Pedalling Forward: The Evolution of Dedicated Cycling Infrastructure in Canadian Cities from 2010 to 2022

R Code for Preprocessing Raw Data prepared by Konrad Samsel

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Contents

Libraries

Install R libraries if needed.

```
install.packages("rmarkdown")
install.packages("bookdown")
install.packages("knitr")
install.packages("tidyverse")
install.packages("readxl")
install.packages("sf")
install.packages("lwgeom")
```

Load R libraries.

```
library(readxl)
library(sf)
library(tidyverse)
```

Data

Read in the raw data for each city.

Vancouver Raw Data

Calgary Raw Data

Toronto Raw Data

```
toron_raw <- st_read("../data/raw/Toronto AS Export/Toronto_AS_1323.shp")
```

```
## Reading layer `Toronto_AS_1323' from data source
##   `/Users/rrwen/Desktop/recovr-infracycle/data/raw/Toronto AS Export/Toronto_AS_1323.shp'
##   using driver `ESRI Shapefile'
## Simple feature collection with 1323 features and 66 fields
## Geometry type: MULTILINESTRING
## Dimension:     XY
## Bounding box:  xmin: -79.63039 ymin: 43.58221 xmax: -79.11803 ymax: 43.85546
## Geodetic CRS:  WGS 84
```

```
toron_raw
```

```
## Simple feature collection with 1323 features and 66 fields
## Geometry type: MULTILINESTRING
## Dimension:     XY
## Bounding box:  xmin: -79.63039 ymin: 43.58221 xmax: -79.11803 ymax: 43.85546
## Geodetic CRS:  WGS 84
## First 10 features:
##    X_id1 OBJECTI2 SEGMENT3 INSTALL4 UPGRADE5 PRE_AMA6          STREET_7
## 1      8        8        8     2001     2021     <NA>        Bloor St E
## 2     17       17       17     2001     2015     <NA> Lake Shore Blvd W
## 3     18       18       18     2001     2015     <NA> Lake Shore Blvd W
## 4     19       19       19     2001     2015     <NA> Lake Shore Blvd W
## 5     38       38       38     2001        0     <NA>     Queens Quay W
## 6     39       39       39     2001     2016     <NA>      Davenport Rd
## 7     40       40       40     2001     2016     <NA>      Elizabeth St
## 8     41       41       41     2001        0     <NA>      Gerrard St E
## 9     42       42       42     2001     2016     <NA>    Macpherson Ave
## 10    43       43       43     2001     2016     <NA> Lake Shore Blvd W
##                FROM_ST8                TO_STRE9 ROADCLA10 CNPCLAS11 SURFACE12
## 1          Parliament St          Castle Frank Rd      <NA>      <NA>      <NA>
## 2  Humber Bay Park Rd W Humber Bay Park East Trl      <NA>      <NA>      <NA>
## 3  37 M E Fleeceline Rd     Humber Bay Park Rd W      <NA>      <NA>      <NA>
## 4    50.7 M E Louisa St     37 M E Fleeceline Rd      <NA>      <NA>      <NA>
## 5    Martin Goodman Trl              Bathurst St      <NA>      <NA>      <NA>
## 6          Cottingham Rd           Macpherson Ave      <NA>      <NA>      <NA>
## 7             College St             Gerrard St W      <NA>      <NA>      <NA>
## 8               Yonge St                Church St      <NA>      <NA>      <NA>
## 9           Davenport Rd         Poplar Plains Rd      <NA>      <NA>      <NA>
## 10     Marine Parade Dr          Palace Pier Crt      <NA>      <NA>      <NA>
##    OWNER13 DIR_LOW14                INFRA_L15 SEPA_LO16 SEPB_LO17 ORIG_LO18
## 1     <NA>      <NA>              Cycle Track      <NA>      <NA>      <NA>
## 2     <NA>      <NA>                    <NA>      <NA>      <NA>      <NA>
## 3     <NA>      <NA>               Bike Lane      <NA>      <NA>      <NA>
```

```
## 4     <NA>      <NA>                        <NA>      <NA>      <NA>      <NA>
## 5     <NA>      <NA> Bi-Directional Cycle Track      <NA>      <NA>      <NA>
## 6     <NA>      <NA>                   Bike Lane      <NA>      <NA>      <NA>
## 7     <NA>      <NA>                   Bike Lane      <NA>      <NA>      <NA>
## 8     <NA>      <NA>                 Cycle Track      <NA>      <NA>      <NA>
## 9     <NA>      <NA>                   Bike Lane      <NA>      <NA>      <NA>
## 10    <NA>      <NA>                        <NA>      <NA>      <NA>      <NA>
##    DIR_HIG19                   INFRA_H20 SEPA_HI21 SEPB_HI22 ORIG_HI23 BYLAWED24
## 1       <NA>                 Cycle Track      <NA>      <NA>      <NA>      <NA>
## 2       <NA>                   Bike Lane      <NA>      <NA>      <NA>      <NA>
## 3       <NA>                   Bike Lane      <NA>      <NA>      <NA>      <NA>
## 4       <NA>                   Bike Lane      <NA>      <NA>      <NA>      <NA>
## 5       <NA> Bi-Directional Cycle Track      <NA>      <NA>      <NA>      <NA>
## 6       <NA>                   Bike Lane      <NA>      <NA>      <NA>      <NA>
## 7       <NA>                   Bike Lane      <NA>      <NA>      <NA>      <NA>
## 8       <NA>                 Cycle Track      <NA>      <NA>      <NA>      <NA>
## 9       <NA>                   Bike Lane      <NA>      <NA>      <NA>      <NA>
## 10      <NA>                   Bike Lane      <NA>      <NA>      <NA>      <NA>
##    EDITOR25           LAST_ED26 UPGRADE27 CONVERT28 OBJ2 ID_SEAN C_INST_YR
## 1      <NA> 2023-01-16T19:53:01      <NA>         0    8    2676      2001
## 2      <NA> 2023-01-16T19:53:01      <NA>      <NA>   17    2685      2001
## 3      <NA> 2023-01-16T19:53:01      <NA>      <NA>   18    2686      2001
## 4      <NA> 2023-01-16T19:53:01      <NA>      <NA>   19    2687      2001
## 5      <NA> 2023-01-16T19:53:01      <NA>      2015   38      NA      2001
## 6      <NA> 2023-01-16T19:53:01      <NA>      <NA>   39    2707      2001
## 7      <NA> 2023-01-16T19:53:01      <NA>      <NA>   40    2708      2001
## 8      <NA> 2023-01-16T19:53:01      <NA>      2016   41      NA      2001
## 9      <NA> 2023-01-16T19:53:01      <NA>      <NA>   42    2710      2001
## 10     <NA> 2023-01-16T19:53:01      <NA>      <NA>   43    2711      2001
##    C_UPGR_YR                   C_INFRA_H                  C_INFRA_L
## 1       2021                 Cycle Track                Cycle Track
## 2       2015                   Bike Lane                         NA
## 3       2015                   Bike Lane                  Bike Lane
## 4       2015                   Bike Lane                         NA
## 5          0 Bi-Directional Cycle Track Bi-Directional Cycle Track
## 6       2016                   Bike Lane                  Bike Lane
## 7       2016                   Bike Lane                  Bike Lane
## 8          0                 Cycle Track                Cycle Track
## 9       2016                   Bike Lane                  Bike Lane
## 10      2016                   Bike Lane                         NA
##                   C_REV C_CONVERT  LENGTH_M          STR_NAME
## 1  2023-01-16T19:53:01         0 326.39321        Bloor St E
## 2  2023-01-16T19:53:01        NA 236.53458 Lake Shore Blvd W
## 3  2023-01-16T19:53:01        NA 225.95587 Lake Shore Blvd W
## 4  2023-01-16T19:53:01        NA 112.81407 Lake Shore Blvd W
## 5  2023-01-16T19:53:01      2015 225.35235     Queens Quay W
## 6  2023-01-16T19:53:01        NA 179.40185      Davenport Rd
## 7  2023-01-16T19:53:01        NA 272.55179      Elizabeth St
## 8  2023-01-16T19:53:01      2016 301.12641      Gerrard St E
## 9  2023-01-16T19:53:01        NA  59.63888    Macpherson Ave
## 10 2023-01-16T19:53:01        NA 157.84926 Lake Shore Blvd W
##                 FROM_STR                  TO_STR EXCL_FLAG CHECK_FLAG
## 1          Parliament St          Castle Frank Rd        NA         NA
## 2  Humber Bay Park Rd W Humber Bay Park East Trl        NA         NA
```

```
## 3  37 M E Fleeceline Rd     Humber Bay Park Rd W        NA         NA
## 4    50.7 M E Louisa St     37 M E Fleeceline Rd        NA         NA
## 5    Martin Goodman Trl              Bathurst St        NA         NA
## 6         Cottingham Rd           Macpherson Ave        NA         NA
## 7            College St             Gerrard St W        NA         NA
## 8              Yonge St                Church St        NA         NA
## 9           Davenport Rd         Poplar Plains Rd        NA         NA
## 10     Marine Parade Dr          Palace Pier Crt        NA         NA
##
## 1
## 2
## 3
## 4
## 5
## 6
## 7              PL with diamond marking also functioning as parking shoulder; SV Sep 2007: https://ww
## 8
## 9  Street segment is an intersection core where all three street merge, May2019 SV: https://www.goog
## 10
##    INST_YR    INST_DATE INST_TYPE INST_TMAJ INST_TMIN
## 1     2001     Pre-2007        PL        PL        PL
## 2     2015           NA        PL        PL        PL
## 3     2015           NA        PL        PL        PL
## 4     2015           NA        PL        PL        PL
## 5     2009     Pre-2009        PL        PL        PL
## 6     2007     Pre-2007        PL        PL        PL
## 7     2007 pre Sep 2007        PL        PL        PL
## 8     2007 pre Sep 2007        PL        PL        PL
## 9     2007 pre Sep 2007        PL        PL        PL
## 10    2016 May-Nov 2016        PL        PL        PL
##
## 1                                                                                  PL pre-2007: https:/
## 2  Painted Lane: https://www.google.com/maps/@43.621083,-79.4826483,3a,75y,18.21h,88.06t/data=!3m8!1
## 3                                                                                        Pain
## 4                                                                                Painted Lane: https
## 5                                                                      PL installed pre-2009: https
## 6                                                                           Pre 2007: https
## 7                                                          PL pre 2007: SV (https://www.google.com/ma
## 8                                                                        Sep 2007 SV: https:/
## 9                                                                  Sep 2007 road signage SV: https:/
## 10 PL installed between May 2016 and Jul 2017: https://www.google.com/maps/@43.6312765,-79.4755769,3
##    UPGR1_YR          UPGR1_DATE UPGR1_TYPE UPGR1_TMAJ UPGR1_TMIN
## 1      2021           23-Sep-21        PBL        PBL        PBL
## 2        NA                  NA         NA         NA         NA
## 3        NA                  NA         NA         NA         NA
## 4        NA                  NA         NA         NA         NA
## 5      2015     April-Sept 2015        PBL        PBL        PBL
## 6      2016                  NA         PL         PL         PL
## 7      2016                  NA         PL        `PL        `PL
## 8      2017 Oct 2016 - Mar 2017        PBL        PBL        PBL
## 9        NA                  NA         NA         NA         NA
## 10       NA                  NA         NA         NA         NA
##
## 1  PBL upgraded between 2020 and 2021: https://www.google.com/maps/@43.673219,-79.3690773,3a,75y,86.
```

```
## 2
## 3
## 4
## 5                                                                    PBL upgrade April - Sept 2015: https
## 6
## 7
## 8                                                                                  Aug 2017 SV: https
## 9
## 10
##    UPGR2_YR UPGR2_DATE UPGR2_TYPE UPGR2_TMAJ UPGR2_TMIN UPGR2_COMM
## 1        NA         NA         NA         NA         NA         NA
## 2        NA         NA         NA         NA         NA         NA
## 3        NA         NA         NA         NA         NA         NA
## 4        NA         NA         NA         NA         NA         NA
## 5        NA         NA         NA         NA         NA         NA
## 6        NA         NA         NA         NA         NA         NA
## 7        NA         NA         NA         NA         NA         NA
## 8        NA         NA         NA         NA         NA         NA
## 9        NA         NA         NA         NA         NA         NA
## 10       NA         NA         NA         NA         NA         NA
##                                                                                                GEOJSON_I
## 1   {"type": "LineString", "coordinates": [[-79.37123215,43.67189314],[-79.3682041,43.67377549]]}
## 2   {"type": "LineString", "coordinates": [[-79.4813491,43.62279026],[-79.48274947,43.62092569]]}
## 3  {"type": "LineString", "coordinates": [[-79.48274947,43.62092569],[-79.48512645,43.61995029]]}
## 4  {"type": "LineString", "coordinates": [[-79.48512645,43.61995029],[-79.48619319,43.61933736]]}
## 5     {"type": "LineString", "coordinates": [[-79.4006056,43.63446412],[-79.39836554,43.635675]]}
## 6  {"type": "LineString", "coordinates": [[-79.40369012,43.67668014],[-79.40524887,43.67782373]]}
## 7  {"type": "LineString", "coordinates": [[-79.38641551,43.65817393],[-79.38742549,43.66051487]]}
## 8  {"type": "LineString", "coordinates": [[-79.38211785,43.65909596],[-79.37853555,43.65985789]]}
## 9  {"type": "LineString", "coordinates": [[-79.40298419,43.67684018],[-79.40369012,43.67668014]]}
## 10  {"type": "LineString", "coordinates": [[-79.4755406,43.63126263],[-79.47691449,43.63026962]]}
##
## 1   {"type": "Feature", "geometry": {"type": "LineString", "coordinates": [[-79.37123215,43.67189314]
## 2   {"type": "Feature", "geometry": {"type": "LineString", "coordinates": [[-79.4813491,43.62279026]
## 3  {"type": "Feature", "geometry": {"type": "LineString", "coordinates": [[-79.48274947,43.62092569]
## 4  {"type": "Feature", "geometry": {"type": "LineString", "coordinates": [[-79.48512645,43.61995029]
## 5     {"type": "Feature", "geometry": {"type": "LineString", "coordinates": [[-79.4006056,43.6344641
## 6  {"type": "Feature", "geometry": {"type": "LineString", "coordinates": [[-79.40369012,43.67668014]
## 7  {"type": "Feature", "geometry": {"type": "LineString", "coordinates": [[-79.38641551,43.65817393]
## 8  {"type": "Feature", "geometry": {"type": "LineString", "coordinates": [[-79.38211785,43.65909596]
## 9  {"type": "Feature", "geometry": {"type": "LineString", "coordinates": [[-79.40298419,43.67684018]
## 10  {"type": "Feature", "geometry": {"type": "LineString", "coordinates": [[-79.4755406,43.63126263]
##                                                                                                    M
## 1   https://www.google.com/maps/dir/43.67189314,-79.37123215/43.67275343,-79.36966176/43.67377549,-79
## 2   https://www.google.com/maps/dir/43.62279026,-79.4813491/43.62186257,-79.48205721/43.62092569,-79
## 3  https://www.google.com/maps/dir/43.62092569,-79.48274947/43.62025523,-79.48388336/43.61995029,-79
## 4  https://www.google.com/maps/dir/43.61995029,-79.48512645/43.61974203,-79.48572034/43.61933736,-79
## 5     https://www.google.com/maps/dir/43.63446412,-79.4006056/43.63507963,-79.39949108/43.635675,-79
## 6  https://www.google.com/maps/dir/43.67668014,-79.40369012/43.67728769,-79.40444055/43.67782373,-79
## 7    https://www.google.com/maps/dir/43.65817393,-79.38641551/43.6593444,-79.3869205/43.66051487,-79
## 8  https://www.google.com/maps/dir/43.65909596,-79.38211785/43.65947074,-79.38032536/43.65985789,-79
## 9  https://www.google.com/maps/dir/43.67684018,-79.40298419/43.67676016,-79.40333715/43.67668014,-79
## 10  https://www.google.com/maps/dir/43.63126263,-79.4755406/43.63072689,-79.47620518/43.63026962,-79
##    YEAR_DIFF POST2019                       geometry
```

```
## 1         NA        1 MULTILINESTRING ((-79.37123...
## 2         14        0 MULTILINESTRING ((-79.48135...
## 3         14        0 MULTILINESTRING ((-79.48275...
## 4         14        0 MULTILINESTRING ((-79.48513...
## 5         NA        0 MULTILINESTRING ((-79.40061...
## 6         NA        0 MULTILINESTRING ((-79.40369...
## 7         NA        0 MULTILINESTRING ((-79.38642...
## 8         NA        0 MULTILINESTRING ((-79.38212...
## 9         NA        0 MULTILINESTRING ((-79.40298...
## 10        15        0 MULTILINESTRING ((-79.47554...
```

Preprocess

Preprocess raw data for each city.

Vancouver Preprocessed Data

Calgary Preprocessed Data

Toronto Preprocessed Data

```
# Preprocess data
toron_prep <- toron_raw %>%
    select( # select and rename
        id = OBJECTI2,
        street = STREET_7,
        street_from = FROM_ST8,
        street_to = TO_STRE9,
        install_year = INSTALL4,
        install_type = INFRA_H20, # similar to C_INFRA_H
        verify_install_year = INST_YR,
        verify_install_date = INST_DATE,
        verify_install_type = INST_TMIN,
        verify_install_comment = INST_COMM,
        verify_upgrade1_year = UPGR1_YR,
        verify_upgrade1_date = UPGR1_DATE,
        verify_upgrade1_type = UPGR1_TMIN,
        verify_upgrade1_comment = UPGR1_COMM,
        verify_upgrade2_year = UPGR2_YR,
        verify_upgrade2_date = UPGR2_DATE,
        verify_upgrade2_type = UPGR2_TMIN,
        verify_upgrade2_comment = UPGR2_COMM,
        verify_excl_flag = EXCL_FLAG
    ) %>%
    mutate( # data types
        id = as.character(id),
        street = as.character(street),
        street_from = as.character(street_from),
        street_to = as.character(street_to),
        install_year = as.numeric(install_year),
        install_type = as.character(install_type),
        verify_install_year = as.numeric(verify_install_year),
        verify_install_date = as.character(verify_install_date),
        verify_install_type = as.character(verify_install_type),
```

```
        verify_install_comment = as.character(verify_install_comment),
        verify_upgrade1_year = as.numeric(verify_upgrade1_year),
        verify_upgrade1_date = as.character(verify_upgrade1_date),
        verify_upgrade1_type = as.character(verify_upgrade1_type),
        verify_upgrade1_comment = as.character(verify_upgrade1_comment),
        verify_upgrade2_year = as.numeric(verify_upgrade2_year),
        verify_upgrade2_date = as.character(verify_upgrade2_date),
        verify_upgrade2_type = as.character(verify_upgrade2_type),
        verify_upgrade2_comment = as.character(verify_upgrade2_comment),
        verify_excl_flag = as.character(verify_excl_flag)
    ) %>%
    mutate( # clean values
        install_year = na_if(install_year, 0),
        verify_install_year = na_if(verify_install_year, 0),
        verify_install_date = na_if(verify_install_date, "NA"),
        verify_install_type = na_if(verify_install_type, "NA") %>%
            str_replace_all("[^[:alpha:]]|\\s", ""),
        verify_install_comment = na_if(verify_install_comment, "NA"),
        verify_upgrade1_year = na_if(verify_upgrade1_year, 0),
        verify_upgrade1_date = na_if(verify_upgrade1_date, "NA"),
        verify_upgrade1_type = na_if(verify_upgrade1_type, "NA") %>%
            str_replace_all("[^[:alpha:]]|\\s", ""),
        verify_upgrade1_comment = na_if(verify_upgrade1_comment, "NA"),
        verify_upgrade2_year = na_if(verify_upgrade2_year, 0),
        verify_upgrade2_date = na_if(verify_upgrade2_date, "NA"),
        verify_upgrade2_type = na_if(verify_upgrade2_type, "NA") %>%
            str_replace_all("[^[:alpha:]]|\\s", ""),
        verify_upgrade2_comment = na_if(verify_upgrade2_comment, "NA"),
        verify_excl_flag =  na_if(verify_excl_flag, "NA") %>%
            str_replace_all("\\s", "")
    ) %>%
    mutate( # create columns
        len_km = as.numeric(st_length(geometry)) / 1000,
        .before = geometry
    )
```

```
## Warning: There were 2 warnings in `stopifnot()`.
## The first warning was:
## i In argument: `verify_upgrade1_year = as.numeric(verify_upgrade1_year)`.
## Caused by warning:
## ! NAs introduced by coercion
## i Run `dplyr::last_dplyr_warnings()` to see the 1 remaining warning.
```

```
# Save geojson
toron_prep %>%
    st_write("../data/toronto_bikeways_v1.geojson", delete_dsn = TRUE)
```

```
## Deleting source `../data/toronto_bikeways_v1.geojson' using driver `GeoJSON'
## Writing layer `toronto_bikeways_v1' to data source
##   `../data/toronto_bikeways_v1.geojson' using driver `GeoJSON'
## Writing 1323 features with 20 fields and geometry type Multi Line String.
```

```
# Save csv
# st_read("../data/toronto_bikeways_v1.csv", options = "GEOM_POSSIBLE_NAMES=geometry", crs = "urn:ogc:d
toron_prep %>%
```

```
    mutate(
        geometry = st_as_text(geometry),
        geometry_crs = "urn:ogc:def:crs:OGC:1.3:CRS84",
        .before = geometry
    ) %>%
    write_csv("../data/toronto_bikeways_v1.csv", na = "")
toron_prep
```

```
## Simple feature collection with 1323 features and 20 fields
## Geometry type: MULTILINESTRING
## Dimension:     XY
## Bounding box:  xmin: -79.63039 ymin: 43.58221 xmax: -79.11803 ymax: 43.85546
## Geodetic CRS:  WGS 84
## First 10 features:
##    id            street          street_from                street_to
## 1   8        Bloor St E        Parliament St          Castle Frank Rd
## 2  17 Lake Shore Blvd W Humber Bay Park Rd W Humber Bay Park East Trl
## 3  18 Lake Shore Blvd W 37 M E Fleeceline Rd     Humber Bay Park Rd W
## 4  19 Lake Shore Blvd W   50.7 M E Louisa St     37 M E Fleeceline Rd
## 5  38     Queens Quay W   Martin Goodman Trl              Bathurst St
## 6  39      Davenport Rd        Cottingham Rd           Macpherson Ave
## 7  40      Elizabeth St           College St             Gerrard St W
## 8  41      Gerrard St E             Yonge St                Church St
## 9  42    Macpherson Ave         Davenport Rd         Poplar Plains Rd
## 10 43 Lake Shore Blvd W     Marine Parade Dr          Palace Pier Crt
##    install_year               install_type verify_install_year
## 1          2001                Cycle Track                2001
## 2          2001                  Bike Lane                2015
## 3          2001                  Bike Lane                2015
## 4          2001                  Bike Lane                2015
## 5          2001 Bi-Directional Cycle Track                2009
## 6          2001                  Bike Lane                2007
## 7          2001                  Bike Lane                2007
## 8          2001                Cycle Track                2007
## 9          2001                  Bike Lane                2007
## 10         2001                  Bike Lane                2016
##    verify_install_date verify_install_type
## 1             Pre-2007                  PL
## 2                 <NA>                  PL
## 3                 <NA>                  PL
## 4                 <NA>                  PL
## 5             Pre-2009                  PL
## 6             Pre-2007                  PL
## 7         pre Sep 2007                  PL
## 8         pre Sep 2007                  PL
## 9         pre Sep 2007                  PL
## 10        May-Nov 2016                  PL
##
## 1                                                                                                PL pre-2007: https:/
## 2  Painted Lane: https://www.google.com/maps/@43.621083,-79.4826483,3a,75y,18.21h,88.06t/data=!3m8!1
## 3                                                                                                              Paint
## 4                                                                                              Painted Lane: https
## 5                                                                                  PL installed pre-2009: https
## 6                                                                                                  Pre 2007: https
```

```
## 7                                                                PL pre 2007: SV (https://www.google.com/ma
## 8                                                                                     Sep 2007 SV: https:/
## 9                                                                                Sep 2007 road signage SV: https:
## 10 PL installed between May 2016 and Jul 2017: https://www.google.com/maps/@43.6312765,-79.4755769,3
##    verify_upgrade1_year verify_upgrade1_date verify_upgrade1_type
## 1                  2021            23-Sep-21                  PBL
## 2                    NA                 <NA>                 <NA>
## 3                    NA                 <NA>                 <NA>
## 4                    NA                 <NA>                 <NA>
## 5                  2015      April-Sept 2015                  PBL
## 6                  2016                 <NA>                   PL
## 7                  2016                 <NA>                   PL
## 8                  2017  Oct 2016 - Mar 2017                  PBL
## 9                    NA                 <NA>                 <NA>
## 10                   NA                 <NA>                 <NA>
##
## 1  PBL upgraded between 2020 and 2021: https://www.google.com/maps/@43.673219,-79.3690773,3a,75y,86.
## 2
## 3
## 4
## 5                                                          PBL upgrade April - Sept 2015: https
## 6
## 7
## 8                                                                                Aug 2017 SV: https
## 9
## 10
##    verify_upgrade2_year verify_upgrade2_date verify_upgrade2_type
## 1                    NA                 <NA>                 <NA>
## 2                    NA                 <NA>                 <NA>
## 3                    NA                 <NA>                 <NA>
## 4                    NA                 <NA>                 <NA>
## 5                    NA                 <NA>                 <NA>
## 6                    NA                 <NA>                 <NA>
## 7                    NA                 <NA>                 <NA>
## 8                    NA                 <NA>                 <NA>
## 9                    NA                 <NA>                 <NA>
## 10                   NA                 <NA>                 <NA>
##    verify_upgrade2_comment verify_excl_flag     len_km
## 1                     <NA>             <NA> 0.32600563
## 2                     <NA>             <NA> 0.23653384
## 3                     <NA>             <NA> 0.22555382
## 4                     <NA>             <NA> 0.11266642
## 5                     <NA>             <NA> 0.22502464
## 6                     <NA>             <NA> 0.17923435
## 7                     <NA>             <NA> 0.27268584
## 8                     <NA>             <NA> 0.30039368
## 9                     <NA>             <NA> 0.05949573
## 10                    <NA>             <NA> 0.15769752
##                         geometry
## 1  MULTILINESTRING ((-79.37123...
## 2  MULTILINESTRING ((-79.48135...
## 3  MULTILINESTRING ((-79.48275...
## 4  MULTILINESTRING ((-79.48513...
## 5  MULTILINESTRING ((-79.40061...
```

```
## 6  MULTILINESTRING ((-79.40369...
## 7  MULTILINESTRING ((-79.38642...
## 8  MULTILINESTRING ((-79.38212...
## 9  MULTILINESTRING ((-79.40298...
## 10 MULTILINESTRING ((-79.47554...
```

R Version

R and RMarkdown in RStudio was used to generate this document.

```
##                _
## platform       x86_64-apple-darwin20
## arch           x86_64
## os             darwin20
## system         x86_64, darwin20
## status
## major          4
## minor          3.1
## year           2023
## month          06
## day            16
## svn rev        84548
## language       R
## version.string R version 4.3.1 (2023-06-16)
## nickname       Beagle Scouts
```

R Code

The full R code is provided below.

```r
knitr::opts_chunk$set(echo = TRUE)
install.packages("rmarkdown")
install.packages("bookdown")
install.packages("knitr")
install.packages("tidyverse")
install.packages("readxl")
install.packages("sf")
install.packages("lwgeom")
library(readxl)
library(sf)
library(tidyverse)
toron_raw <- st_read("../data/raw/Toronto AS Export/Toronto_AS_1323.shp")
toron_raw

# Preprocess data
toron_prep <- toron_raw %>%
    select( # select and rename
        id = OBJECTI2,
        street = STREET_7,
        street_from = FROM_ST8,
        street_to = TO_STRE9,
        install_year = INSTALL4,
        install_type = INFRA_H20, # similar to C_INFRA_H
        verify_install_year = INST_YR,
```

```
        verify_install_date = INST_DATE,
        verify_install_type = INST_TMIN,
        verify_install_comment = INST_COMM,
        verify_upgrade1_year = UPGR1_YR,
        verify_upgrade1_date = UPGR1_DATE,
        verify_upgrade1_type = UPGR1_TMIN,
        verify_upgrade1_comment = UPGR1_COMM,
        verify_upgrade2_year = UPGR2_YR,
        verify_upgrade2_date = UPGR2_DATE,
        verify_upgrade2_type = UPGR2_TMIN,
        verify_upgrade2_comment = UPGR2_COMM,
        verify_excl_flag = EXCL_FLAG
    ) %>%
    mutate( # data types
        id = as.character(id),
        street = as.character(street),
        street_from = as.character(street_from),
        street_to = as.character(street_to),
        install_year = as.numeric(install_year),
        install_type = as.character(install_type),
        verify_install_year = as.numeric(verify_install_year),
        verify_install_date = as.character(verify_install_date),
        verify_install_type = as.character(verify_install_type),
        verify_install_comment = as.character(verify_install_comment),
        verify_upgrade1_year = as.numeric(verify_upgrade1_year),
        verify_upgrade1_date = as.character(verify_upgrade1_date),
        verify_upgrade1_type = as.character(verify_upgrade1_type),
        verify_upgrade1_comment = as.character(verify_upgrade1_comment),
        verify_upgrade2_year = as.numeric(verify_upgrade2_year),
        verify_upgrade2_date = as.character(verify_upgrade2_date),
        verify_upgrade2_type = as.character(verify_upgrade2_type),
        verify_upgrade2_comment = as.character(verify_upgrade2_comment),
        verify_excl_flag = as.character(verify_excl_flag)
    ) %>%
    mutate( # clean values
        install_year = na_if(install_year, 0),
        verify_install_year = na_if(verify_install_year, 0),
        verify_install_date = na_if(verify_install_date, "NA"),
        verify_install_type = na_if(verify_install_type, "NA") %>%
            str_replace_all("[^[:alpha:]]|\\s", ""),
        verify_install_comment = na_if(verify_install_comment, "NA"),
        verify_upgrade1_year = na_if(verify_upgrade1_year, 0),
        verify_upgrade1_date = na_if(verify_upgrade1_date, "NA"),
        verify_upgrade1_type = na_if(verify_upgrade1_type, "NA") %>%
            str_replace_all("[^[:alpha:]]|\\s", ""),
        verify_upgrade1_comment = na_if(verify_upgrade1_comment, "NA"),
        verify_upgrade2_year = na_if(verify_upgrade2_year, 0),
        verify_upgrade2_date = na_if(verify_upgrade2_date, "NA"),
        verify_upgrade2_type = na_if(verify_upgrade2_type, "NA") %>%
            str_replace_all("[^[:alpha:]]|\\s", ""),
        verify_upgrade2_comment = na_if(verify_upgrade2_comment, "NA"),
        verify_excl_flag =  na_if(verify_excl_flag, "NA") %>%
            str_replace_all("\\s", "")
```

```
    ) %>%
    mutate( # create columns
        len_km = as.numeric(st_length(geometry)) / 1000,
        .before = geometry
    )

# Save geojson
toron_prep %>%
    st_write("../data/toronto_bikeways_v1.geojson", delete_dsn = TRUE)

# Save csv
# st_read("../data/toronto_bikeways_v1.csv", options = "GEOM_POSSIBLE_NAMES=geometry", crs = "urn:ogc:d
toron_prep %>%
    mutate(
        geometry = st_as_text(geometry),
        geometry_crs = "urn:ogc:def:crs:OGC:1.3:CRS84",
        .before = geometry
    ) %>%
    write_csv("../data/toronto_bikeways_v1.csv", na = "")
toron_prep
version
```