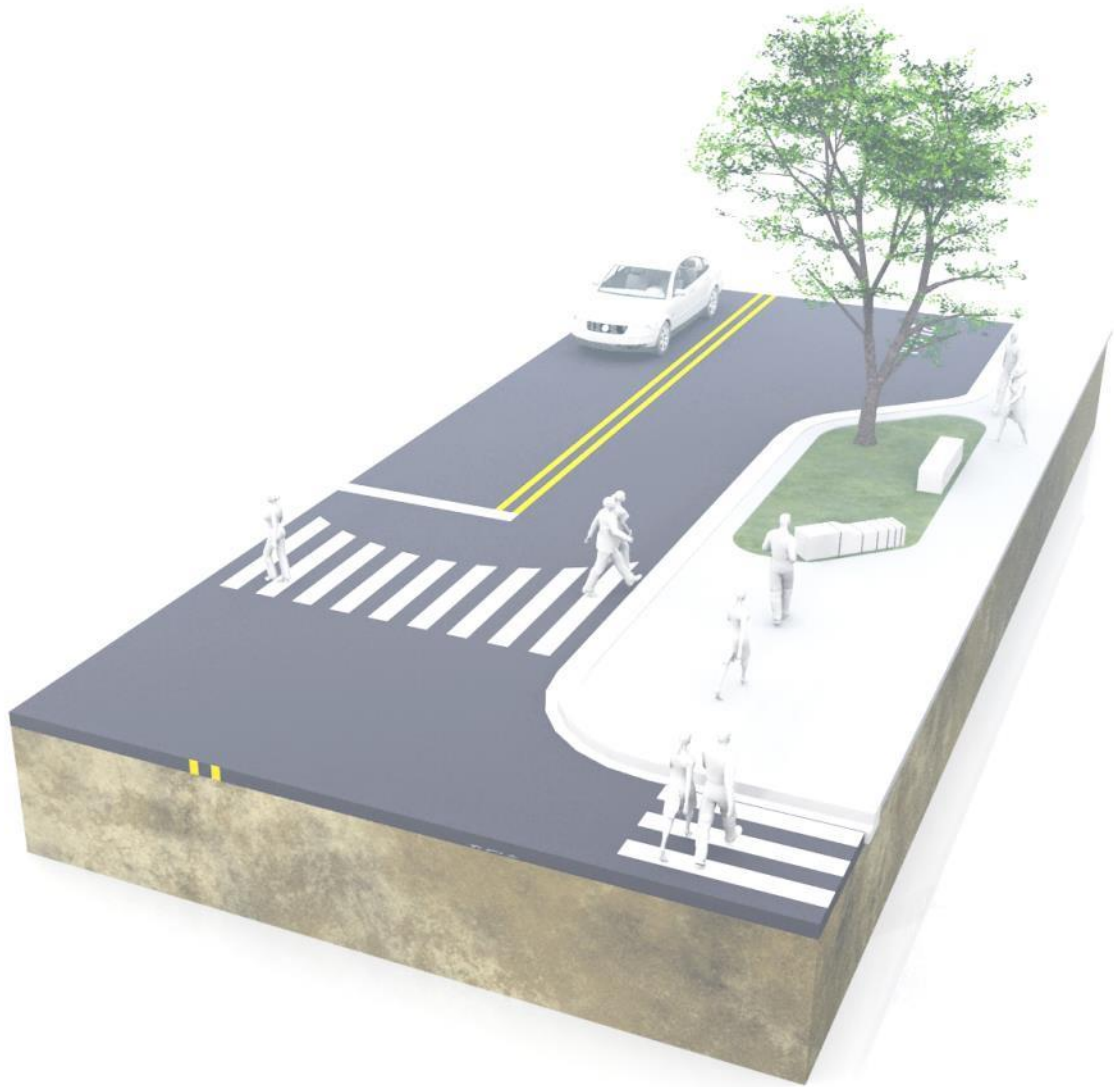
Bulbouts cut the width of streets for pedestrian. Cost of installations will be decreased if there's existing grate on the corner of the sidewalk. Interesting drainage installations attract pedestrians, which indirectly promote yielding to each other between vehicles and pedestrians.



**Illustration 42 Bulbout with Attractive Drainage Facilities.**

### 3.3.2.14 Bulbout Extension Park

With similar features as 3.2.2.13, this improvement adds significant gathering space and greenery to the streets. Additionally, it could incorporate with public transit stop or coffee shop to enhance street activities.

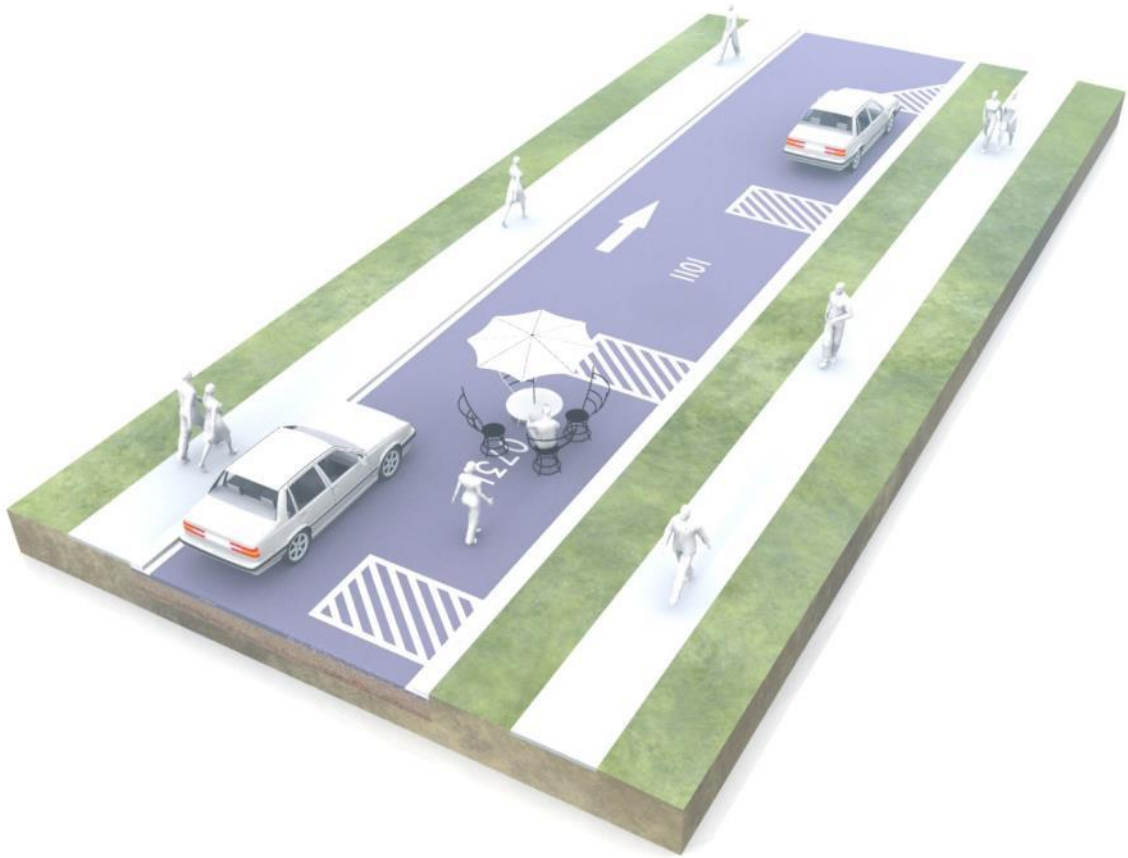


**Illustration 43 Bulbout Extension Park.**

### 3.3.2.15 Periodical Parking

Periodical parking is an improvement promoting multiple use of land, which results in higher efficiency of transportation land use. It increases on street open spaces for pedestrian activities, as well as the chance of conversation and communication during certain time periods. Temporary installations and additional managements are needed.

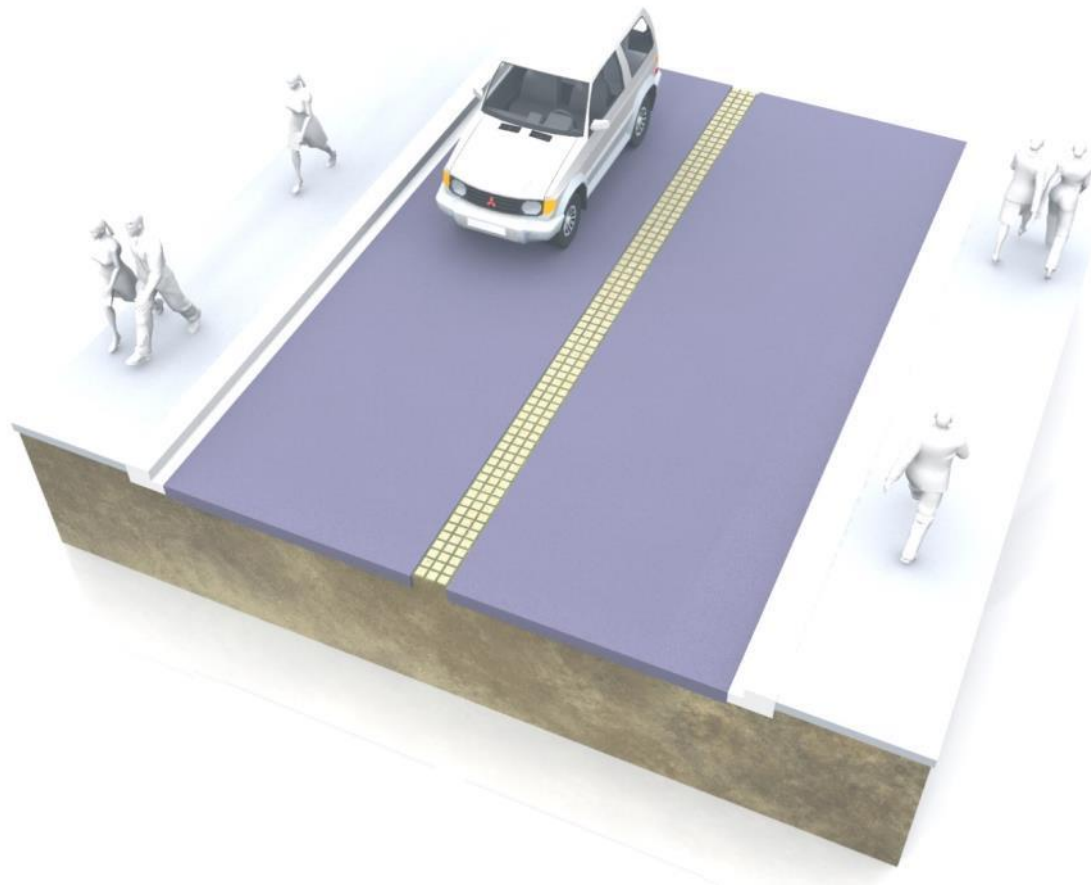
Consider incorporate with coffee shop or other merchants.



**Illustration 44 Periodical Parking.**

### 3.3.2.16 Cobble Stone Infiltration Strip

Using permeable pavements (not limited to cobble stones) to replace painted markings on secondary and lower level streets. This improvement adds interesting features to streets, discourages driving over strips, and increase streets permeable. Drainage relocation might be needed depends on the location of the permeable strips installed.



**Illustration 45 Cobble Stone Infiltration Strip.**

### 3.3.2.17 Public Arts

This improvement is more of a student involvement program, which reinforces campus identity as unique UMCP context.

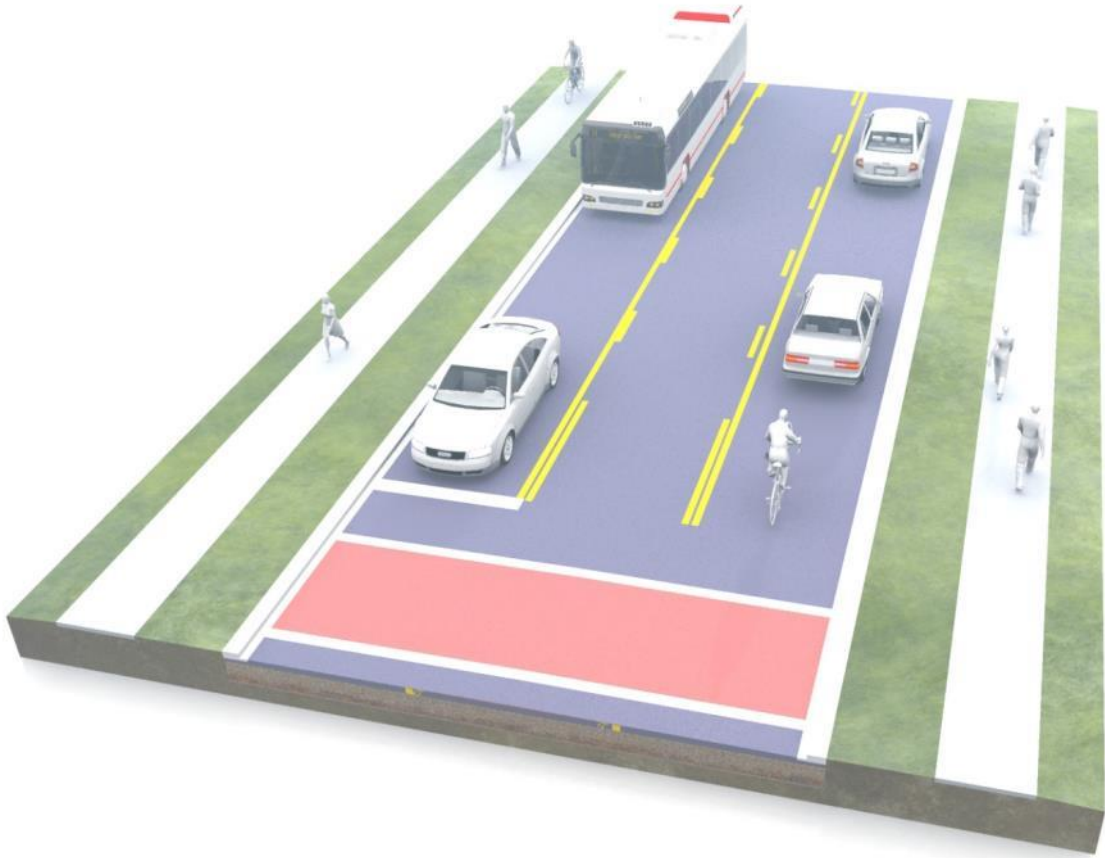




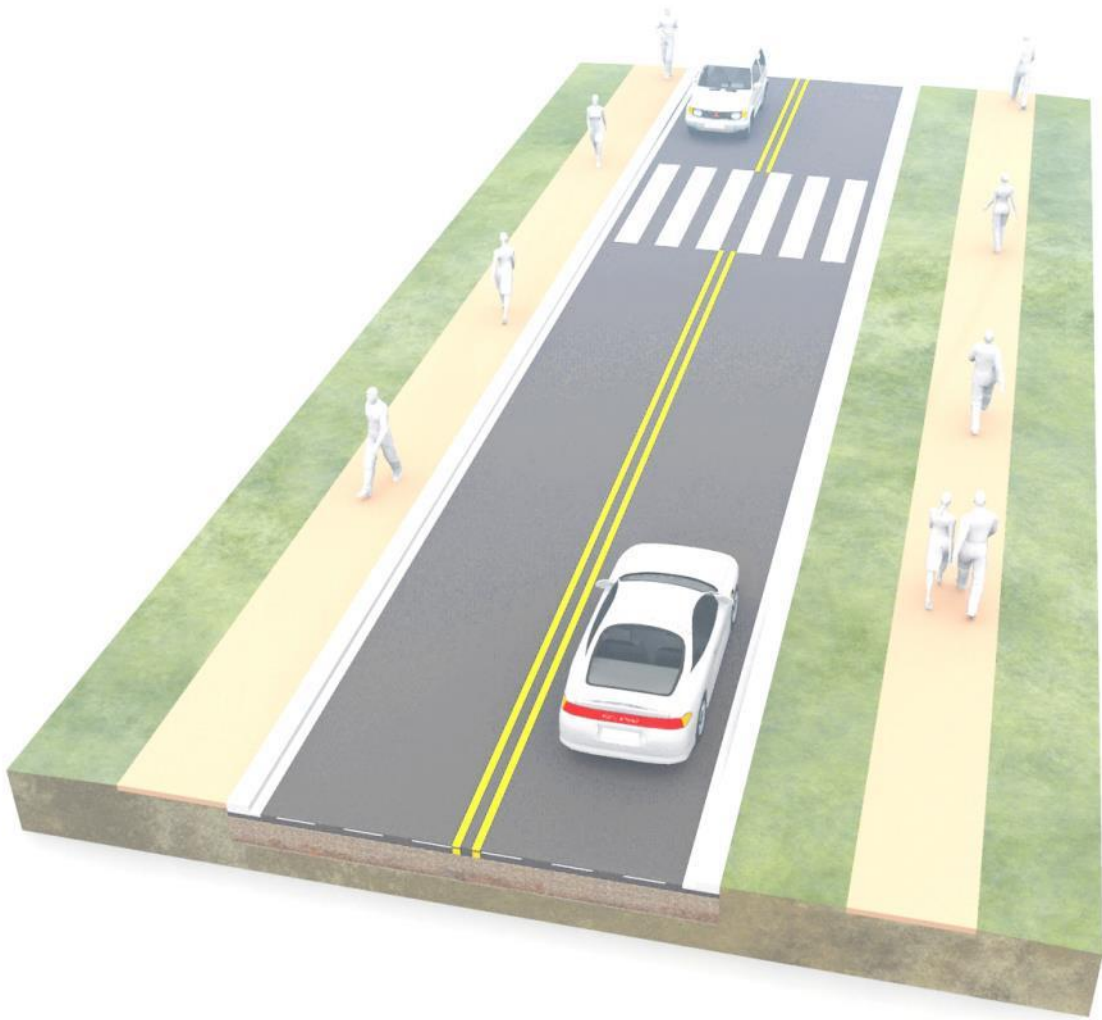
**Illustration 46 Public Arts.**

### 3.3.2.18 Permeable Pavements

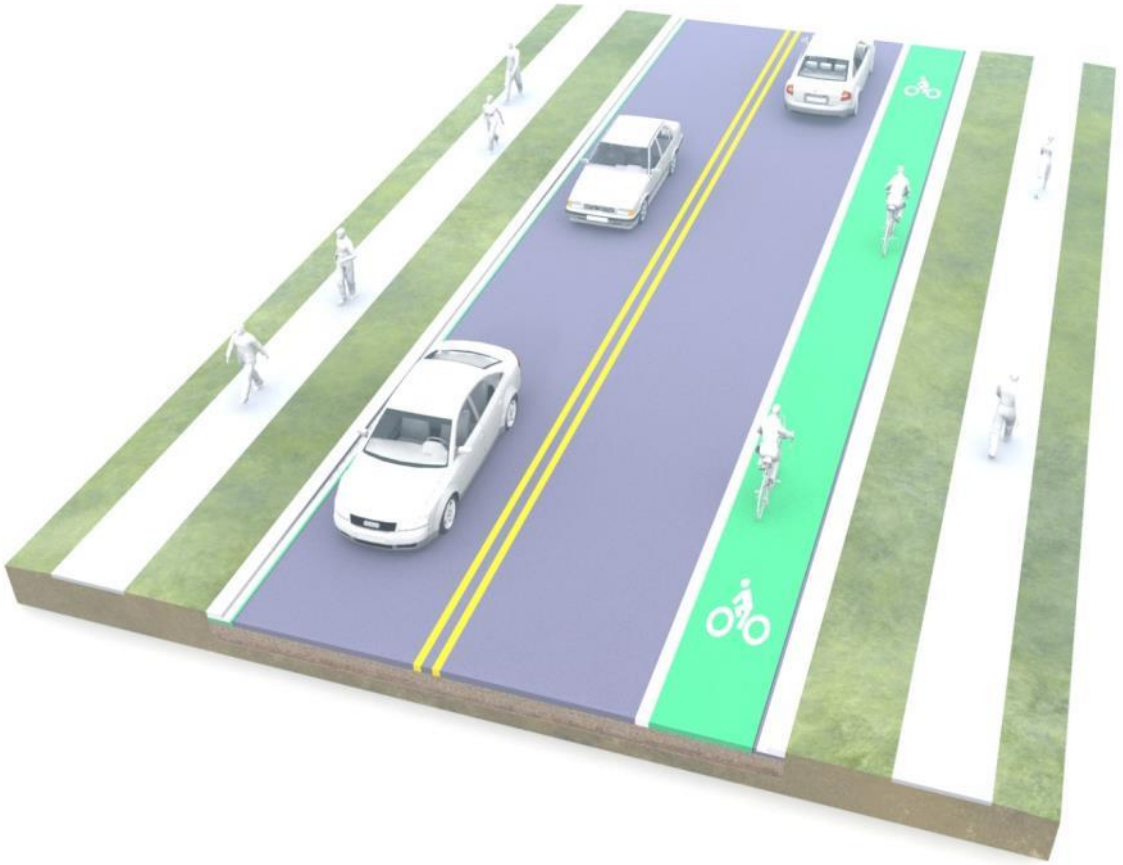
Permeable pavements significantly decrease imperviousness of roadways. Applications on vehicle lanes or bike paths could clear R-o-W visually. It is not applicable to streets frequently used by operation / freight vehicles. There are multiple parts of streets where this improvement could be installed (which affect the applicability of this improvement):



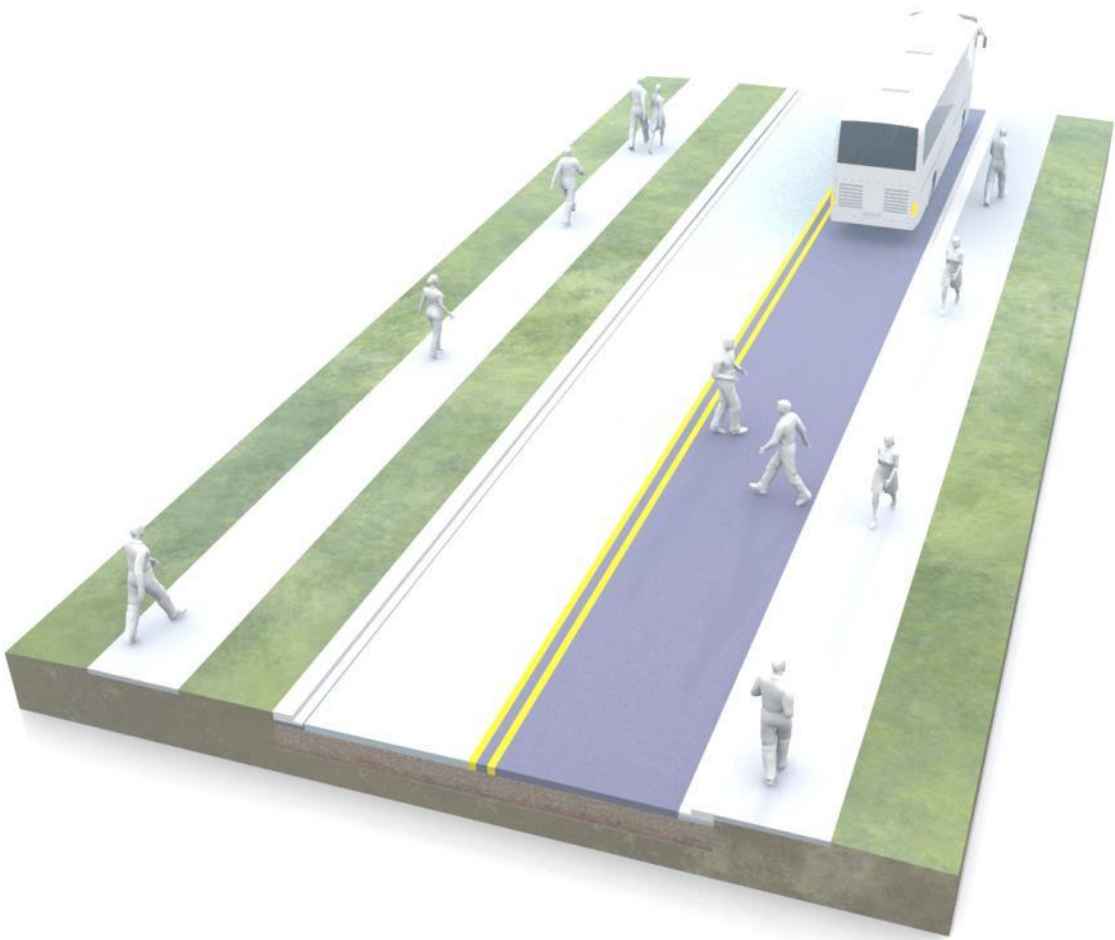
**Illustration 47 Permeable Pavements on Pedestrian Crosswalk.**



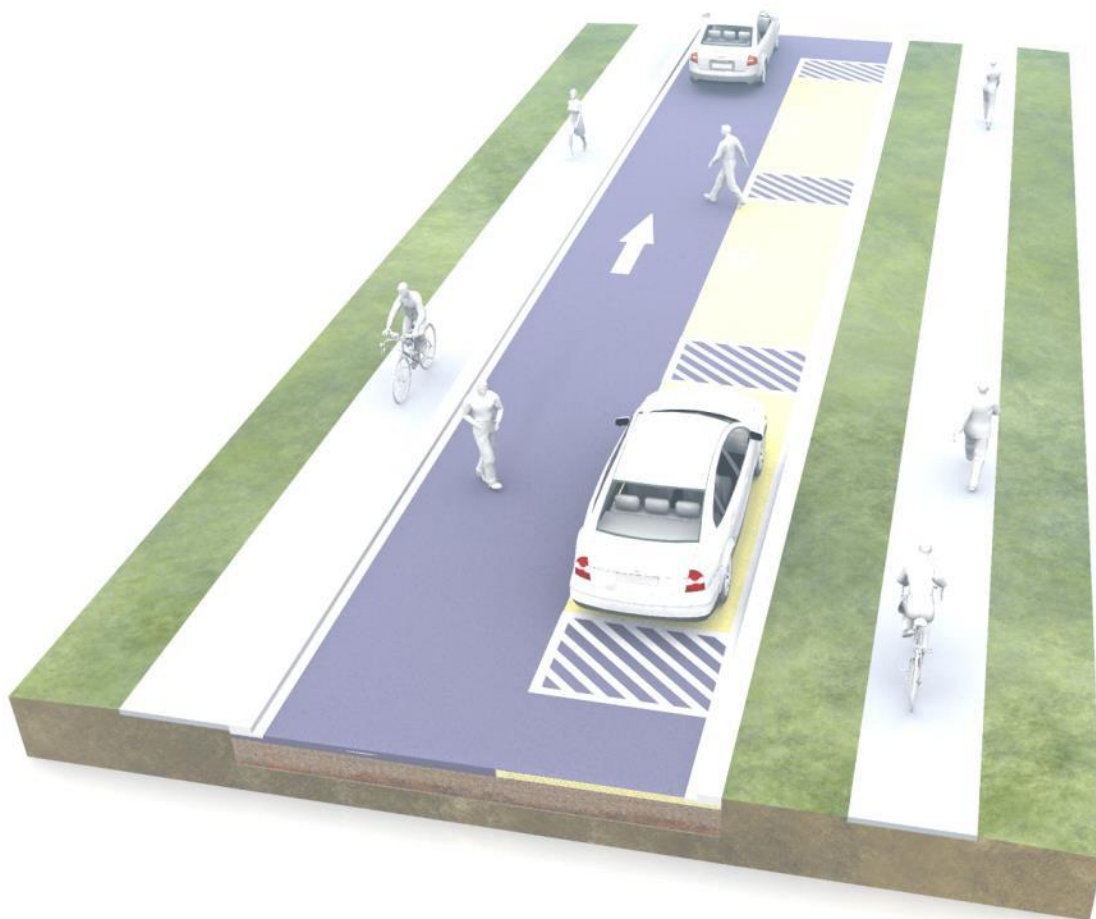
**Illustration 48 Permeable Pavements on Pedestrian Sidewalk.**



**Illustration 49 Permeable Pavements on Bike Lanes.**



**Illustration 50 Permeable Pavements on Light-Load Vehicle Lanes.**



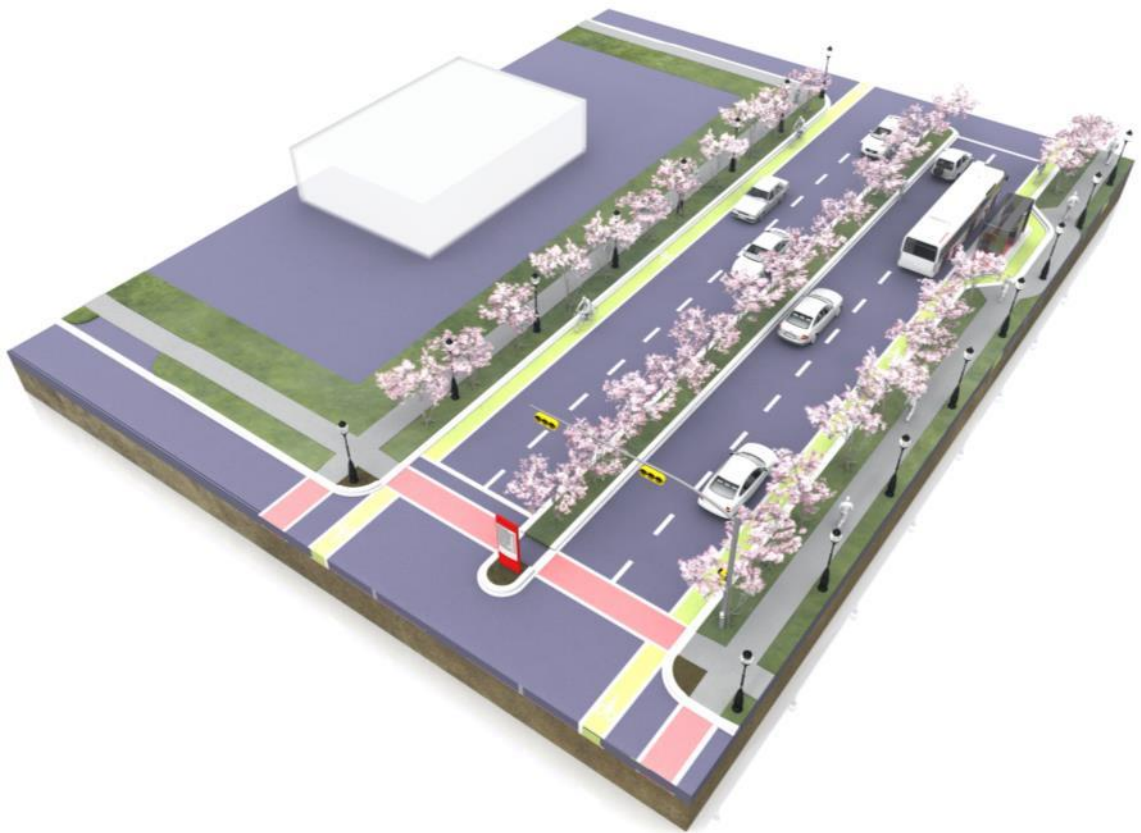
**Illustration 51 Permeable Pavements on On-Street Parking Lots.**

### 3.4 Improvement Combination Themes and Installation Examples

Improvement combination themes are categories of different combinations of selected improvements on specific roadway segments targeting different functional focus. These themes are designed for better localization of Complete Streets improvements listed above. Totally 5 themes were developed according to campus inventory including aesthetic guidelines for each campus district.

### 3.4.1 Main Street

Main street theme is designed for streets serving as campus arterials, accepting visitors during events and carrying multi-modal transportation. Improvement selection should consider travelling convenience of all possible user groups, and mainly focusing on mitigating R-o-W conflicts by clarifying R-o-W for each user group. Attracting installations should be kept within a threshold of not affecting smoothness of normal traffic flow.



**Illustration 52 Design Example 1: 4 lanes with median. Improvement on pedestrian facilities, biking facilities, public transit facilities and planting.**



**Illustration 53 Design Example 2: 4 lanes with central turning lane. Improvement on pedestrian facilities, biking facilities, public transit facilities and planting.**





**Illustration 54 Design Example 3: 4 lanes with/without extra lane. Improvement on pedestrian facilities, biking facilities and planting.**



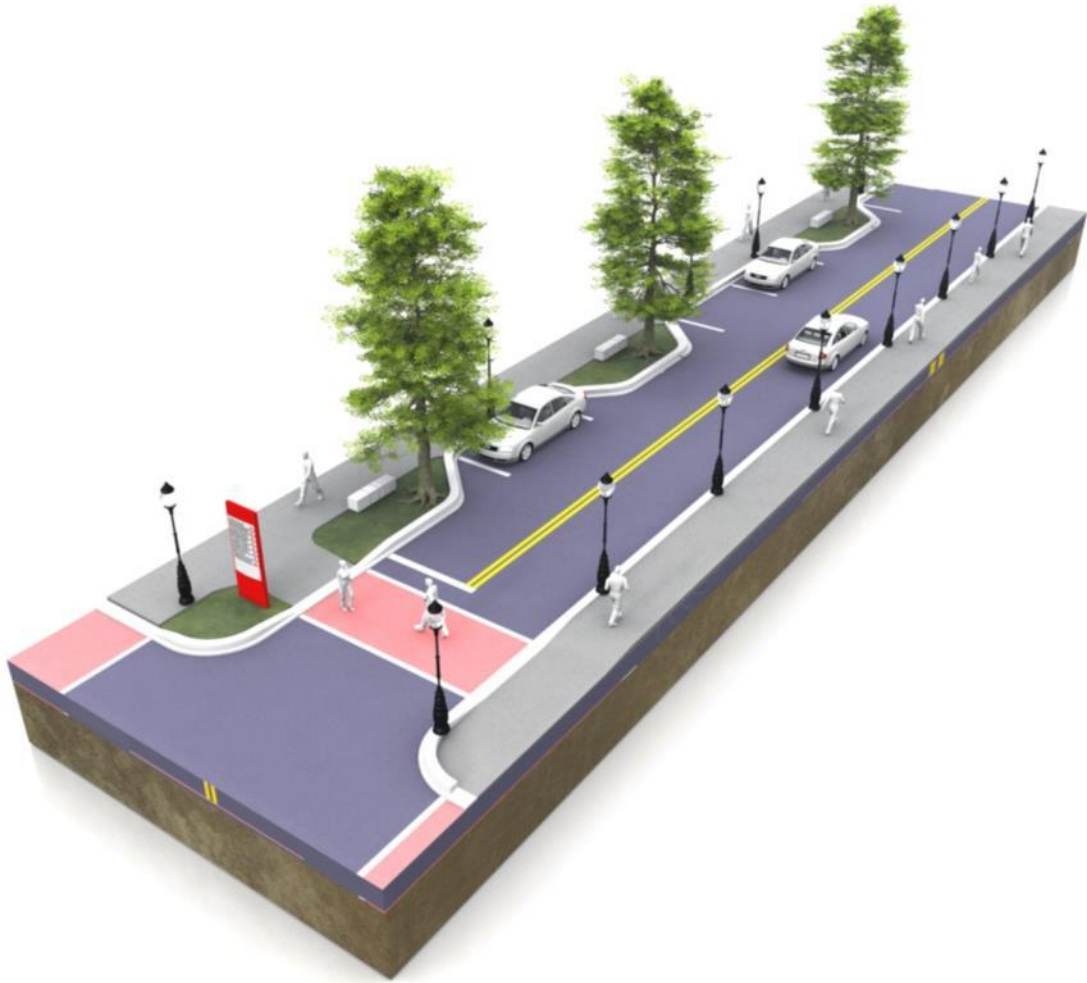
**Illustration 55 Design Example 4: 2 lanes with median. Improvement on pedestrian facilities, green infrastructure and planting.**



**Illustration 56 Design Example 5: 2 lanes. Improvement on biking facilities, pedestrian facilities, green infrastructure and planting. Incorporated with the Purple Line.**

### **3.4.2 Pedestrian Boulevard**

Pedestrian boulevard theme is mainly designed for frequently used pedestrian routes and streets serving as major pedestrian connectors as shown in illustrations in 2.3.3. The improvement combinations are designed for pedestrians to dominate these streets with light motorized-traffic loaded. The improved streets will provide new gathering and recreational spaces, carry open spaces and educational green infrastructures along one or both sides, and connect existing major campus open spaces.



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**Illustration 57 Design Example 1: 2 lanes with parking lane. Improvement on pedestrian facilities, green infrastructure and planting.**



**Illustration 58 Design Example 2: 2 lanes. Improvement on biking facilities, pedestrian facilities and planting.**



**Illustration 59 Design Example 3: 1 lane with parking lane. Improvement on pedestrian facilities and planting.**



**Illustration 60 Design Example 4: 1 lane. Improvement on pedestrian facilities and planting.**

### **3.4.3 Public Transit Hub**

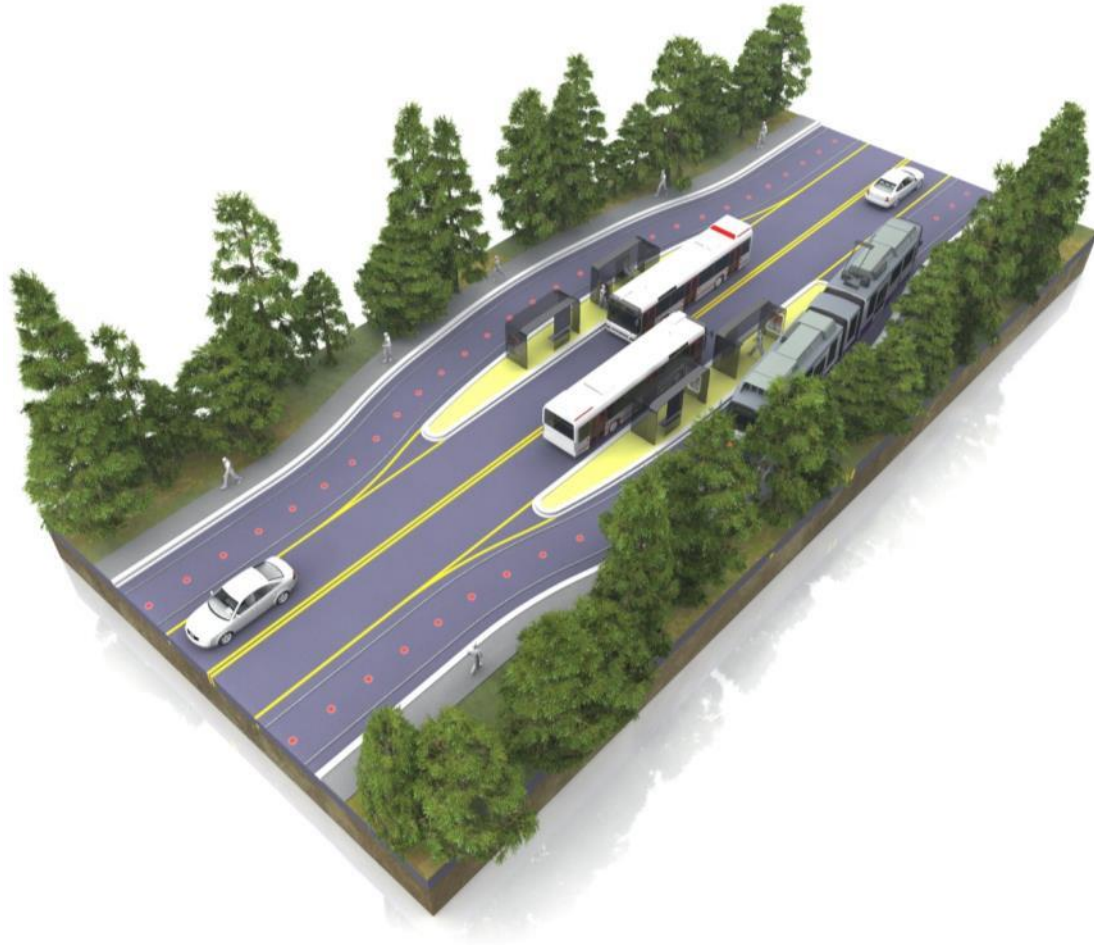
With Shuttle-UM stops distributed all across the campus, and Metro Buses, regional buses and proposed Purple Line cutting through, public transit stop design should be compact and integrated to save space, improve efficiency and potentially calm vehicular traffic. Public transit hub theme is designed for roadway segments serving as major public transit nodes, especially those overlapping with proposed Purple Line. On certain segments the design need to balance between the convenience of public transit users and

the smoothness of other traffic mode. Weather-protection shelters are required to be installed to improve public transit user experiences. A well-designed public transit hub should also have the potential of driving the surrounding area serving as a gathering place for social activities.



**Illustration 61 Design Example 1: 2 lanes. Improvement on public transit facilities, pedestrian facilities and planting. Incorporated with the Purple Line.**



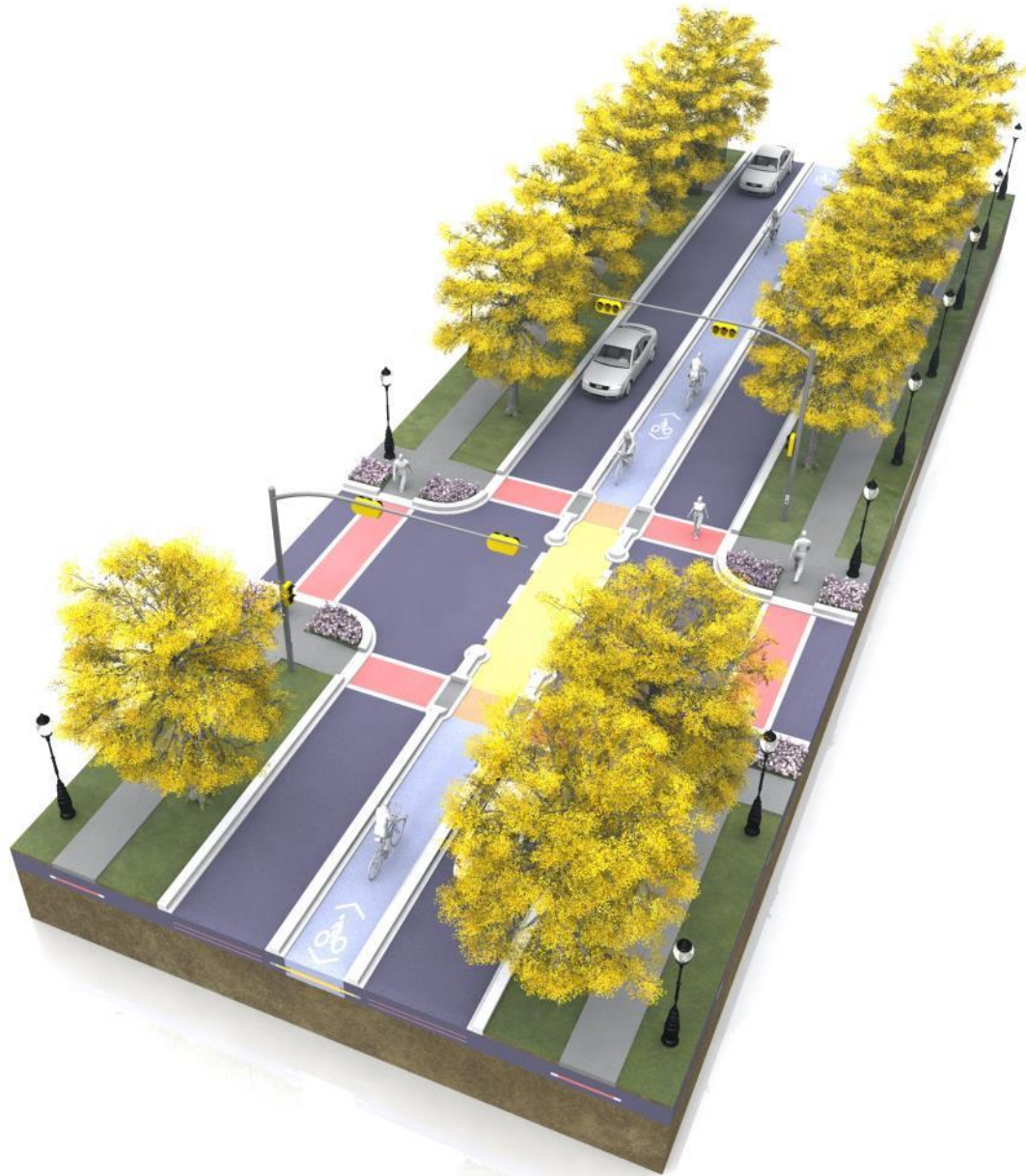


**Illustration 62 Design Example 2: 2 lanes. Improvement on public transit facilities and planting. Incorporated with the Purple Line.**

### **3.4.4 Bike Route**

Bike tracks, bike lanes and shared lanes are installed to clarify cyclists R-o-W on roadway segments in this theme, which are mainly designed for Active Bike Routes as illustrated in 2.3.2.1. Bike lane type in different directions could be different to adapt to sloped topography.

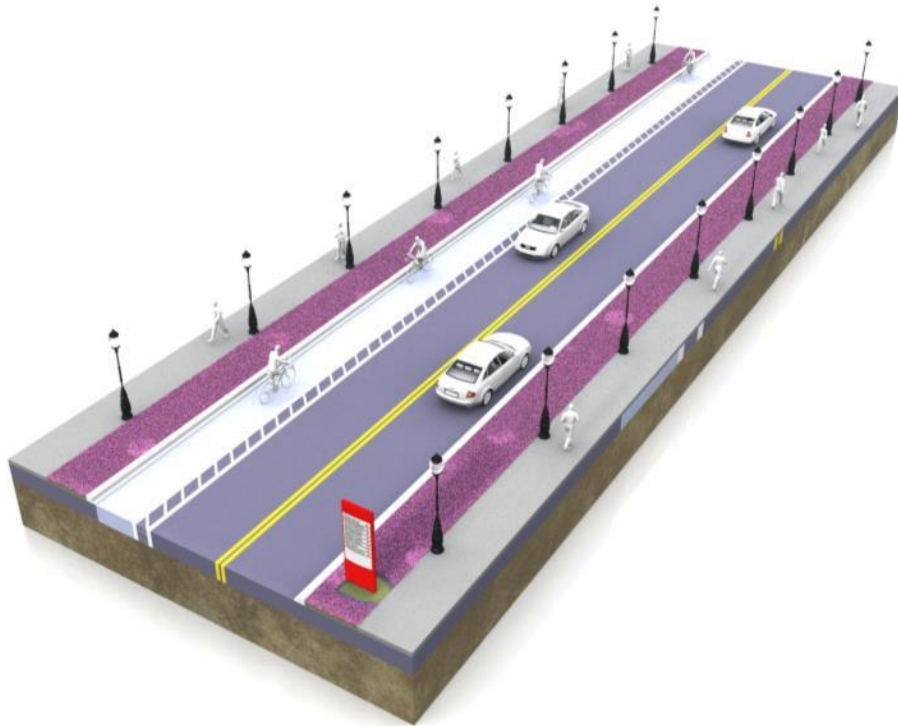




**Illustration 64 Design Example 2: 2 lanes with median. Improvement on biking facilities, pedestrian facilities, green infrastructures and planting.**



**Illustration 65 Design Example 3: 2 lanes with parking lane. Improvement on biking facilities, pedestrian facilities and green infrastructures.**



**Illustration 66 Design Example 4: 2 lanes. Improvement on biking facilities and green infrastructures.**

### **3.4.5 Arboretum**

Arboretum theme is designed for streets with low traffic volume. Roadway segments in this theme are designed to be densely vegetated with diverse plant species, equipped with adequate facilities for joggers and walkers based upon demand and site context. Open spaces and seating are provided along the road, potentially provide a place for recreation and exterior classes. Pairs of single-vehicle-lane roads can add up to meet higher Level-of-Service.



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**Illustration 67 Design Example 1: 2 lanes with median. Improvement on biking facilities, pedestrian facilities, green infrastructures and planting.**



**Illustration 68 Design Example 2: 1 lane with parking lane. Improvement on pedestrian facilities, green infrastructures and planting.**



**Illustration 69 Design Example 3: 1 lane. Improvement on pedestrian facilities, green infrastructures and planting.**

### 3.5 CCS Code Applicability Charts

#### 3.5.1 Color Code

Color code used throughout the CCS Code is consistent. Red stands for mitigating R-o-W conflicts; Yellow stands for improving user experiences; Green stands for achieving institutional functions. For the landscape elements improvement part, colored dots represent applicability of improvement in a column to segment typologies in the corresponding rows. Cluster of dots in the place of one dot indicates installation will



potentially achieve more than one objective. (See Appendix 2)

### **3.5.2 Applicability and Flexibility**

The code was designed and developed in the site context of the main campus of UMCP campus, but could be adjusted to be applied to roadway segment improvement on roadway segments in other parts of UMCP campus. It could also be used as a reference for similar projects in other urban commuter university campus with similar site sub-contexts.

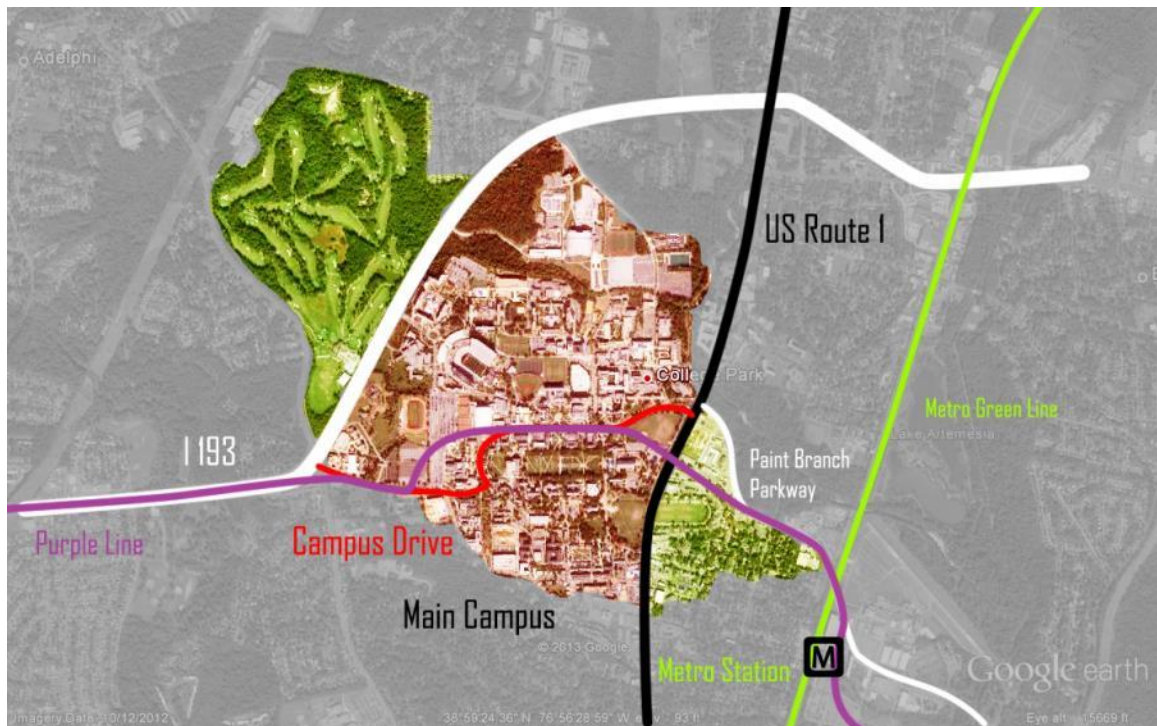
The suggested complete street element improvements listed in the Code are groups of all possible designs and forms serving the same purposes. There are no limitations on the design of the suggested improvements; therefore the flexibility of the Code is well controlled. All designs are suggested to be localized to targeting roadway segments' surrounding context.

## Chapter 4: Campus Drive

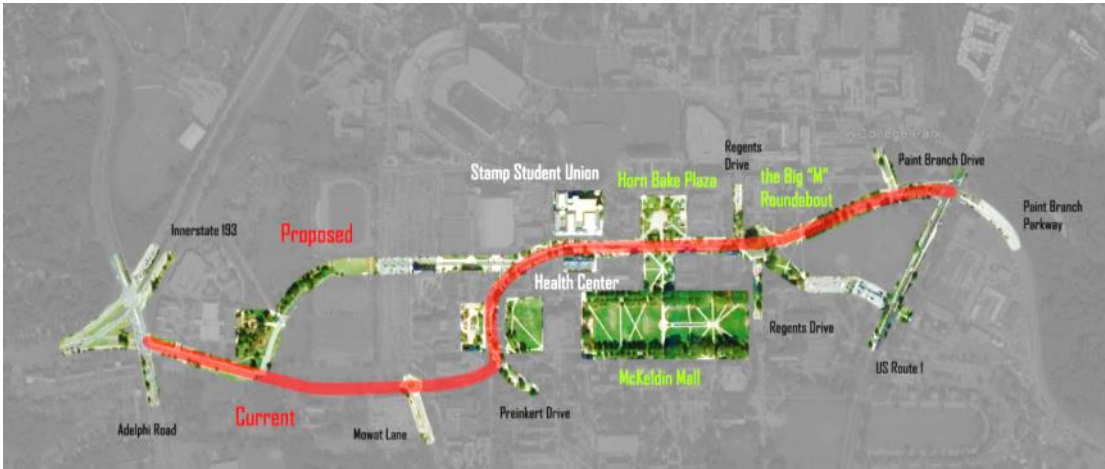
### 4.1 Site Analysis

#### 4.1.1 Scope

Campus Drive is one of the main arterial in the main campus, connecting Adelphi Road and Interstate 193 on the West end, and US Route 1 and Paint Branch Parkway on the East end. With Adele H. Stamp Student Union locating approximately in the middle, which is considered as the center for campus life, Campus Drive serves not only as the main arterial of the main campus, but also one of the major connector for commuter traffic going East and West.



**Illustration 70** Campus Drive and proposed the Purple Line layout in main campus.



**Illustration 71 Campus Drive site context.**

#### **4.1.2 Pilot Closure**

A phased experiment of closing Campus Drive was conducted during the summer of 2010 to collect data on the potential impact of a proposed permanent closure of sections of Campus Drive (Baker, 2011).

Phase I of the Pilot closed the road section to vehicles except service vehicles, operation vehicles, emergency vehicles, and public transit vehicles. The duration of Phase I was about 2 weeks. Phase II further restricted Shuttle-UM and regional buses, except twice hourly Shuttle-UM Campus Connectors and ADA access vehicles (Baker, 2011).

The followed survey results revealed that the majority of the campus population is opposed to both closures in Phase I and II. Comparing with the analysis on FMP survey results mentioned in 2.4, it indicates that restrictions should be set on cut-through traffics, but a closure of any level will not be well accepted within a considerable period.

## 4.2 Segment Facility Analysis

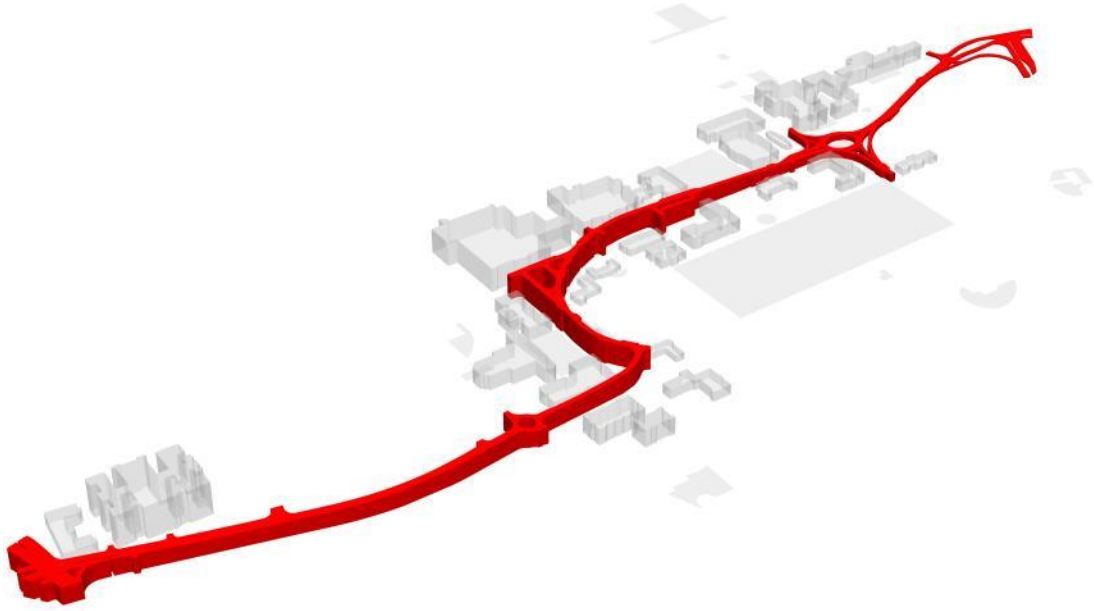
Segment facility analysis is performed in ArcGIS 10 based on Campus Drive facility inventory. Data created were exported to ArcScene 10 to be transformed into spatial graphics elevated according to the value in each cell for better comprehension visually. Color code for all illustrations in this section (4.2) is consistent: Reddish color represents lower value and demand of improvement, and greenish color stands for higher value and better facility conditions.

### 4.2.1 Topography and Context

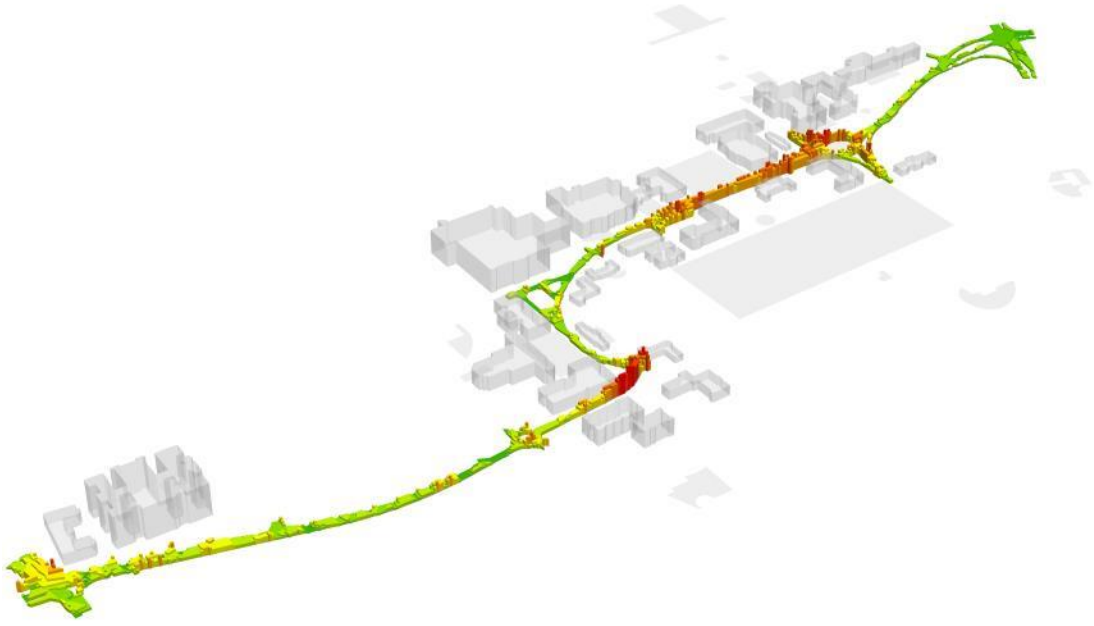
Campus Drive goes across a ridge about the location of Cole Student Activity Center and Adele H. Stamp Student Union, with slope goes down on both directions. Intersection with Route 1 is the lowest point. Woody plants are densely planted all along Campus Drive reach, with a convenient distance and connection to many of the major green space in the main campus.

(Illustrations in this section are intuitive graphics generated from quantitative analysis in Arc Scene, for original illustration, please see Appendix 1)

#### 4.2.1.1 Topography



**Illustration 72 Campus Drive Topography.**



**Illustration 73 Campus Drive Slope Map.**

#### 4.2.1.2 Vegetation



**Illustration 74 Campus Drive Vegetation Coverage.**

#### **4.2.2 Pedestrian Facilities**

Located about right in the middle of the main campus, a considerable portion of all pedestrian paths connecting northern and southern campus cross Campus Drive at certain points. Whether pedestrian crosswalks are located within a reasonable distance to these crossing points is used as an indicator of pedestrian connectivity in the transverse direction of Campus Drive.

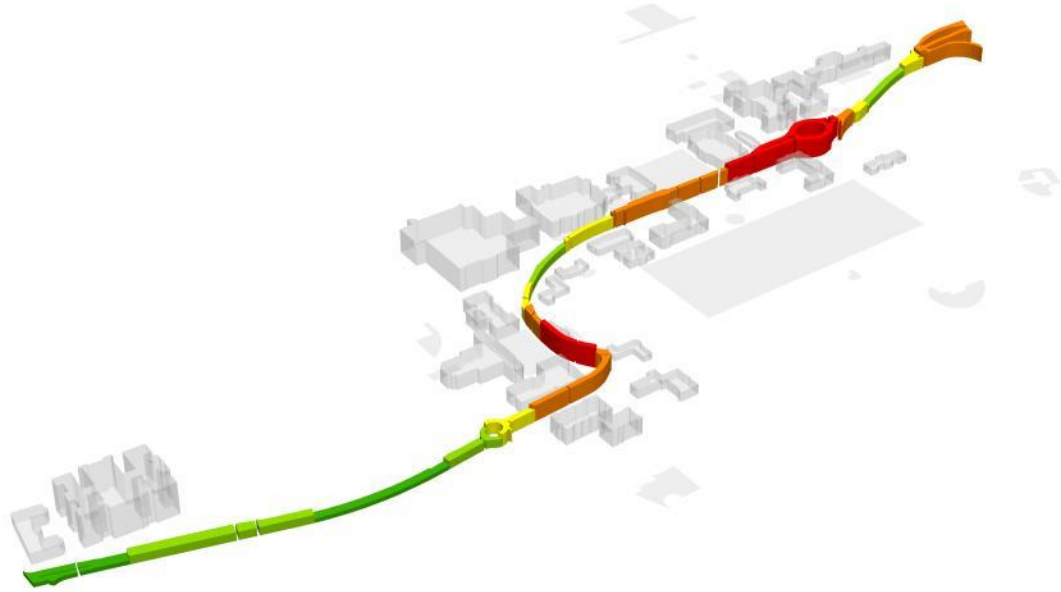
#### 4.2.2.1 Pedestrian Paths Connectivity



**Illustration 75 Campus Drive pedestrian path intersection linear density (quantity per ¼ mile).**



#### 4.2.2.2 Pedestrian Crosswalk



**Illustration 76 Campus Drive pedestrian crosswalk linear density(quantity per ¼ mile).**

#### 4.2.2.3 Overall Pedestrian Facility Assessment

Illustration 77 shows a Boolean calculation of two density maps shown in Illustration 75 and 76. Higher value (Red color) shows pedestrian paths and crosswalks are highly unmatched, which implicates improvements are needed for better pedestrian connection across the street.



**Illustration 77 Campus Drive pedestrian path intersection / crosswalk linear density unmatched.**

Illustration 78 shows pedestrian sidewalk completeness on Campus Drive from connectivity perspective. Color code from green to red represents:

Pedestrian sidewalks on both sides without buffer;

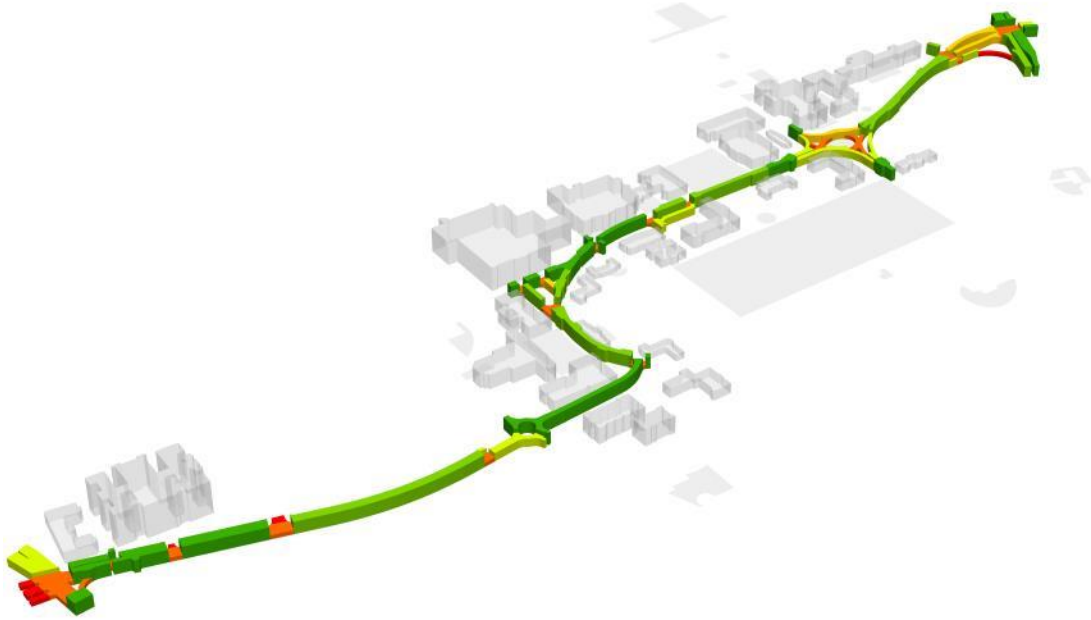
Pedestrian sidewalks on both sides with buffer;

Pedestrian sidewalk on one side without buffer;

Pedestrian sidewalk on one side with buffer;

No pedestrian sidewalks; and

Intersections.

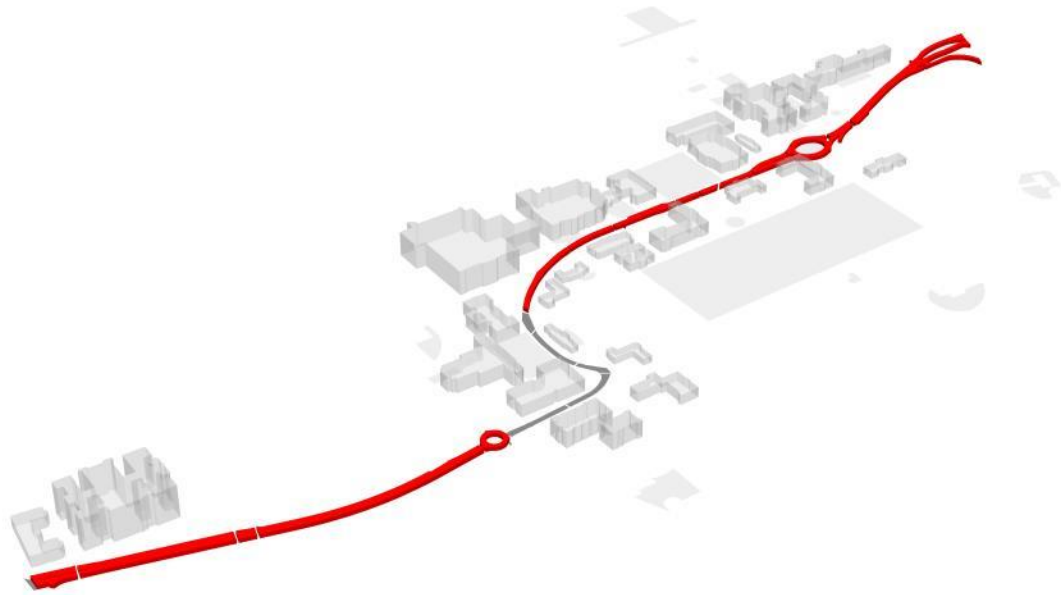


**Illustration 78 Campus Drive pedestrian pedestrian facility completeness.**

### **4.2.3 Active Bike Route**

Active Bike Route overlaps with Campus Drive on two segments: From the West end to the roundabout near School of Architecture Building, and from the intersection with US Route 1 to the intersection with Union Line.

Biking facility installation incorporating with improvements on other multi-modal transportation should be considered on these segments.

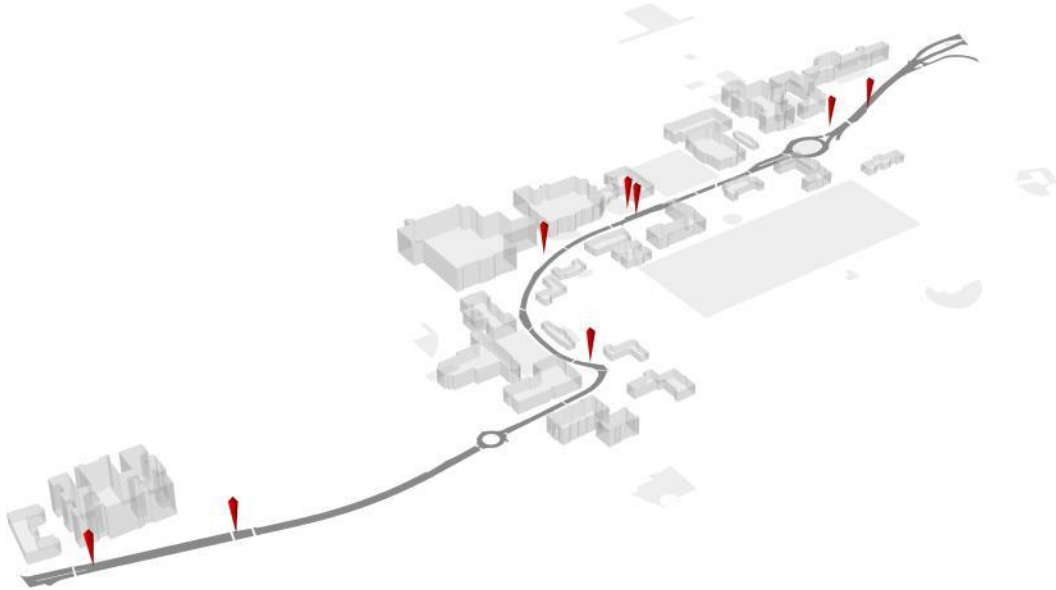


**Illustration 79 Campus Drive ABR overlapping.**

#### **4.2.4 Public Transit Facilities**

Campus Drive is the most heavily used routes by mass transit systems. Almost all Shuttle-UM buses travel at least part of Campus Drive in their complete circular routes, and Washington Metropolitan Area Transit Authority (WMATA) buses including J4, C2, C8 and F6 also regularly go through Campus Drive. One of the proposed layouts of the Purple Line mostly overlaps with Campus Drive.

#### 4.2.4.1 Metro Bus, Regional Bus and Shuttle-UM Stops



**Illustration 80 Campus Drive public transit stops.**

#### 4.2.4.2 The Purple Line

The layout of the Purple Line has not been set up in FMP, and the planning of the Purple Line is beyond the scope of this project. For the following design part, the most commonly seen layout option was adopted in the master plan.

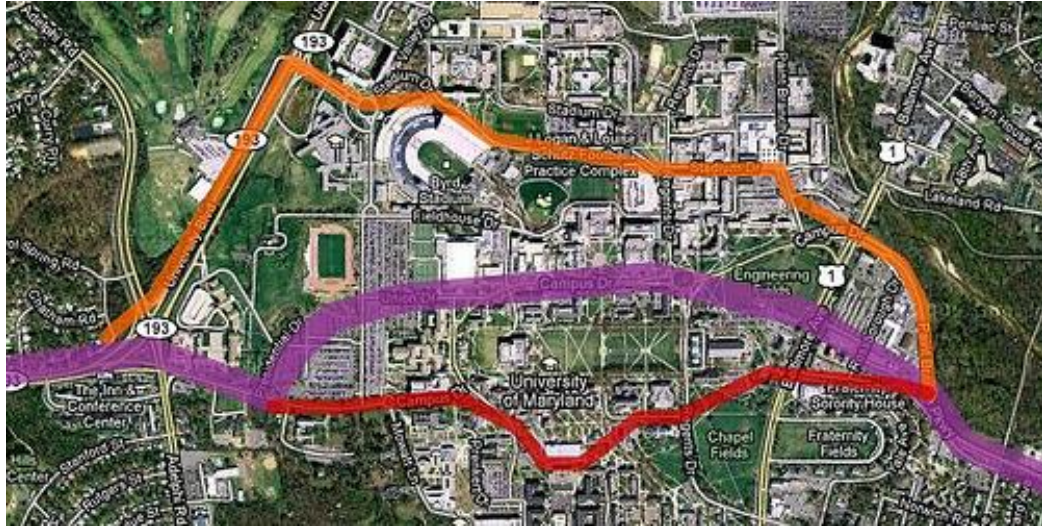
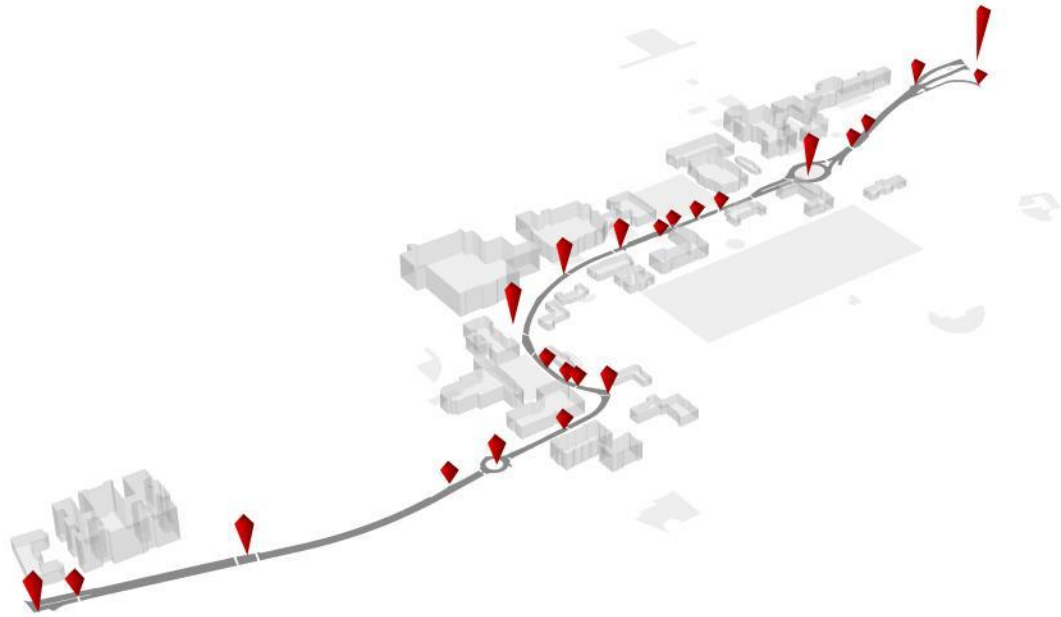


Figure 18 Campus Drive the Purple Line overlapping (the purple line shown in the map is the layout adopted in this thesis, red and orange lines are two alternative layouts discussed by campus departments). Source: rethinkcollegepark.net, [http://farm3.static.flickr.com/2800/4194087976\\_3df1793d05.jpg](http://farm3.static.flickr.com/2800/4194087976_3df1793d05.jpg)

#### 4.2.5 Conflict at Intersections

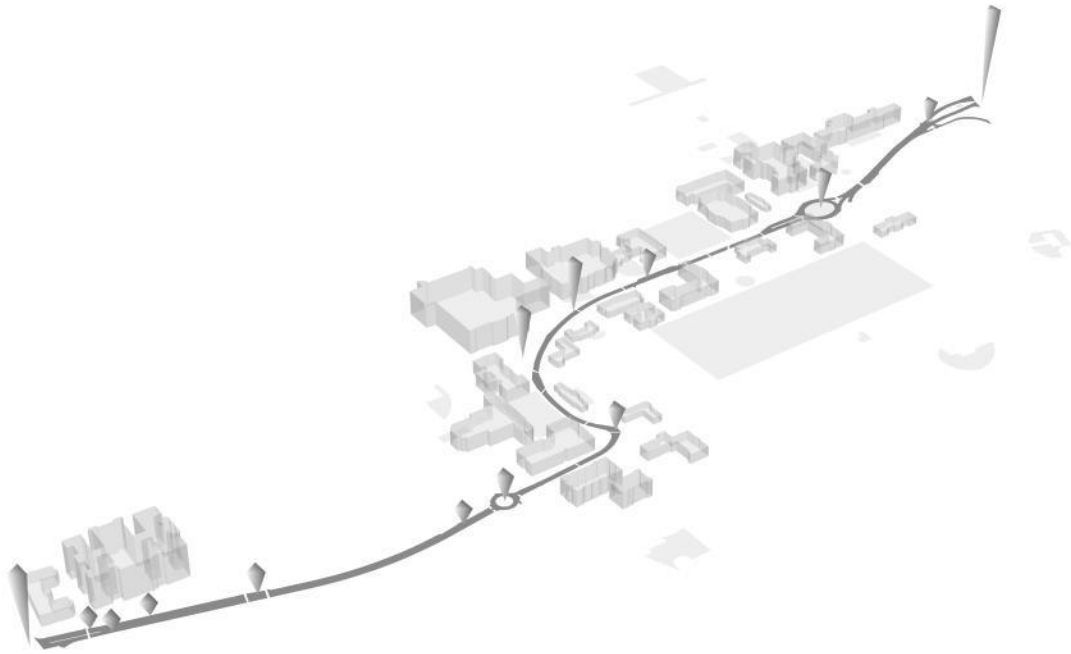
Conflict points between wheeled traffic and pedestrian are counted at each intersection along Campus Drive. Each user groups' R-o-W should be better clarified and protected as the conflict point amount goes up.

#### 4.2.5.1 Conflict Points between Vehicle/Bicycle and Pedestrian



**Illustration 81 Campus Drive conflict points between vehicle/bicycle and pedestrian.**

#### 4.2.5.2 Conflict Points among Vehicle/Bicycle



**Illustration 82 Campus Drive conflict points among vehicle/bicycle.**

### **4.2.6 Overall Facility Completeness Assessment**

#### 4.2.6.1 Calculation Basis, Criteria and Parameter Set

The focus of improvement design on Campus Drive is targeted on pedestrians, cyclists and public transit users to promote adopting of healthier and more sustainable travel means on campus. Besides, considering the well-maintained-status of current vehicular traffic facility, it was excluded from factors affecting the assessment on completeness of Campus Drive roadway facilities.

Linear density of intersections of pedestrian sidewalk along Campus Drive and pedestrian



paths (I) is converted into percentages within 100% scale, and is evenly classified into 5 levels from highest to lowest. Each level is assigned with integer credits from 1 to 5 following gradient from lowest to highest.

Linear density of pedestrian crosswalk on Campus Drive (X) is converted into percentages within 100% scale, and is evenly classified into 5 levels from highest to lowest. Each level is assigned with integer credits from 1 to 5 following gradient from lowest to highest.

Linear density of public transit stop on Campus Drive (Ps) is converted into percentages within 100% scale, and is evenly classified into 5 levels from highest to lowest. Each level is assigned with integer credits from 1 to 5 following gradient from lowest to highest.

Without supporting facilities, assigned Active Bike Routes (ABR) has little affection on the overall connectivity and “bikability” of their overlapping segments. Segments overlapping with ABR will contribute 1 point.

Steeper slope negatively impact walkability and extend weighted distance between two locations. Campus Drive slope (S) ranges from 0 to ~9.5%. In the urban context, slopes below 2% are considered flat and no sensible impacts on walk appeal, and slopes above 8.3% (1:12) are considered ADA inaccessible. Thus Campus Drive slope map is classified into 3 levels: 0 - 2.5% is considered as flat and assigned with 2 points; 2.5% - 8.3% is assigned with 1 point; 8.3% - 9.5% is assigned with 0 point due to ADA incompatible.

Pedestrian facilities’ completeness on Campus Drive segments (F) is classified into 6

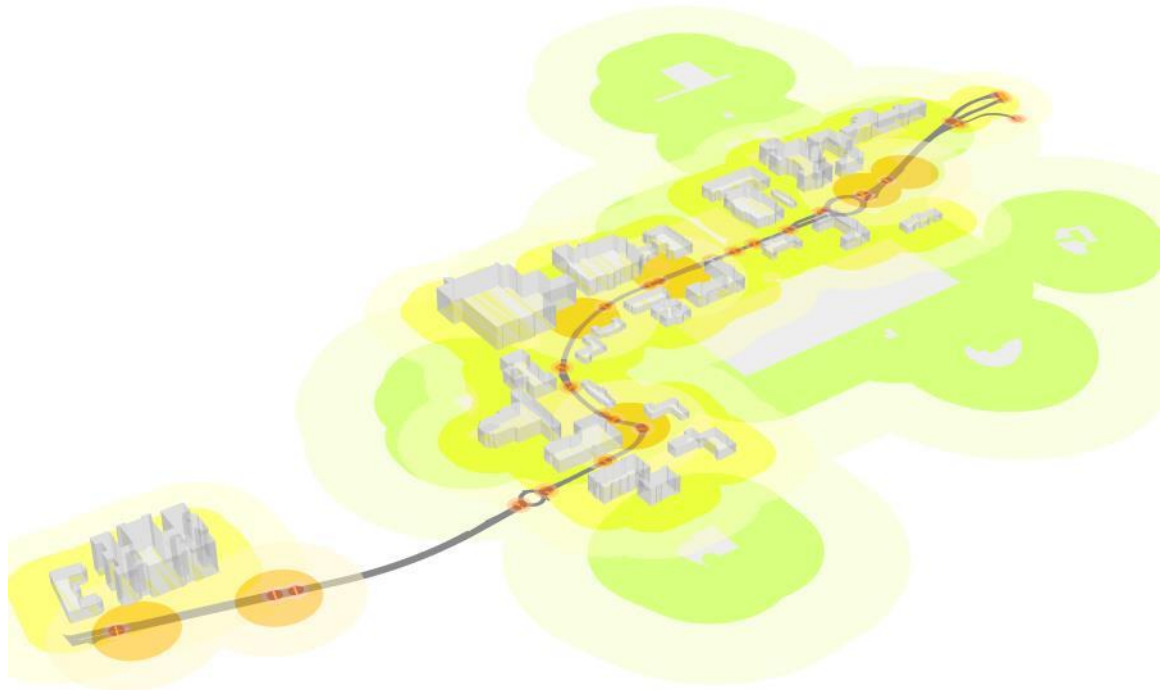
categories falling into 3 groups: Sidewalk on both sides with/ without buffer, Sidewalk on one side with/without buffer, and no sidewalks / vehicle lane intersections. The 3 groups contribute 2, 1 and 0 points respectively.

The Overall Completeness Assessment Map is generated from calculations involving all factors listed above, and the resulting values (C) are given by the formula below:

$$C = (F + S) * 5 / 2 + I + Ps + X + ABR$$

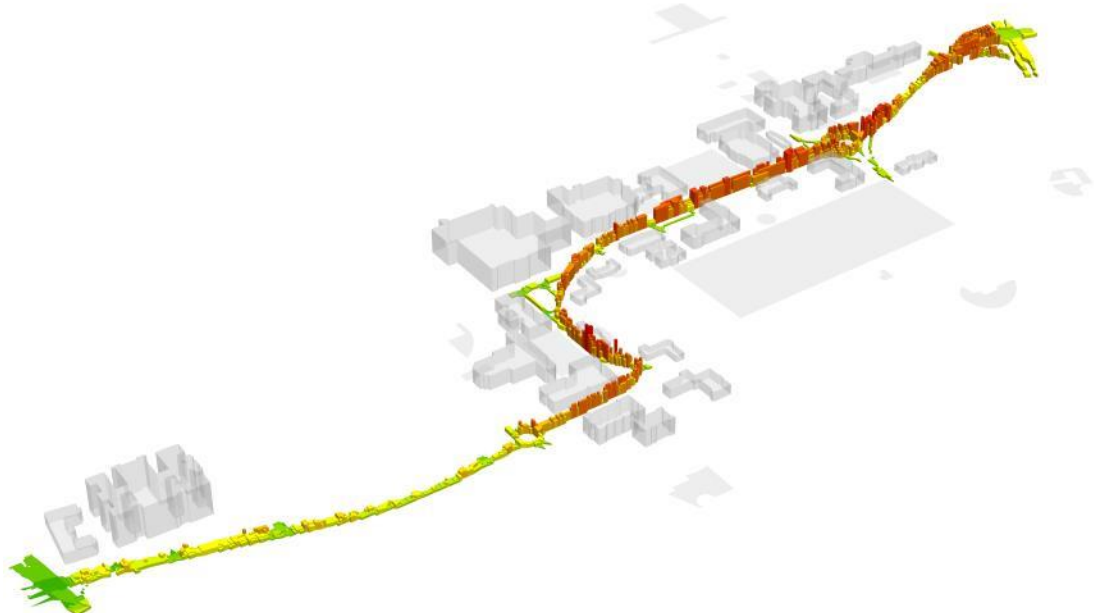
Factors are weighted according to their impacts. (See Illustration 85)

#### 4.2.6.2 Composite Connectivity Indices



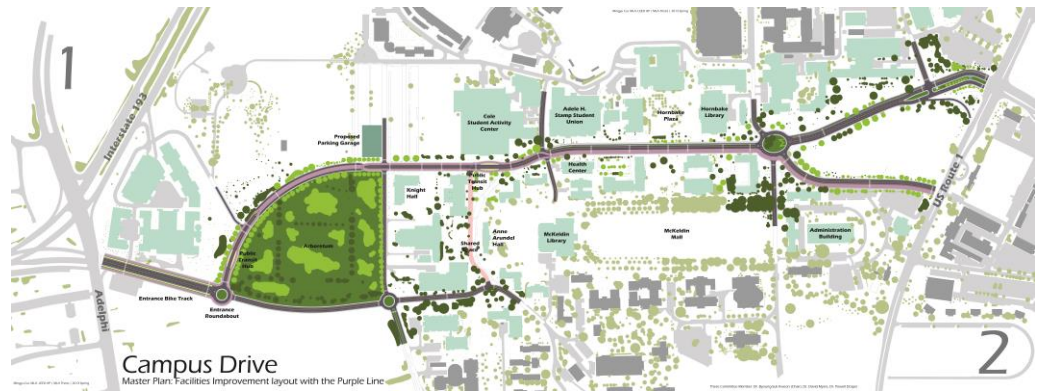
**Illustration 83 Campus Drive Composite Connectivity Indices.**

### 4.2.6.3 Overall Facility Completeness Assessment



**Illustration 84 Campus Drive overall facility completeness assessment.**

### 4.3 Master Plan



**Illustration 85 Campus Drive improvement master plan.**

## Chapter 5: Summary and Conclusion

### 5.1 Summary and Implications

The goal of this thesis has been to apply Complete Streets principles and practices to a case study: University of Maryland main Campus Drive. Chapter 1 provided an overview of Context-Sensitive Solutions and Complete Streets literature. Theories and principles about Context-Sensitive Solutions were studied and utilized to inform this project, due to the limited scope of literature specifically related to university campus transportation facility improvements. Several Complete Streets practices at municipal scales have been documented as case studies to provide precedent ideas that might be applicable to this project. Chapter 2 inventoried campus roadway facilities using both GIS data offered by campus Facility Management and on-site investigation.

Using the literature review, case studies, and the campus roadway facility inventory, Chapter 3 documents the development of a Campus Complete Streets Code. The Campus Complete Streets Code is designed to provide a framework and guidance to future campus roadway facility managers to create design improvements. As an application of examples of the developed Campus Complete Streets Code, Campus Drive was used as a case study in the final part of the thesis. Roadway segments were analyzed and assessed based whether on the completeness of facilities found in the segments. Transportation infrastructure elements were then added if those elements were missing from the current roadway. Then complete street elements were then adapted to the segments using site sub-context and the guidelines of the code. An improved master plan of Campus Drive

was developed to illustrate the layout of roadway facilities incorporating the Purple Line. The Campus Complete Streets Code is a guideline and a framework for transportation designers and planners to help guide future campus roadway improvements towards Complete Streets. The modular and assembling design approach it provides will help to improve the integrity and efficiency of roadway improvement projects. With the suggested mandatory requirement that the complete street element improvements respond to the local conditions of the site, the Campus Complete Streets Code enables transportation designers and planners to better design and plan the road to fit the site context.

## 5.2 Future Suggested Research

This project leaves several open ends for future study, due to the limitation of information and data collected. Considering transportation engineering factors involved in intersection and roundabout design, this project is mainly focusing on linear segments of roadway facilities. Although the designs in several proposed Campus Complete Streets Code have touched upon intersections and roundabouts, more in-depth and systematic research and design explorations should be developed in future studies to expand the coverage of the CCS Code to other applications. Typologies, construction details and display designs of green infrastructures are not covered in this project, which could also become a design project in future studies.

Parking lots, especially on-street parking and parking lanes, are not discussed from a demand perspective in this thesis. Although some certain forms of parking facilities could

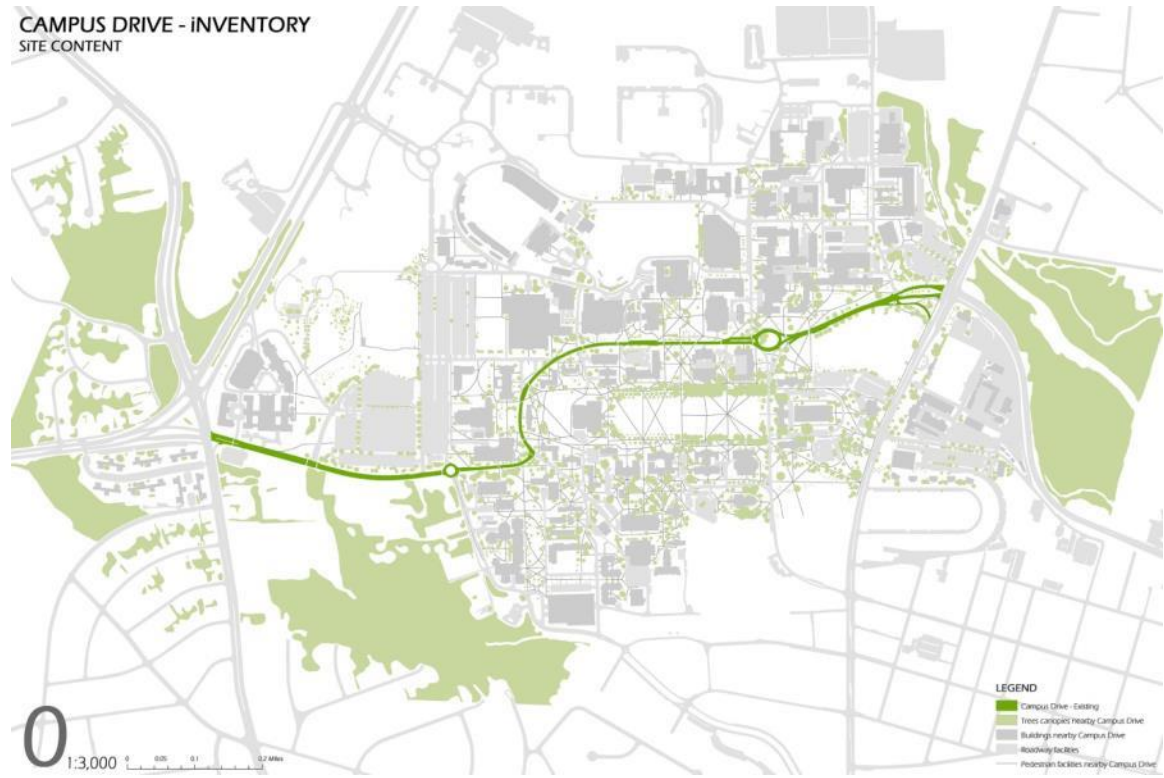
directly or indirectly contribute to achieving some of the objectives of the CCS Code, this topic was intentionally avoided under the for the purpose of reducing driving on campus. In order to improve the applicability of the Code in similar projects in other university campuses, discussion on parking facilities is inevitable.

Little study and research have been done on the evaluation and assessment of Complete Streets practices in university campuses. Benefit assessment, performance evaluations, and case studies on relevant improvements (i.e., campus biking program, as commonly seen) could convince transportation researcher, planners and designers of the necessity to improving university campus roadway segments towards Complete Streets. University branding is also a field that may be of future research. Transportation and institutional issues in the university campuses are tightly connected. Thus brand concept mapping and city branding (Brandt and Mortanges, 2010) of a university town is an excellent area for future study to explore how university campus roadway systems impact university branding.

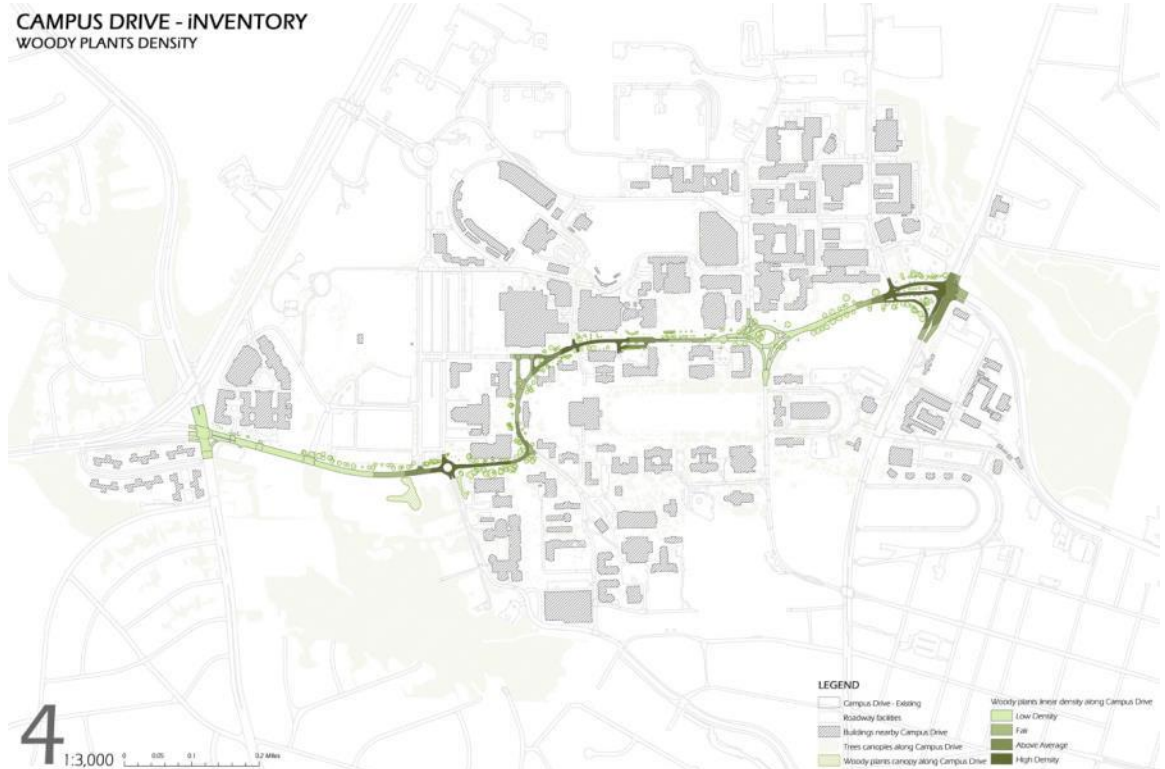
### 5.3 Conclusion

In summary, improvements on campus roadway facilities are systematic, important and needed. Roadway design practice should be performed as both a network planning process and a segment level design exercise. The literature review reveals the tools and ideas for improving campus roadways to better serve multimodal transportation users. The proposed Campus Complete Streets Code in this research design thesis is a modular approach which provides not only better transportation facilities, but also a more unified streetscape throughout the University of Maryland campus.

# Appendix 1 Campus Drive Roadway Facility Analysis Quantitative Graphics



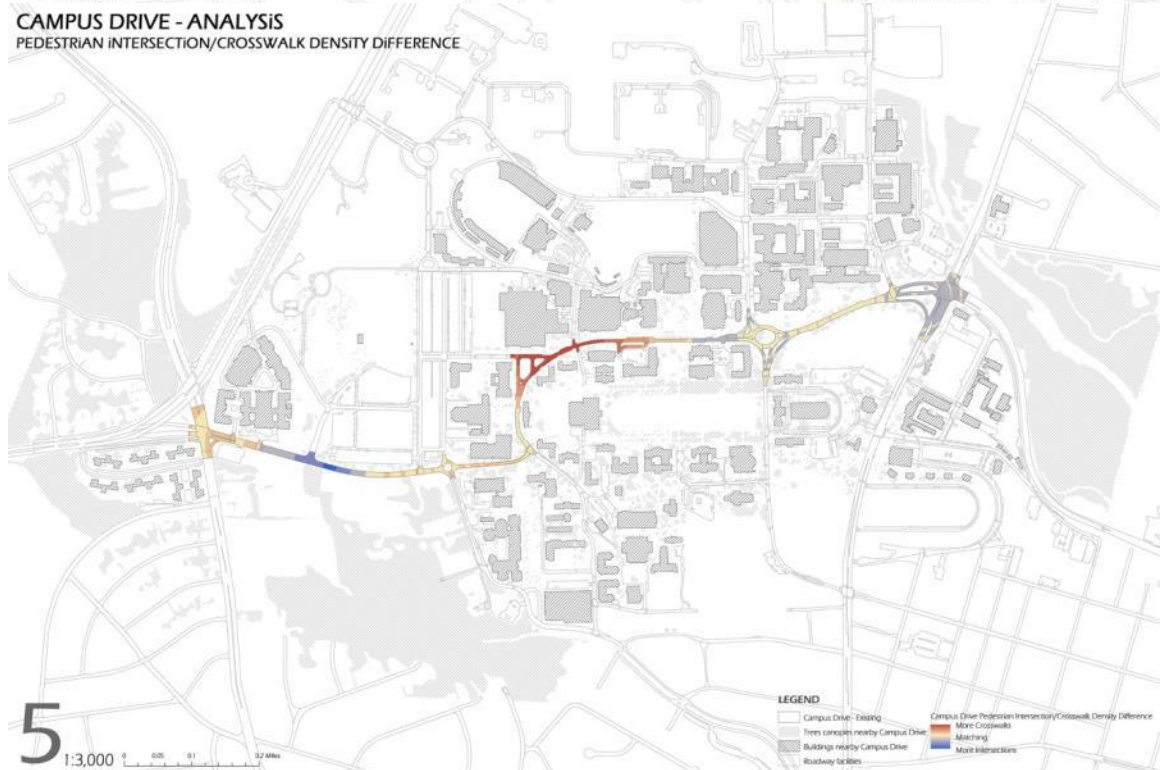
**CAMPUS DRIVE - INVENTORY**  
WOODY PLANTS DENSITY



4

1:3,000 0 0.05 0.1 0.2 Miles

**CAMPUS DRIVE - ANALYSIS**  
PEDESTRIAN INTERSECTION/CROSSWALK DENSITY DIFFERENCE

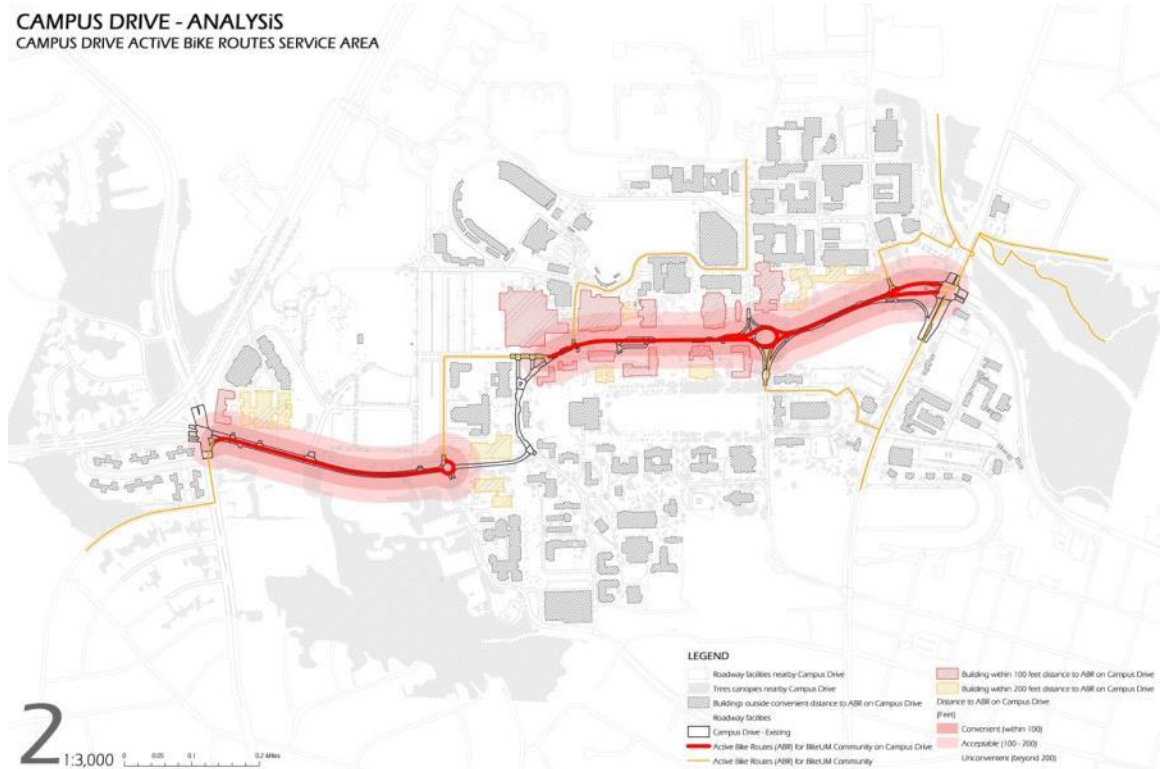


5

1:3,000 0 0.05 0.1 0.2 Miles



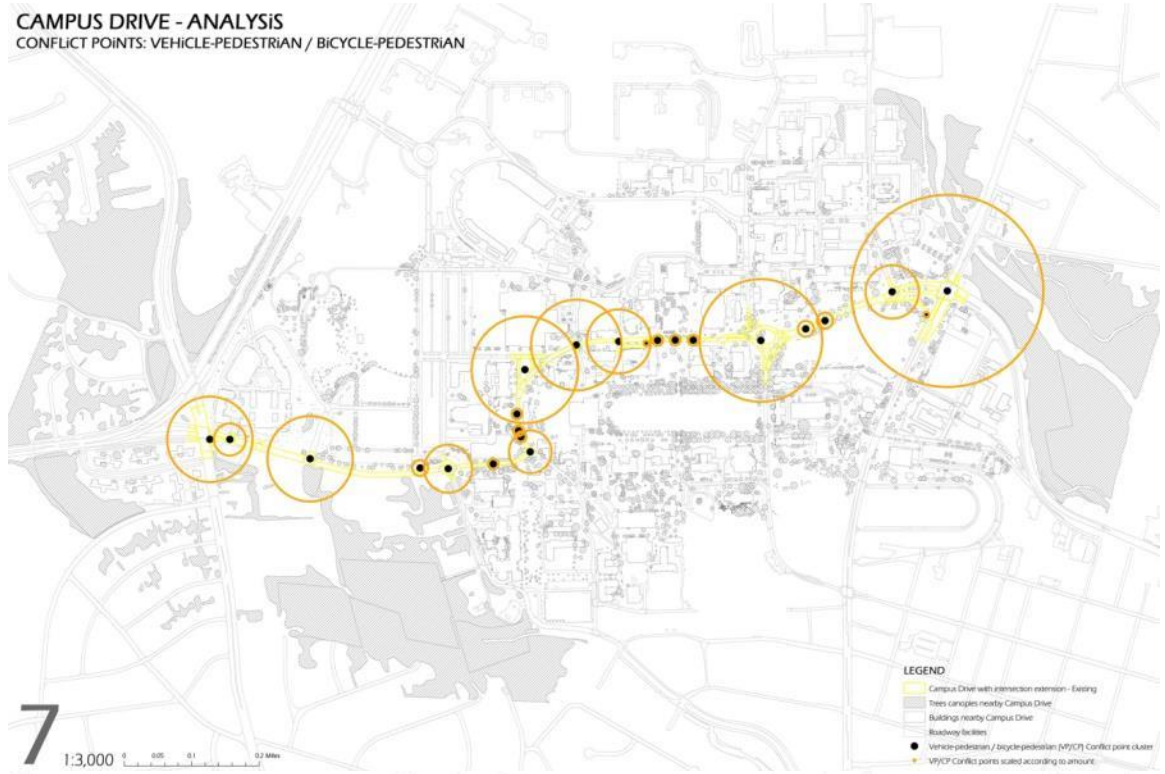
**CAMPUS DRIVE - ANALYSIS**  
**CAMPUS DRIVE ACTIVE BIKE ROUTES SERVICE AREA**



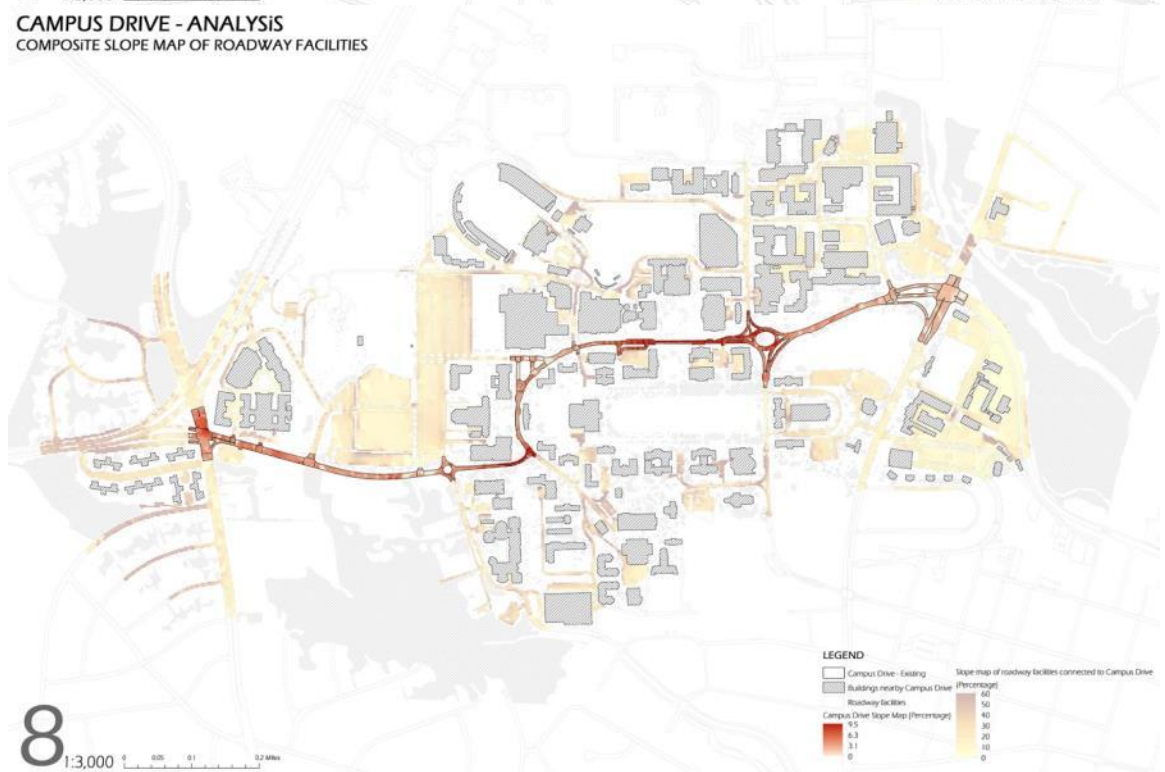
**CAMPUS DRIVE - ANALYSIS**  
**CONFLICT POINTS: VEHICLE-VEHICLE / VEHICLE-BICYCLE**



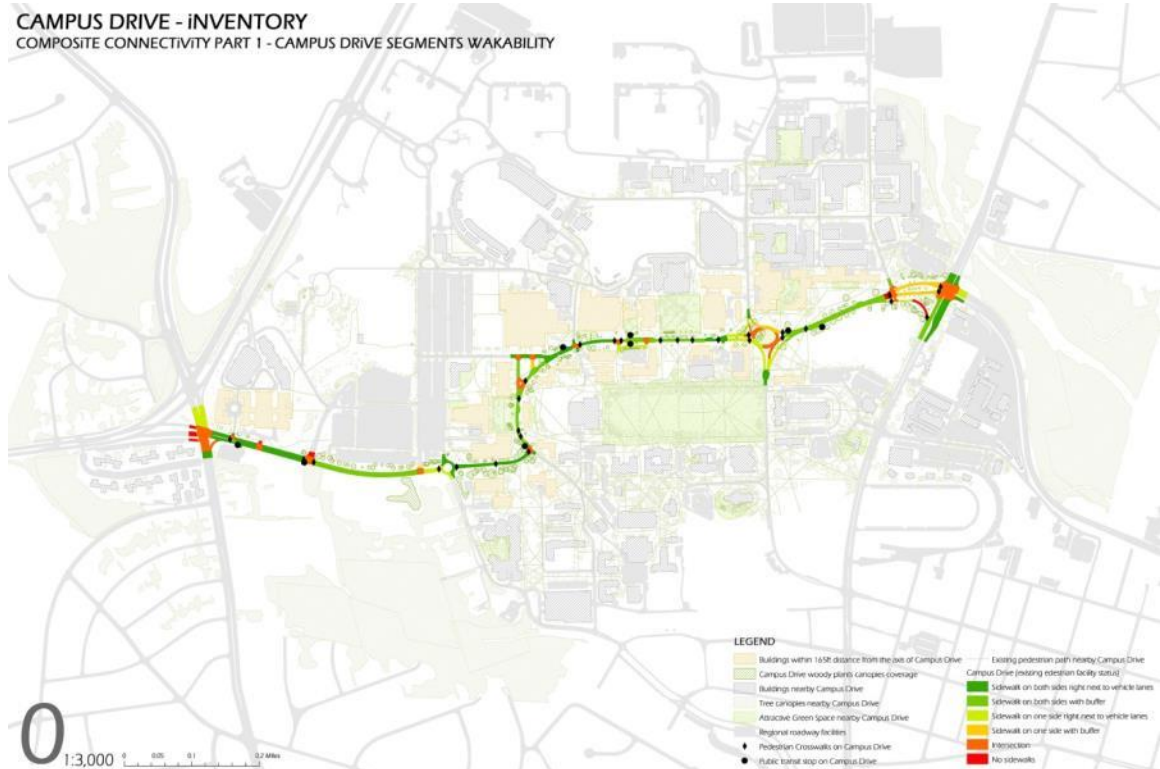
**CAMPUS DRIVE - ANALYSIS**  
 CONFLICT POINTS: VEHICLE-PEDESTRIAN / BICYCLE-PEDESTRIAN



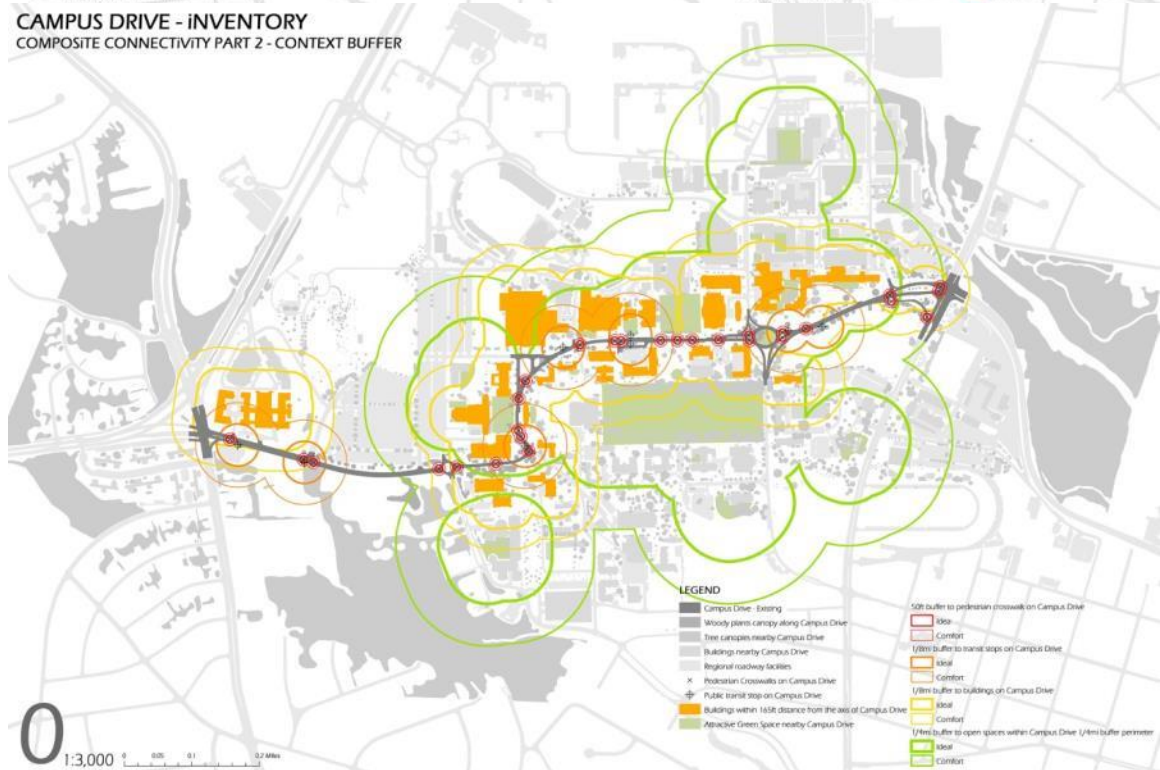
**CAMPUS DRIVE - ANALYSIS**  
 COMPOSITE SLOPE MAP OF ROADWAY FACILITIES



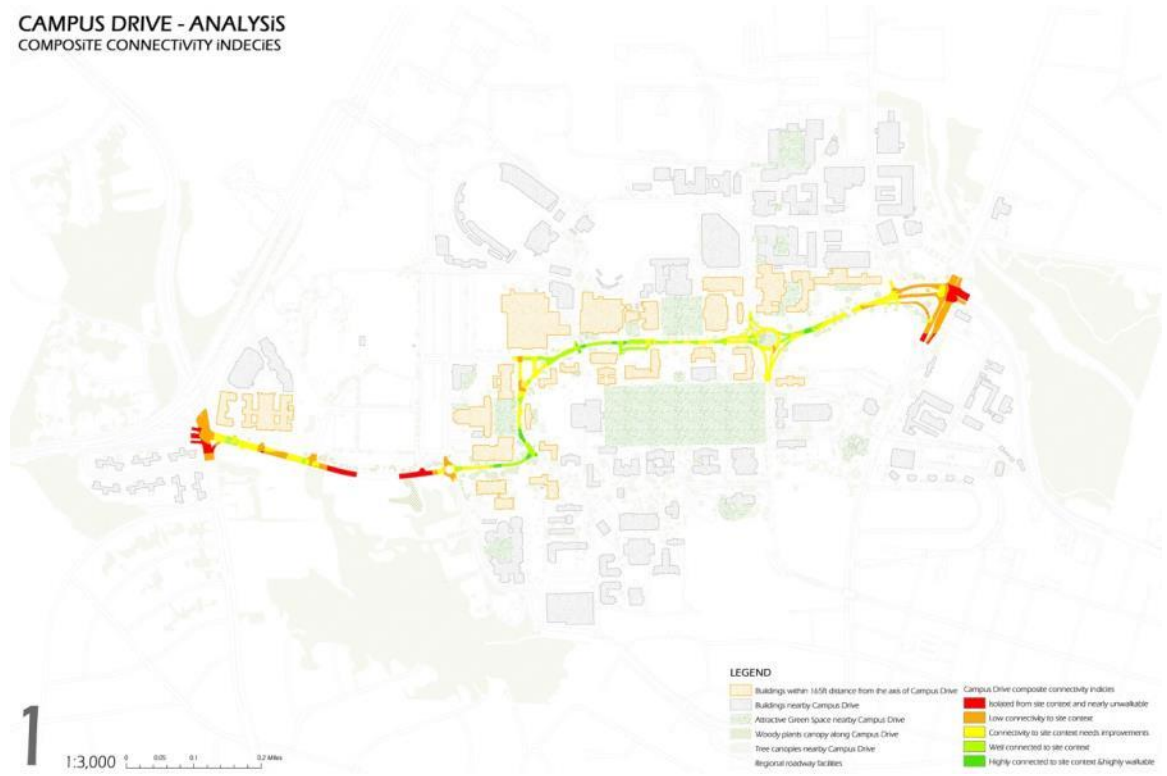
**CAMPUS DRIVE - INVENTORY**  
 COMPOSITE CONNECTIVITY PART 1 - CAMPUS DRIVE SEGMENTS WALKABILITY



**CAMPUS DRIVE - INVENTORY**  
 COMPOSITE CONNECTIVITY PART 2 - CONTEXT BUFFER



**CAMPUS DRIVE - ANALYSIS**  
**COMPOSITE CONNECTIVITY INDECIES**



# Appendix 2 Campus Complete Street Code Illustration Graphics

## CAMPUS COMPLETE STREETS CODE

The 2-step improvements are designed to implement 3 objectives of Complete Streets principles color-coded and listed below:

### Mitigating Right-of-Way Conflicts



- Pedestrian
- ADA Accessibility
- Public Transit User
- Cyclist
- Public Transit
- Traffic Calming Measures
- Emergency Vehicle

### Improving User Experiences



- Attracting Landscape Elements
- Recreational Features
- Social and Gathering Place
- Direction and Way Finding
- Illumination
- Parking and On-street Parking

### Achieve Institutional Functions



- Vegetation and Tree Canopy
- Infiltration Facilities
- Stormwater Management Facilities
- Student Involvement Programs

For "IMPROVEMENT: Landscape Elements" Part,

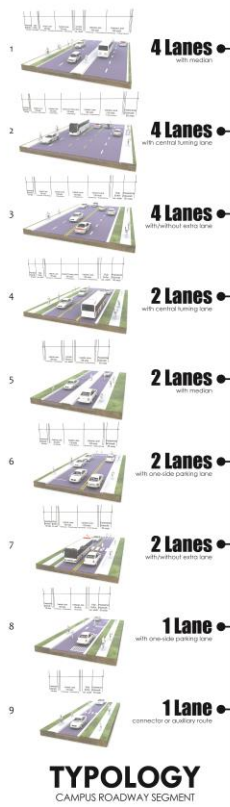
Colored dots represent applicability of improvement in a column to segment typology in corresponding row. Multiple dots indicate installation will result in achieving more than one objective.



Practice on improving campus roadway towards Complete Streets is performed under the Framework of campus Facility Master Plan. It addresses non-isolated road users Right-of-Way, with minimum attention on vehicular traffic facilities. Thus campus roadway segments are categorized based on vehicle facility.

### COLOR CODE

& Illustration of the CCS Code



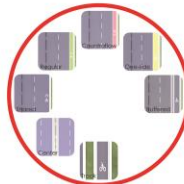
### Traffic Signal Lights

- Accommodate pedestrian safety on busy traffic streets
- Gradually slow down traffic before entering campus
- Provide clear entrance
- Reduce traffic volume in urban street



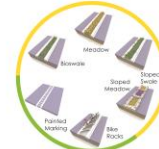
### ADA Accessibility

- Accommodate consistent and complete ADA Access



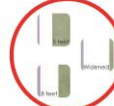
### Bike Lane & Bike Track

- On campus Active Bike Routes (ABR)
- One-side Right-of-Way
- Right-of-Way with recreation



### Buffer

- Center / bike track / pedestrian sidewalk
- Power lines and overhead wires
- Better stormwater management
- Provide greenery / tree facilities
- Discourage pedestrians from crossing street boundaries

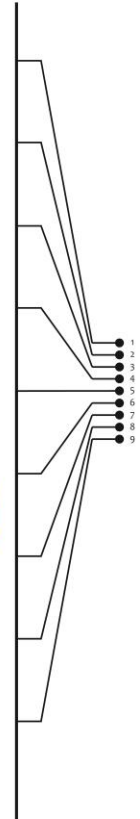


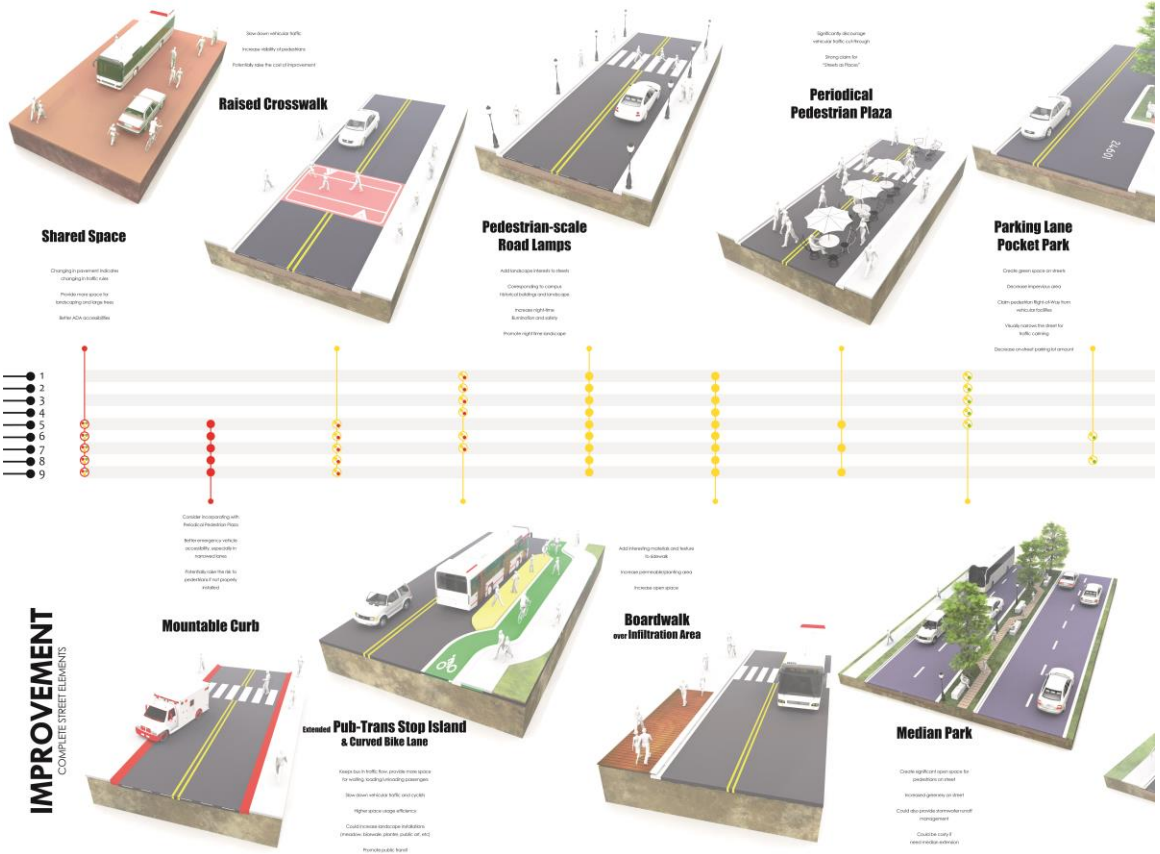
### Pedestrian Sidewalk

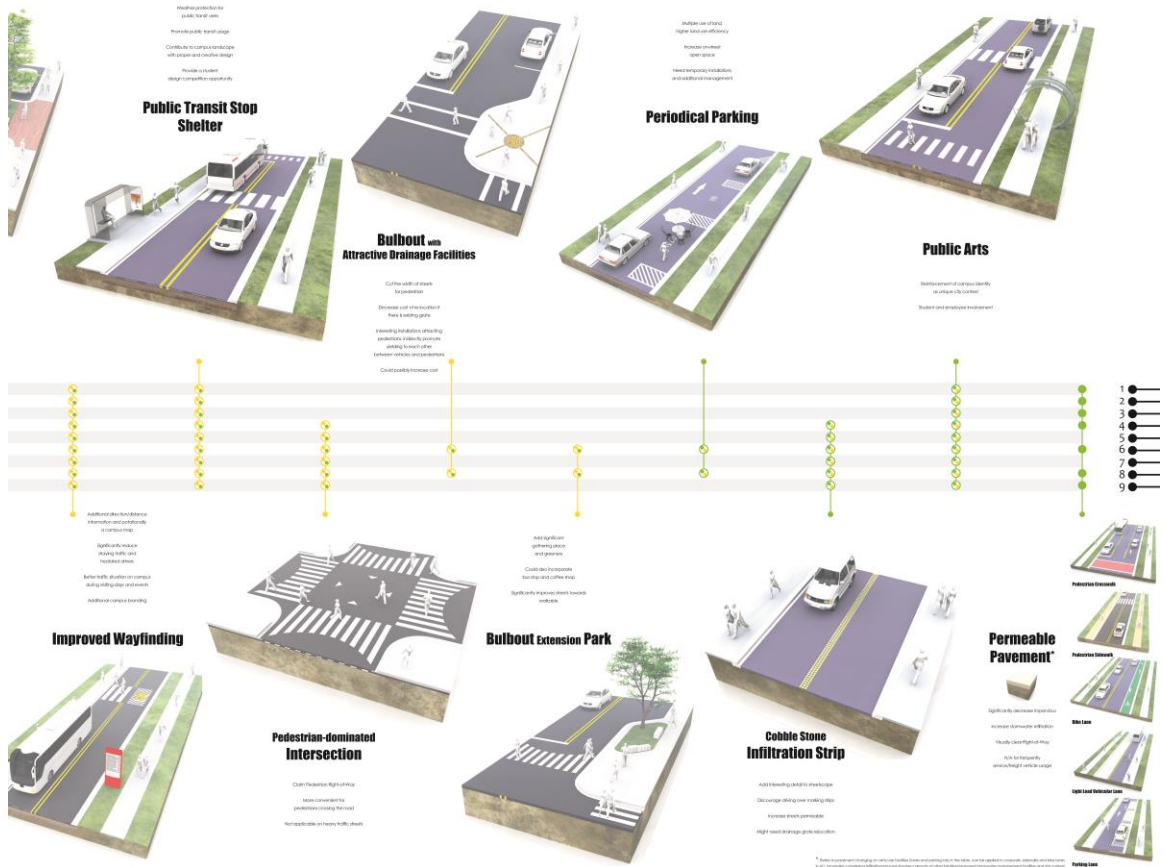
- 5 feet / 6 feet / wider road boulevard
- Provide ADA-compliant pavement

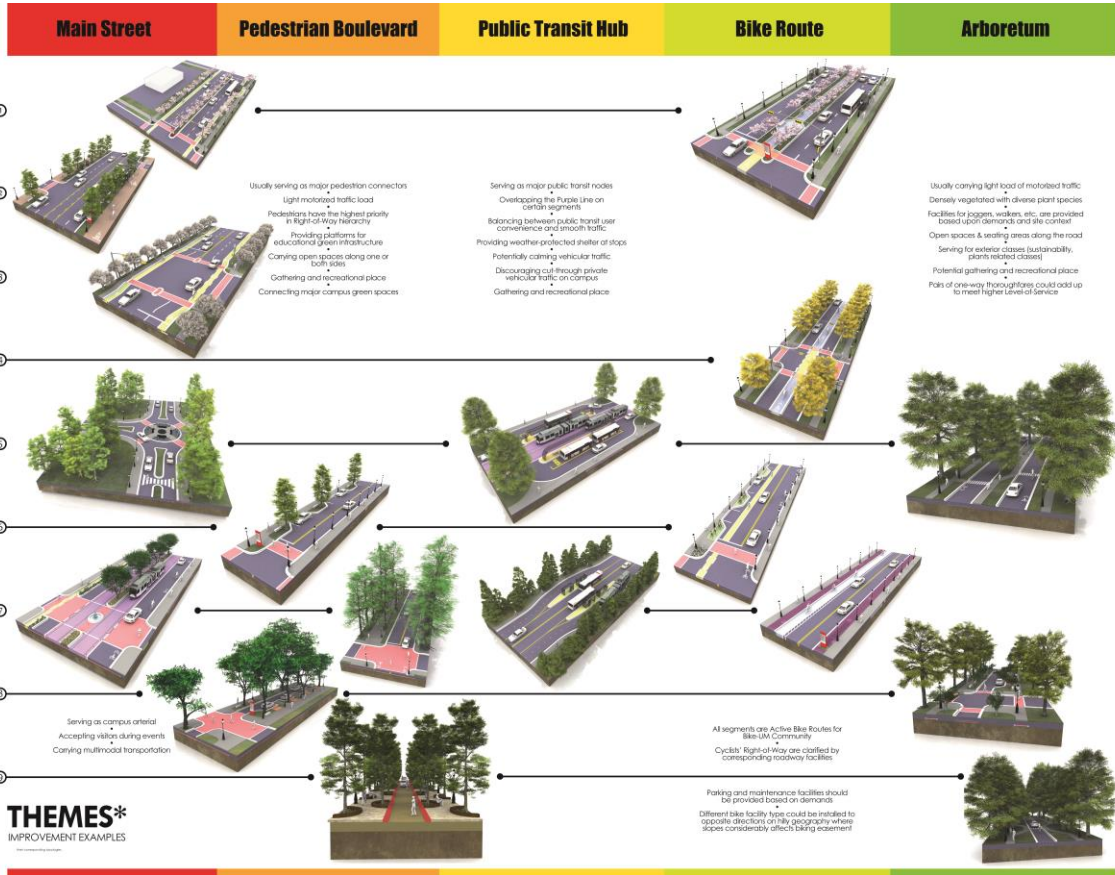
### IMPROVEMENT

TRANSPORTATION INFRASTRUCTURE











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