STOP AND SIGNALIZED INTERSECTION DESIGN VEHICLE GUIDANCE

BURLINGTON, VERMONT
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Stantec

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INTRODUCTION

The City of Burlington is committed to the creation of a multi-modal transportation network with streets designed for slow traffic to protect pedestrians and bicyclists while still meeting the vehicular mobility needs of a vibrant downtown. Achieving this balance is an objective stated in the Safe Streets Design Principles of the Plan *BTV Walk Bike Master Plan.*

> *"Streets should allow people to travel in a safe, dignified, and efficient manner no matter their age, gender or level of ability. Though the focus of this plan is on improving conditions for walking and biking, recommendations must also consider the needs of people driving. Streets must allow for harmony between multiple modes - allowing for safe and efficient movement of trucks, public transit, and emergency response vehicles."*

The City of Burlington *Great Streets* and *Traffic Calming Guidance* documents design considerations for pedestrians and bicyclists. Potential treatments improving conditions for walking and biking may mean making traditional signal or stop controlled intersections as compact as possible or replacing them with modern roundabouts. For traditional intersections, compact configurations with narrow lanes, curb extensions, and tight curb radii, minimize pedestrian crossing distances and help slow vehicular traffic. Improving the efficient movement of vehicles, however, often means building larger intersections with wide lanes and large curb radii. This guidance document is intended to help designers achieve the balance between accommodating vehicular traffic and non-vehicular traffic desired by the City of Burlington at traditional intersections.

APPLICATION

This guidance should be followed by engineers when redesigning traditional signal or stop controlled intersections or designing new traditional intersections in downtown Burlington and adjacent neighborhoods. The guidance should also be applied by designers to temporary conditions such as detours associated with roadway construction or Burlington Quick-Build projects. The guidance is generally intended to ensure that intersection improvements made to better accommodate pedestrians and bicyclists do not result in designs that are too restrictive for vehicular movements. The guidance is not intended to prescribe the enlargement of intersections to better accommodate existing vehicular traffic. The scope of the guidance is limited to traditional intersection layout and is intended to be used after that alternative has been selected through the scoping process. Other City guidelines and policies apply to design elements such as the number of lanes proposed, traffic controls, and materials. The limitations of this guidance are not intended to encourage the selection of traditional intersections over alternative treatments, such as roundabouts. Such alternatives will be considered during the project scoping process. For modern roundabouts, designers shall consult with the Department of Public Works to identify the preferred design guidance.

DESIGN VEHICLE CONCEPT

This design vehicle concept is described in A Policy on Geometric Design of Highways and Streets published by the American Association of State Highway and Transportation Officials (AASHTO)[1] and other documents reviewed in developing this guidance[2]. A Policy on Geometric Design of Highways and Streets, also known as the AASHTO Green Book states:

"Key controls in geometric highway design are the physical characteristics and the proportions of vehicles of various sizes using the highway. Therefore, it is appropriate to examine all vehicle types, establish general class groupings, and select vehicles of representative size within each class for design use. These selected vehicles…are known as design vehicles."

The Green Book goes on to say:

"In the design of any highway facility, the designer should consider the largest design vehicle likely to use that facility with considerable frequency or a design vehicle with special characteristics appropriate to a particular intersection in determining the design of such critical features as radii at intersections…"

The Green Book also provides detailed information regarding the dimensional and operating characteristics of various vehicle types, such as turning paths. However, it points out that the type of vehicles that will be accommodated and the manner in which they are accommodated may be determined based on the vehicular and pedestrian traffic demands at an intersection. For example, where significant pedestrian demands should be accommodated, a more compact design may be realized by assuming that the occasional large truck using the intersection may swing wide, "encroaching on other traffic lanes without disrupting traffic significantly".

This guidance document adheres to the design vehicle concept and includes specific guidance on its application in the City of Burlington. It provides guidance for:

- The selection of the design vehicle or vehicles depending on the vehicle mix at the subject intersection;
- The appropriate accommodation of each design vehicle; and,
- The accommodation of emergency vehicles.

In doing so, it helps define imprecise terms from the AASHTO Green Book design vehicle policy. Specifically, it indicates volume thresholds that should be applied when determining if a particular class of vehicle uses an intersection with "considerable frequency". The volume thresholds in combination with operational criteria indicate when lane encroachment constitutes "disrupting traffic significantly".

1 A policy on Geometric Design of Highways and Streets, American Association of State Highway and Transportation Officials, Washington, DC, 2004.
2 See "Additional References" section for other sources consulted.

DESIGN PROCESS OVERVIEW

The design guidance should be implemented in a three-step process. First, design traffic volumes for the subject intersection should be determined. The volume data will indicate the least maneuverable class of vehicles that uses or is expected to use the intersection routinely or with "considerable frequency." Next, a design vehicle is selected to represent this vehicle class, typically the largest or least maneuverable vehicle in that class. In the final step, the turning path of the design vehicle is applied to determine the intersection configuration, typically corner radii, lane widths, stop bar locations, and on-street parking restrictions proximate to the intersection. These steps are described in greater detail below along with some of the terms used in this guidance document.

STEP 1: DESIGN TRAFFIC VOLUMES

Step 1 is to determine design volumes for the subject intersection. Ideally, turning movement diagrams for the intersection will be developed showing vehicle turning movements by vehicle class for a peak hour and for a twelve-hour period. Examples of such diagrams, based on data collected in Burlington by the Vermont Agency of Transportation (VTrans), are shown in Appendix A. The vehicle classes are groupings of similar vehicle types. The vehicular volumes by group should be determined through a traffic count program.

Vehicle Types

The many types of vehicles operating on our roadways range in size and maneuverability. Vehicle types or vehicle classifications are listed in the AASHTO Green Book. Listed vehicle types range in size from passenger cars (P) to semitrailers with a 62-foot wheelbase (WB-62). The National Association of City Transportation Officials (NACTO) lists two additional vehicle types, delivery vehicles and recycle trucks in its Urban Street Design Guide.[1] The Burlington Fire Department also provides dimensional and performance data for its representative emergency vehicles, the Tower Truck and Tanker/Pumper Truck. These vehicle types are organized into groups in this guidance document.

Vehicle Groups

Vehicle types of comparable size and maneuverability are combined into four vehicle groups: Small Vehicles; Intermediate Vehicles; Large Vehicles; and Very Large Vehicles. A fifth group applies to emergency vehicles, or more specifically, fire apparatus. These groupings, shown in Table 1, help limit the number of vehicle types to consider when selecting a design vehicle and simplify the data collection process when traffic counts are conducted

1 https://nacto.org/publication/urban-street-design-guide/design-controls/design-vehicle/

TABLE 1. VEHICLE TYPES AND GROUPINGS

GROUP 1: SMALL VEHICLES

PASSENGER CAR - P

GROUP 2: INTERMEDIATE VEHICLES

DELIVERY VEHICLE - DL23
CAR AND BOAT TRAILER - P/B

GROUP 3: LARGE VEHICLES

SINGLE UNIT TRICK - SU30
INTERCITY/COACH BUS
SCHOOL BUS
CITY TRANSIT BUS
SEMITRAILER - WB-40
MOTOR HOME - MH
CAR AND CAMPER TRAILER - P/T
RECYCLE TRUCK

GROUP 4: VERY LARGE VEHICLES

SEMITRAILER - WB - 50
SEMITRAILER - WB - 62
MOTOR HOME AND BOAT TRAILER - MH/B

GROUP 5: FIRE APPARATUS

TANKER/PUMPER TRUCK
TOWER TRUCK

Note: Letter/Number combinations following the vehicle names relate to design vehicle codes used by the American Association of State Highway and Transportation Officials (AASHTO) and/or the National Association of City Transportation Officials (NACTO). The numbers typically refer to the vehicle's wheelbase length.

Traffic Count Data

This guidance promotes a data-driven approach, whereby vehicle turning movement counts should first be done to establish existing peak hour and 12-hour travel demands at the subject intersection. Existing traffic count data can be used to determine traffic conditions provided that the data is no more than five-years-old upon commencement of the design process. The use of older data may be allowed by the City on a case-by-case basis. If a new count is conducted, the procedures described in Appendix B should be followed. New counts should record vehicles by the groupings cited above.

Traffic Volume Estimates

The requirement to conduct new counts may be waived when the City determines that there is sufficient data available to estimate traffic demands with reasonable accuracy. For example, consideration of older data may be allowed if the City determines that traffic conditions at the intersection have not changed significantly since the older count was completed. Likewise, volumes for a nearby intersection may be substituted if the City deems that the nearby intersection exhibits similar traffic conditions as the subject intersection. Roadway functional classifications may aid in identifying comparable intersections as the classifications are typically indicative of the mix of traffic using the roadway. A discussion of roadway classifications and classifications applied to Burlington Streets is included in Appendix C.

Design Volumes

It may be necessary to adjust the existing condition volumes to reflect design conditions. Design conditions may be representative of a future year reflecting anticipated future traffic growth, new land development proposals, and/or planned roadway system changes. Unless waived by the City, current policies, master plans, and future development proposals should be considered when developing design volumes, as major land-use changes can influence traffic patterns. Likewise, transportation system improvement projects, including maintenance projects that may temporarily change traffic patterns, should be considered. Appendix D provides a checklist of documents for review considered in identifying projects or policies that could impact future traffic patterns. The designer should consult with the Department of Public Works to determine appropriate adjustments to the existing traffic conditions.

STEP 2: DESIGN VEHICLE SELECTION

In Step 2, the design vehicle (or vehicles) for the intersection is selected. The choice of design vehicle(s) depends on the design volume data and the need to accommodate fire apparatus at all intersections. The selected design vehicle will typically be the design vehicle for the least maneuverable group of vehicles that uses or is expected to use, the intersection *with considerable frequency*, or the design vehicle for Group 5, Fire Apparatus. Group 5 vehicles are not expected to use any intersections with considerable frequency, however, per the direction of Burlington DPW, they must be accommodated at all locations for public safety reasons.

Design Vehicles

One vehicle type from each of the five groups listed in Table 1 represents the group as a potential design vehicle. The potential design vehicle is the least maneuverable vehicle type in each group. These design vehicles are listed below.

- Group 1/Small Vehicles: Passenger Cars (P);
- Group 2/Intermediate Vehicles: Delivery Vehicle (DL);
- Group 3/Large Vehicles: Single Unit Truck (SU30);
- Group 4/Very Large Vehicles: Semi-Trailer (WB-50); and,
- Group 5/Fire Apparatus: Tower Truck

Travel paths or turning templates for design vehicles are used to lay out the intersection, described in Step 3 of this guidance.

Intersection Types

The above criteria lead to the definition of four intersection types listed in Table 2. As shown, two design vehicles should be considered for three of the four types of intersections. The two design vehicles include the fire apparatus design vehicle and the design vehicle for the least maneuverable group of vehicles at the intersection. Since the design vehicle for the Very Large Vehicles group is less maneuverable than the fire apparatus design vehicle only the design vehicle for the Very Large Vehicles group needs to be considered for this intersection type.

TABLE 2. INTERSECTION TYPES

LEAST MANEUVERABLE VEHICLE GROUP OCCURRING WITH CONSIDERABLE FREQUENCY	INTERSECTION TYPE	DESIGN VEHICLE(S)
Group 1: Small Vehicles	A	**Passenger Car** Tower Truck
Group 2: Intermediate Vehicles	B	**Delivery Vehicle** Tower Truck
Group 3: Large Vehicles	C	**Single Unit Truck** Tower Truck
Group 4: Very Large Vehicles	D	**Semi-Trailer (WB-50)**

Note: The design vehicle listed in bold text represents the least maneuverable vehicle group occurring with considerable frequency at the intersection.

Considerable Frequency

The term "considerable frequency" is used in the Green Book to define routine use of an intersection by a particular vehicle type or group. Frequency of use is considered to avoid constructing unnecessarily large intersections. It recognizes that large vehicles may be challenged when negotiating a compact intersection and then disrupt traffic operations while maneuvering through the intersection and/or waiting for other vehicles to clear a path. Such disruption may be tolerated on an infrequent basis and that a high level of tolerance can lead to a more compact design. The Green Book does not quantify the term "considerable frequency." Roadway and highway jurisdictions can choose their own volume thresholds based on their tolerance for disrupted traffic operations relative to their desire to build compact, pedestrian-friendly intersections.

In developing this design guidance, the Burlington DPW has adopted the following traffic volume thresholds to define "considerable frequency."

- Four or more vehicles per peak hour for a group; or
- 12 or more vehicles per 12 hours for a group

These thresholds should be compared to the Design Volumes defined above to determine the intersection type.

When evaluating the design volumes, left and right turning movements should be counted separate from through movements. Typically, even Very Large Vehicles can pass straight through an intersection without significantly disrupting traffic operations. Conflicts only occur when turning movements are attempted and the turning vehicle encroaches into opposing travel lanes. Consequently, through-vehicles can generally be ignored when determining if the above volume thresholds have been met.

However, the designer should confer with DPW before making this assumption. Any planned construction projects and associated detours could result in through movements becoming turning movements.

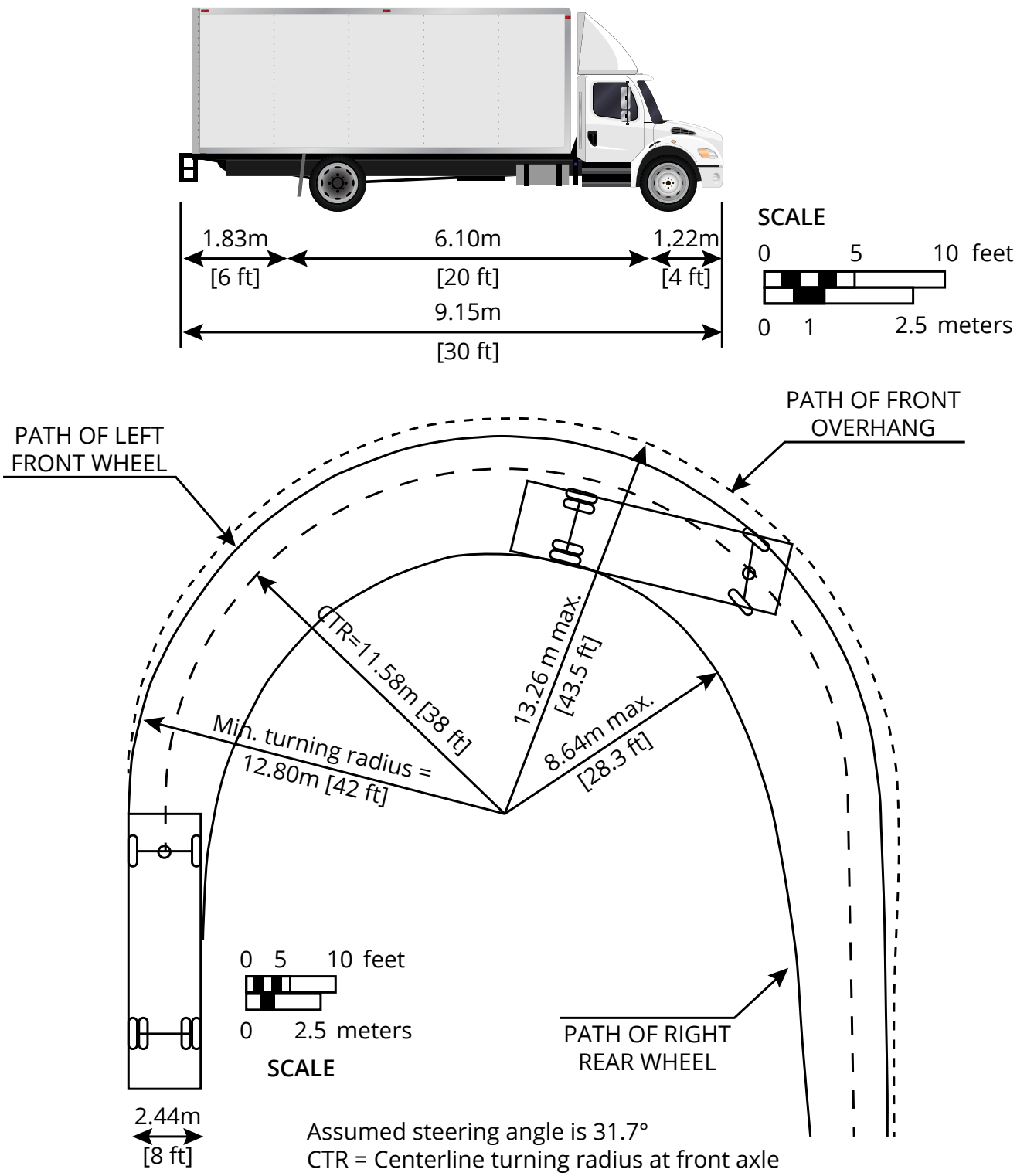
STEP 3: INTERSECTION LAYOUT

In Step 3, the intersection layout should be developed to represent the most compact configuration that accommodates the applicable design vehicle(s) for the intersection type. The manner in which the design vehicle is accommodated depends on several factors described below, including: the type of design vehicle; the level of congestion at the intersection; and the type of traffic control. Under certain conditions it should be assumed that the design vehicle will operate "between the lines," that is, the layout should not require the design vehicle to encroach into opposing travel lanes. In other cases, the design should assume that the design vehicle is permitted to encroach into opposing travel lanes but not encroach on curb lines or parking lanes. In rare cases, the Burlington DPW may also permit consideration of a design vehicle operating beyond the curb lines. In these cases, areas free of vertical obstructions would be designated behind the curb lines assuming that the design vehicle may mount the curb to complete a turning maneuver. In addition to keeping areas free of vertical obstructions, the design could include mountable elements such as slope curbing and truck aprons. The design vehicle considered in this case is referred to as a "control vehicle."

Minimum Vehicle Turning Paths

Minimum vehicle turning paths or turning templates are used to layout the intersection. They are a function of the vehicle's length, width, axle configuration, and turning radius. These dimensional data are provided in the AASHTO Green Book and reprinted in Appendix E. The Green Book also depicts the turning paths for each vehicle type. A representative turning template for a single unit truck (SU 30) is shown in Figure 1. These turning paths assume a travel speed of less than ten miles per hour. Vehicle turning paths have been translated into computer-aided design software such as AutoTurn. When applying the software, crawl speed (typically two miles per hour) turns should be assumed. Turning path templates for Burlington's fire apparatus are available from the Burlington DPW however, templates for the WB-40 design vehicle are comparable to the templates for the Fire Department's least maneuverable vehicle, the Tower Truck, and can be applied instead.

FIGURE 1. TYPICAL VEHICLE TURNING TEMPLATE

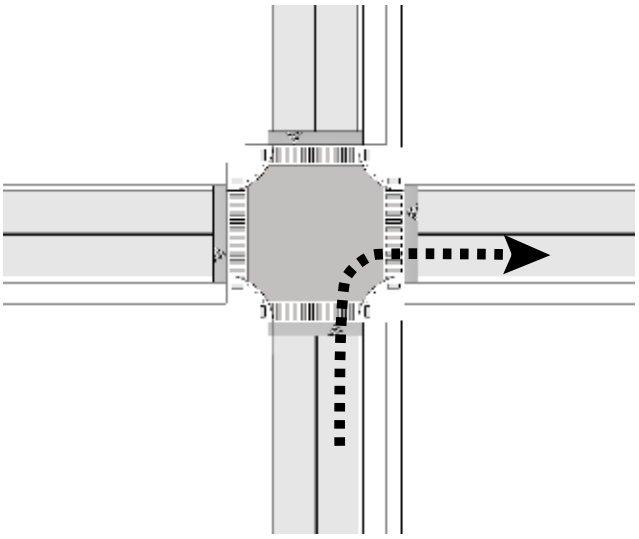


Adapted from: A Policy for the Geometric Design of Highways and Streets, American Association of State Highway Officials, 2008.

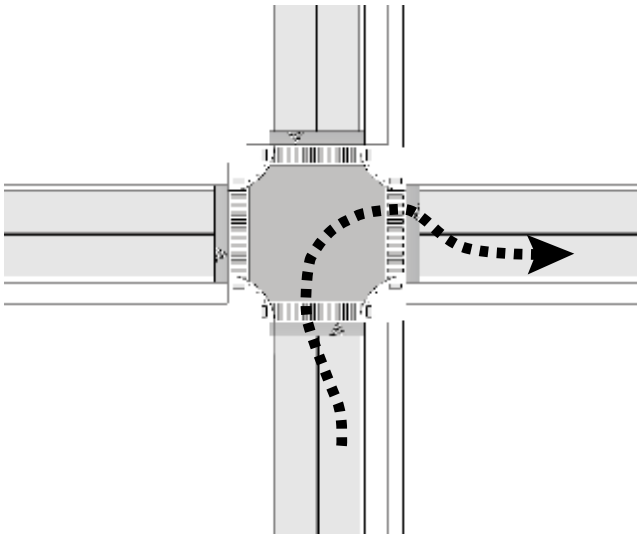
Encroachment

Encroachment relates to vehicles using adjacent, same direction travel lanes, or crossing into opposing direction travel lanes to execute a turn. Figure 2 illustrates examples of these types of encroachment. Encroachment is permissible in the design process when the design vehicle under consideration is the Group 5 - Fire Apparatus design vehicle. Traffic laws require motorists to yield to emergency vehicles so it can be assumed that other vehicles will clear a path allowing emergency vehicles to encroach upon other lanes. For other design vehicles, encroachment is not permissible unless the intersection is considered "uncongested." Consequently, intersection geometries will typically be defined using two types of design vehicles: "Design Vehicle A" which must operate "between the lines" or in its own lane, and "Design Vehicle B" which must operate "between the curbs" or with lane encroachments permitted. Table 3 distinguishes Design Vehicles A and B for the intersection types defined in Table 4 that are under signal control or congested as defined below.

FIGURE 2. TYPICAL ENCROACHMENT BY A DESIGN VEHICLE



No Encroachment
Approach in right hand lane.
Depart in full right hand lane.



Lane Encroachment
Approach into opposing flow,
depart into opposing flow.

TABLE 3. DESIGN VEHICLE BY INTERSECTION TYPE - CONGESTED OR SIGNAL CONTROLLED INTERSECTIONS

INTERSECTION TYPE	LEAST MANEUVERABLE VEHICLE GROUP OCCURRING WITH CONSIDERABLE FREQUENCY	DESIGN VEHICLE A *(NO LANE ENCROACHMENT PERMITTED)*	DESIGN VEHICLE B *(NO LANE ENCROACHMENT PERMITTED)*
A	Group 1: Small Vehicles	Passenger Car	Tower Truck
B	Group 2: Intermediate Vehicles	Delivery Vehicle	Tower Truck
C	Group 3: Large Vehicles	Single Unit Truck	Tower Truck
D	Group 4: Very Large Vehicles	Semi-Trailer (WB-50)	Not Applicable

"Congested" Intersections

Lane encroachment by a design vehicle may not disrupt traffic significantly if the intersection is uncongested. It is assumed that any intersection under traffic signal control is a congested intersection. Presumably, the signal was installed because the intersection would operate with excessive delays without a signal. Also, with signal control, vehicles stopped at a red light on a cross street would not be able to lawfully enter the intersection (except possibly on a right-on-red condition) to clear a path for a design vehicle turning from the intersecting street. Consequently, signalized intersections are considered "congested" intersections. A Stop sign controlled intersection may be considered congested if significant vehicle queuing on the street into which the design vehicle would be turning would prohibit lane encroachment. Significant vehicle queuing is defined by Burlington DPW as an average peak hour queue of three vehicles. Peak hour vehicle queues can be measured in the field or calculated through an intersection operations analysis. If calculated, procedures described in the latest edition of the *Highway Capacity Manual* or other method approved by the Burlington DPW should be followed.

If an intersection is deemed uncongested, then lane encroachment by the design vehicle for the least maneuverable vehicle group occurring with considerable frequency can be assumed when laying out the intersection. In these situations, another Design Vehicle A must be selected to help define the intersection geometry and, in particular, the location of lane lines and Stop bars. The next more maneuverable design vehicle should be selected. For example, if under "congested" conditions the Delivery Vehicle would be chosen as Design Vehicle A then the passenger car design vehicle should be used for a comparable "uncongested" intersection. Accordingly, an alternative design vehicle matrix would apply for uncongested intersections as shown in Table 5.

TABLE 4. DESIGN VEHICLE BY INTERSECTION TYPE - UNCONGESTED INTERSECTIONS

INTERSECTION TYPE	LEAST MANEUVERABLE VEHICLE GROUP OCCURRING WITH CONSIDERABLE FREQUENCY	DESIGN VEHICLE A *(NO LANE ENCROACHMENT PERMITTED)*	DESIGN VEHICLE B *(NO LANE ENCROACHMENT PERMITTED)*
A	Group 1: Small Vehicles	Passenger Car	Tower Truck
B	Group 2: Intermediate Vehicles	Passenger Car	Tower Truck
C	Group 3: Large Vehicles	Delivery Vehicle	Tower Truck
D	Group 4: Very Large Vehicles	Single Unit Truck	WB 50

Context-Sensitive Design - Control Vehicle

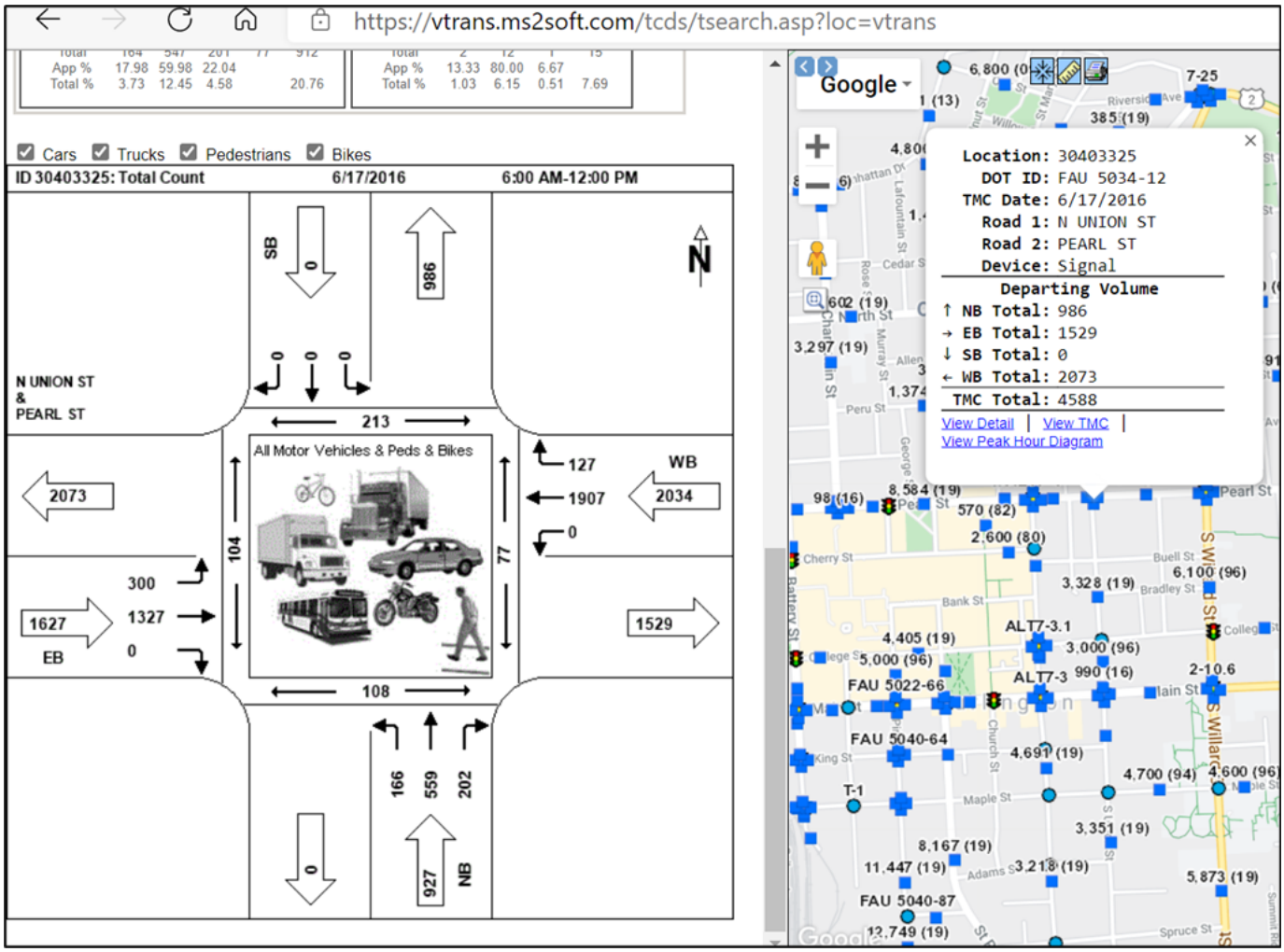
On a case-by-case basis, the Burlington DPW may choose to have a control vehicle considered in the design process to further promote compact intersection design where pedestrian activity is significant. This would apply to Type D intersections where the WB 50 design vehicle would instead be treated as a control vehicle. As noted above, when designing for a control vehicle, the intersection may include elements such as low or mountable curbs, truck aprons, and clear zones outside the roadway edges. These elements would allow the control vehicle to operate outside normal boundaries for vehicular movement. Similarly, for locations that on occasion accommodate the very largest vehicle types, the WB 62 vehicle type could be used as a control vehicle.

Final Design

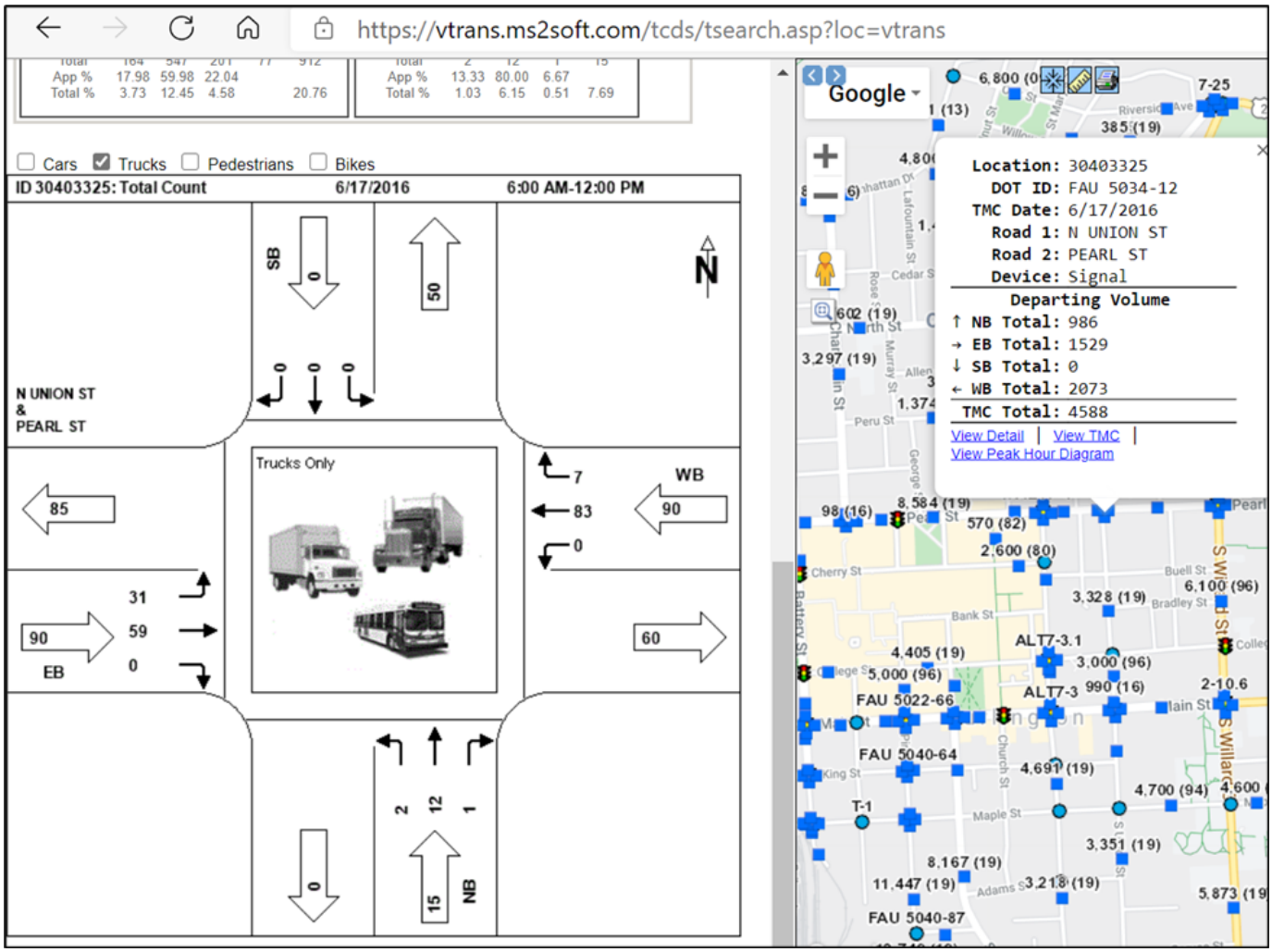
The intersection layout can be completed using the turning paths for the selected design vehicles, and control vehicle if applicable. Again, software such as AutoTurn can be used in this process. The layout should indicate proposed curb radii, lane widths, stop bar locations, and on-street parking, as appropriate. When evaluating vehicle encroachments, parking lanes should be treated the same as curb lines and bike lanes the same as vehicular travel lanes. The needs of each intersection approach should be evaluated separately. However, in the final design, uniformity, for example, a consistent curb radius on all four corners, may be desirable for multiple reasons. Uniformity could reduce construction costs, better meet pedestrian and driver expectations, and provide aesthetic benefits.

APPENDIX A
SAMPLE TRAFFIC COUNT DATA

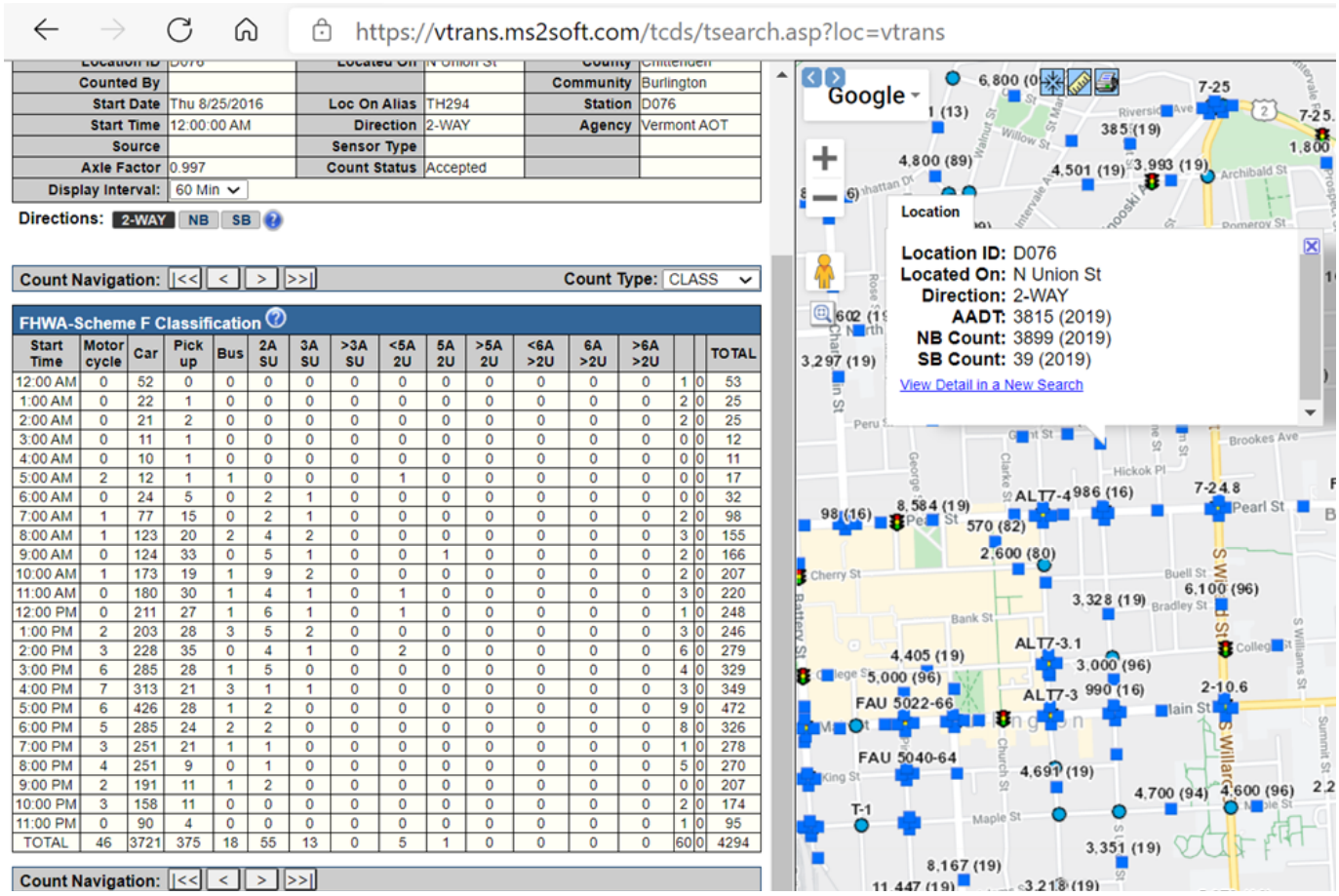
Turning movement count displaying volumes for all vehicle types.



Turning movement count displaying volumes for trucks and buses



Automatic Traffic Recorder count displaying volumes by federal vehicle classes for a roadway segment.



https://vtrans.ms2soft.com/tcds/tsearch.asp?loc=vtrans

Location ID	D076	Located On	N Union St	County	Chittenden
Counted By				Community	Burlington
Start Date	Thu 8/25/2016	Loc On Alias	TH294	Station	D076
Start Time	12:00:00 AM	Direction	2-WAY	Agency	Vermont AOT
Source		Sensor Type			
Axle Factor	0.997	Count Status	Accepted		
Display Interval:	60 Min				

Directions: 2-WAY NB SB

Count Navigation: |<< < > >>| Count Type: CLASS

FHWA-Scheme F Classification

Start Time	Motor cycle	Car	Pick up	Bus	2A SU	3A SU	>3A SU	<5A 2U	5A 2U	>5A 2U	<6A >2U	6A >2U	>6A >2U			TOTAL
12:00 AM	0	52	0	0	0	0	0	0	0	0	0	0	0	1	0	53
1:00 AM	0	22	1	0	0	0	0	0	0	0	0	0	0	2	0	25
2:00 AM	0	21	2	0	0	0	0	0	0	0	0	0	0	2	0	25
3:00 AM	0	11	1	0	0	0	0	0	0	0	0	0	0	0	0	12
4:00 AM	0	10	1	0	0	0	0	0	0	0	0	0	0	0	0	11
5:00 AM	2	12	1	1	0	0	0	1	0	0	0	0	0	0	0	17
6:00 AM	0	24	5	0	2	1	0	0	0	0	0	0	0	0	0	32
7:00 AM	1	77	15	0	2	1	0	0	0	0	0	0	0	2	0	98
8:00 AM	1	123	20	2	4	2	0	0	0	0	0	0	0	3	0	155
9:00 AM	0	124	33	0	5	1	0	0	1	0	0	0	0	2	0	166
10:00 AM	1	173	19	1	9	2	0	0	0	0	0	0	0	2	0	207
11:00 AM	0	180	30	1	4	1	0	1	0	0	0	0	0	3	0	220
12:00 PM	0	211	27	1	6	1	0	1	0	0	0	0	0	1	0	248
1:00 PM	2	203	28	3	5	2	0	0	0	0	0	0	0	3	0	246
2:00 PM	3	228	35	0	4	1	0	2	0	0	0	0	0	6	0	279
3:00 PM	6	285	28	1	5	0	0	0	0	0	0	0	0	4	0	329
4:00 PM	7	313	21	3	1	1	0	0	0	0	0	0	0	3	0	349
5:00 PM	6	426	28	1	2	0	0	0	0	0	0	0	0	9	0	472
6:00 PM	5	285	24	2	2	0	0	0	0	0	0	0	0	8	0	326
7:00 PM	3	251	21	1	1	0	0	0	0	0	0	0	0	1	0	278
8:00 PM	4	251	9	0	1	0	0	0	0	0	0	0	0	5	0	270
9:00 PM	2	191	11	1	2	0	0	0	0	0	0	0	0	0	0	207
10:00 PM	3	158	11	0	0	0	0	0	0	0	0	0	0	2	0	174
11:00 PM	0	90	4	0	0	0	0	0	0	0	0	0	0	1	0	95
TOTAL	46	3721	375	18	55	13	0	5	1	0	0	0	0	60	0	4294

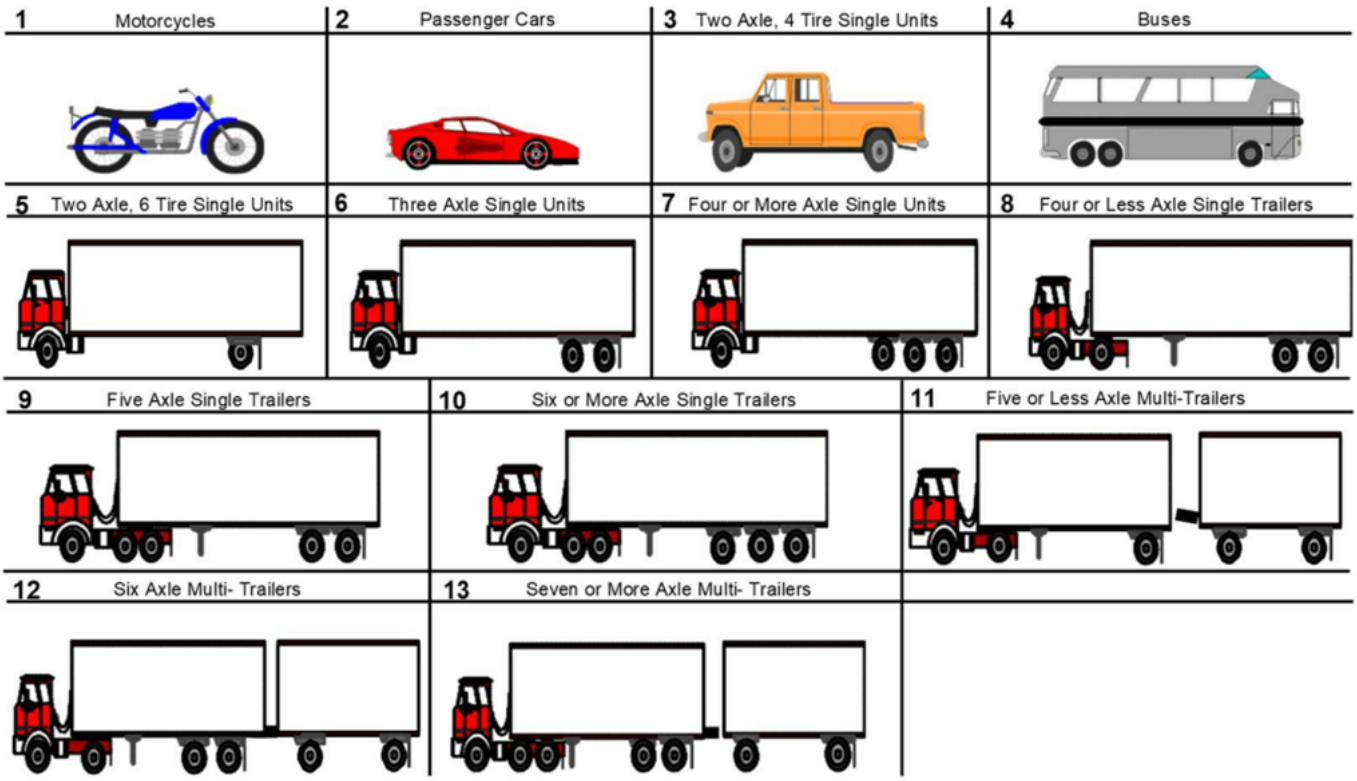
Count Navigation: |<< < > >>|

APPENDIX B
TRAFFIC COUNTING

The selection of design vehicles depends on the volume and mix of vehicles using the intersection. When traffic counts are conducted to support design decisions, a 12-hour vehicle classification/turning movement count conducted by 15-minute intervals on a typical weekday is recommended. The data should be summarized to identify morning and evening commuter peak hour volumes. Roadways providing direct connections to Burlington waterfront attractions shall also be examined for a typical Saturday during the summer season, if possible, to capture recreational vehicle traffic and vehicles towing trailers.

The volume counts should classify vehicles by the five groups listed in Table 1. This is best accomplished through a manual count. Field staff conducting the counts should be trained in advance to identify and group the vehicle types. The illustration provided in Figure A-1 identifies federal vehicle classifications and can be used as a training guide. However, this illustration does not include drawings for delivery vehicles, recycle trucks, recreational vehicles, and cars pulling trailers.

Figure A-1 FHWA Vehicle Classifications



Source: 2019 Automatic Vehicle Classification Report, Vermont Agency of Transportation, Highway Division, Traffic Research Unit, July 2020.

Automated traffic counts are an alternative and less desirable source of data. Automatic Traffic Recorder (ATR) or tube counts can generally identify the vehicle types shown in Figure A-1 however, the counts can only measure volumes by direction on a roadway segment. They cannot collect turning movement data at an intersection. Video Camera Unit (VCU) counts collect video of vehicle turning movements, however, the software that "counts" the vehicles classifies them into only three groups: Cars (Motorcycles, Cars, Light Good Vehicles or Vans); Single Unit Heavy (Buses, Single-Unit Trucks); and, Multi-Unit Heavy (Articulated Trucks). If the VCU data is used directly, then Groups 2 and 3 should be combined and treated as Group 3 under this guidance document. Alternatively, the VCU videos can be reviewed manually to count Group 2 vehicles separately. The approach to collecting, combining, or estimating traffic volumes should be reviewed with the Burlington DPW at the beginning of each design project.

APPENDIX C
ROADWAY FUNCTIONAL CLASSIFICATIONS

Municipalities and states assign functional classifications to roadways defining the roadway system hierarchy. All roadways serve access and mobility needs on a continuum. At one end of the spectrum, local roads provide a high level of land access with many curb cuts, low volumes, short trips, and slow travel speeds. Freeways are at the other end of the spectrum providing a high level of mobility, moving large volumes of traffic long distances at high speeds with limited side friction. The functional classifications VTrans has applied to Burlington streets include:

- Principal Arterials;
- Minor Arterials;
- Major Collectors;
- Minor Collectors; and,
- Local Roads.

HIGH MOBILITY/LOW ACCESS

LOW MOBILITY/HIGH ACCESS

Figure A-2 shows the mapping of Federal-Aid roadways in downtown Burlington by functional classification (as of April 2020). Table A-1 provides a listing of arterial and collector streets and street segments identified by the map. The current VTrans classifications shall apply in this guidance document unless directed otherwise by the City.

Figure A-2 VTrans Roadway Classification Map for Burlington

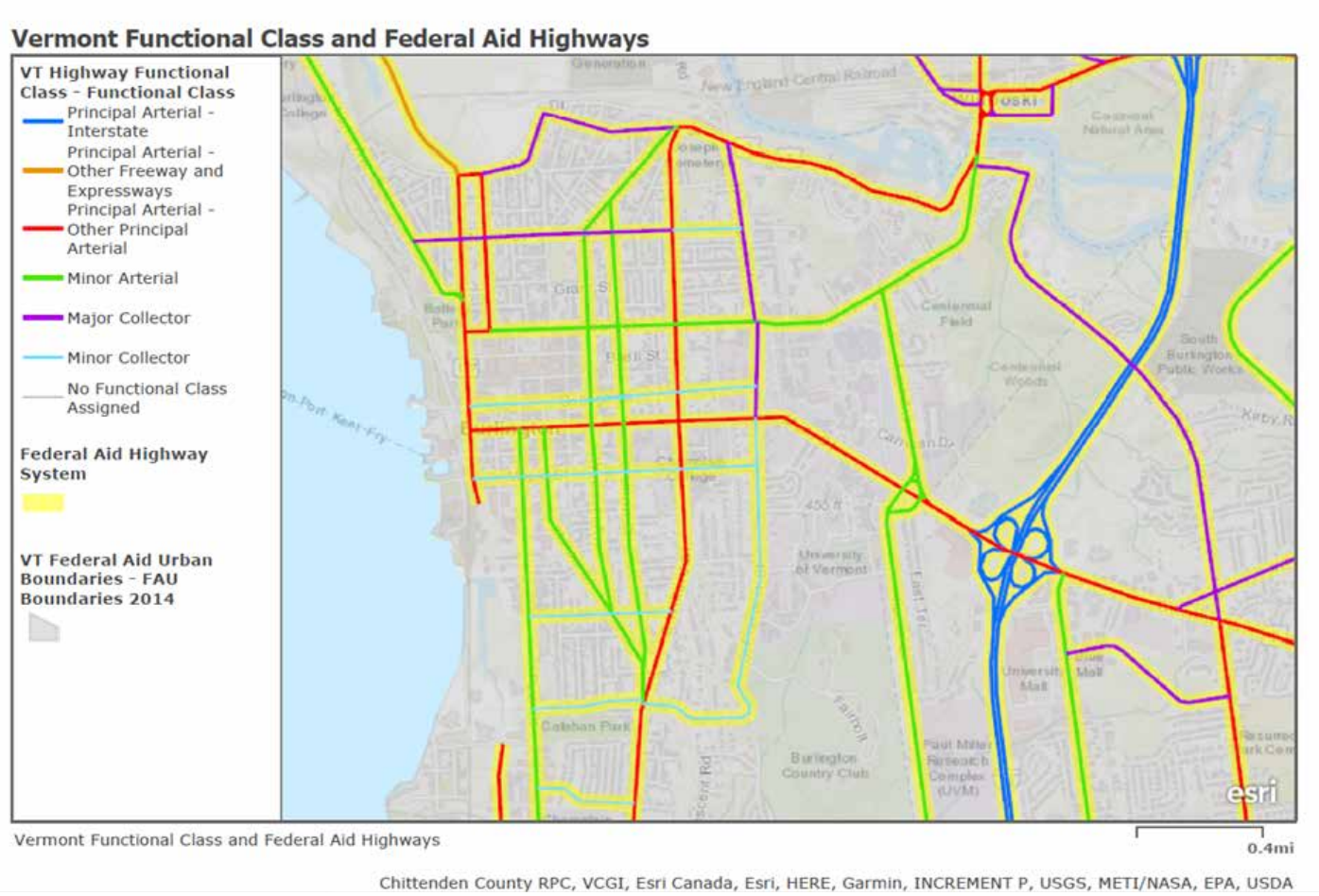


Table A-1 Functional Classifications of Burlington Streets

Functional Classification	Street or Street Segment	
Principal Arterial	Battery Street	Park Street
	Hyde Street (North of Willard)	Pearl Street (Battery to N. Champlain)
	Main Street	Riverside Avenue
	Manhattan Drive (Park to N. Champlain)	Shelburne Street
	N. Champlain Street	Willard Street
Minor Arterial	Colchester Avenue	Pine Street (Main to Flynn)
	East Avenue	Spear Street
	Flynn Avenue	St. Paul Street (South of Main)
	North Avenue	Union Street
	Pearl Street (East of N. Champlain)	Winooski Avenue
Major Collector	Barrett Street	Oak Street
	Grove Street	Prospect Street (North of Main)
	Manhattan Drive (East of N. Champlain)	Riverside Avenue (West of N. Winooski)
	North Street (West of Willard)	
Minor Collector	Birchcliff Parkway	Locust Street
	College Street	Maple Street
	Howard Street	North Street (East of Willard)
	Ledge Road	Prospect Street (South of Main, North of Ledge)
	Locust Street	

APPENDIX D
PLANNING DOCUMENTS

The plans and studies listed below should be considered in anticipating changes in future traffic patterns at the subject intersection. This list is updated periodically. The design engineer should consult with Burlington DPW during the design process to confirm that this list is current.

Studies and Plans
PlanBTV Downtown & Waterfront
PlanBTV Walk/Bike
Plan BTV South End
Burlington Transportation Plan
Colchester Avenue Corridor Plan
North Avenue Corridor Study
Winooski Avenue Transportation Study
Champlain Parkway
Development Review Board Agendas
Capital Improvement Plan
Construction/Repaving Plan

List last updated January 28, 2020.

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